Serum Ferritin Concentrations in Adolescents

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Abstract:
The present study aimed to assess iron stores of Iraqi adolescents by the assessment of their serum ferritin concentration. Collection of data was carried out during the period between the 1st of November 1996 untill the end of April 1997. A sample of 241 adolescents (89 males and 152 females) was included. The study showed that the mean serum ferritin concentration in males was significantly higher than females (24.4 Vs 16.8 microgram /L). Maximum prevalence of severe depletion of iron stores (SF<12 microgram/L) in males and in females was found in the age groups 14-15 and18-19 years respectively. In menstruating females, lowest mean serum ferritin value was found in the first year after menarche. On simple linear regression, in females, significant positive correlations were observed between serum ferritin concentration and dietary intake of calorie, protein and iron and with iron bioavailability of the diet, while significant negative correlation was noticed with the number of pads used during the menstrual period. However, in males, serum ferritin concentration showed significant positive correlations with age, dietary intake of iron and iron bioavailability of the diet. In multiple regression analysis, serum ferritin concentration has significant positive correlations with gender, age-gender interaction and iron bioavailability of the diet, while in females, significant negative correlation was observed with the number of pad used during the menstrual period.

Key wards: Iron stores, serum ferritin concentration, adolescents.

Introduction:

Ferritin is the major iron storage protein in the body[1]. Its serum concentration is closely related to body iron stores in healthy subjects [2]. In population studies, serum ferritin has proved a valuable epidemiological tool in the evaluation of iron status [3]. Scant body iron reserves and latent iron deficiency are common features in childhood and adolescence, due to increased iron requirements in connection with growth and expansion of the red cell mass [4]. Important disturbances in motor, behavior, mental performance and cellular immunity were related to iron deficiency with or without anemia [5]. A high prevalence of iron deficiency resulting in these potential alterations could lead to a larger public health problem [6]. No information is available on serum ferritin concentrations of Iraqi adolescents. The present study was designed to assess the iron stores of Iraqi adolescents by the assessment of their serum ferritin concentrations, also, to study the relationship between serum ferritin concentration in adolescents and some epidemiological variables.

Materials & Methods:

The study was carried out during the period between the first of November 1996 until the end of April 1997. A sample of 241 healthy school adolescents (aged 11-19 years) was included in the present study. The sample was selected from four intermediate and four secondary schools for boys and from the same number of schools for girls in Al-Karkh sector in Baghdad. Selection of schools was done randomly from list of schools provided by the Directorate General of Education/Al-Karkh. The sample included 152females and 89 males. Selected sample did not suffer from acute, chronic or blood diseases; none gave history of blood donation or loss; none smoked; no one was athletics; none used vitamin/or mineral supplementation; none gave family history of blood diseases; for females, none was pregnant and none use contraceptive device. Each student was interviewed directly. A questionnaire form was used which include information on age; in females, also age at menarche and number of pad used through the whole cycle (used as indicator for menstrual blood loss). Number of household and number of rooms were also inquired about and used for calculation of crowding index. Height and weight of the students were measured and used to calculate their Body Mass Index (BMI). Dietary intake of calorie, protein, iron and vitamin C was assessed using the 24- hour recall method at first day of interview and for other two non-consecutive days one of them was weekend day.
Calories and nutrient intake were calculated using Food Composition Tables for Iraqi food [7] and Food Composition Tables for The Middle East [8]. Mean calorie and nutrient intake for three days were calculated for each student. For analysis, the diets consumed were categorized into low, intermediate or high iron bioavailability diet depending on the amount of meat, poultry or fish and the vitamin C content of the diet[9]*(*A low availability diet is one containing < 30 g of meat, poultry or fish (lean raw weight) or < 25

mg of ascorbic acid daily. An intermediate availability diet contains 30-90 g of meat, poultry or fish or 25-75 mg of ascorbic acid daily. A high availability diet is one that contains more than 90 g of meat, poultry or fish or >75 mg of ascorbic acid. Alternatively, a high availability diet may contain 30-90 g of meat, poultry or fish plus 25-75 mg of ascorbic acid.).

Samples of venous blood was drown from students and used to determine their hemoglobin concentrations (Cyanmethemoglobin method) [10] and serum ferritin concentrations (Radio Immune Assay technique [11] using the Clinical Assays Gamma Dab ^{125}I ferritin Radio Immune Assay kit-Incstar corporation –USA. Students iron stores were evaluated according to the cut-off levels suggested by the WHO [12] (individuals are considered to have mild, moderate or severe depletion of iron stores if their serum ferritin concentrations are ≥18-24, 12-18 or <12 microgram/L respectively). Anemia was defined (12) as Hb concentration <12g/dl for females and for males≤ 14 years age; or <13 g/dl for older males.

Statistical Analysis:

Analysis was done using the Statistical Packages for Social Sciences (SPSS version 6). Serum ferritin values were normally distributed on logarithmic scale; therefore, these data were transformed into logarithms for statistical treatment and the results were retransformed as antilogarithms to recover the original data. Significance of association between two categorical variables was tested by using X^2 test, while t- test or F-test (ANOVA) was used to test the significance of difference between means. Strength and direction of linear correlations between serum ferritin and some variables were tested with Pearson Correlation Coefficient (for continuous variables), or with Spearman Correlation Coefficient (for categorical variables).Multiple regression analysis was performed to overcome the interaction between possible predictors of serum ferritin concentration.

Results:

Distribution of serum ferritin concentration in female and male adolescents is shown in figure 1 and 2 respectively. In both genders, the distribution is skewed to the right; however, it becomes normally distributed on log transformation.

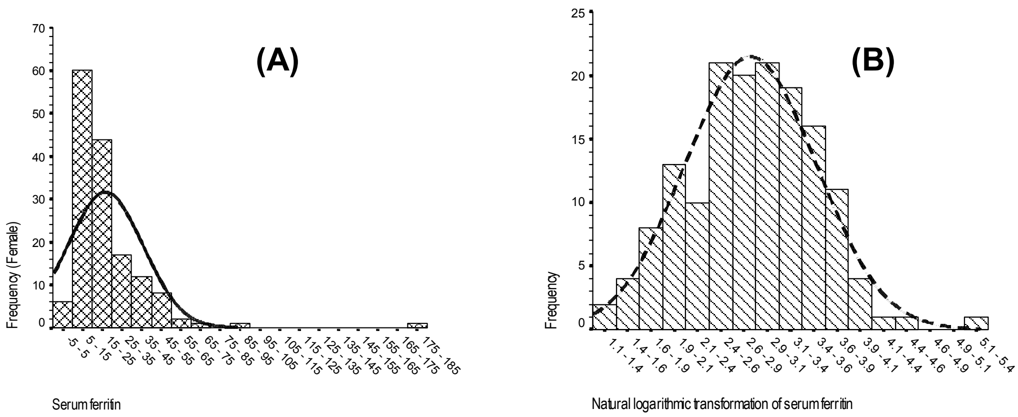

Figure 1: Distribution of serum ferritin concentration in female adolescents before (A) and after (B) logarithmic transformation.

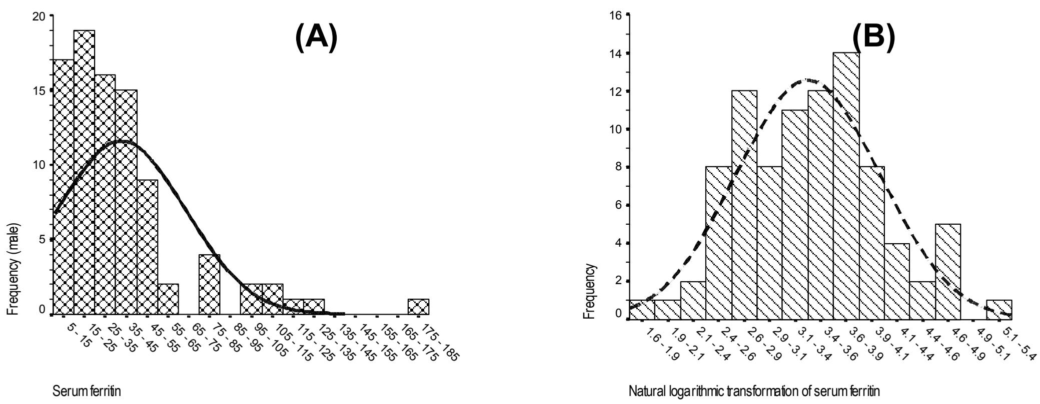

Figure 2: Distribution of serum ferritin concentration in male adolescents before (A) and after (B) logarithmic transformation.

Table1. Shows the means, standard deviations and ranges of serum ferritin concentrations in different age groups and in both genders. The lowest mean serum ferritin concentration in females was found in the age group 16-17 years, while in males, the lowest mean value was found in the age group 14-15 year. The mean serum ferritin concentration of males was significantly higher than that of females ($p<0.001$).

Table 1: The means*, standard deviation (SD) and ranges of serum ferritin concentrations in different age groups and in both genders.

	Serum ferritin conc.(microgram/L)		
Age in years	**Female**	**Male**	**P (t-test)**
<14			
Range	4.2-48.4	8.1-128.1	0.03
Mean	19.1	26	
SD	2.0	1.8	
N	44	38	
14-15			
Range	4.1-87.9	5.1-98.5	0.07$^{[NS]}$
Mean	16.4	22.4	
SD	2.0	2.0	
N	52	24	
16-17			
Range	3.8-179.8	13.4-115.9	<0.001
Mean	15.0	36.6	
SD	2.2	1.8	
N	46	20	
18-19			
Range	10.1-43.7	41-180.9	<0.001
Mean	16.9	72.2	
SD	1.6	1.6	
N	10	7	
Total			
Range	3.8-179.8	5.1-180.9	<0.001
Mean	16.8	29.4	
SD	2.0	2.0	
N	152	89	

*Geometric mean.

Out of the 152 adolescent females studied, 124 females had commenced their menstruation. The means and standard deviations of serum ferritin concentration in menstruating females by number of years since menarche are shown in table2. The lowest mean value was found in the first year after menarche. Statistically significant differences were found between the mean serum ferritin concentrations in various years since menarche.

The mean serum ferritin concentration in females who were not menstruating was significantly higher than that for menstruating ones, P<0.05 (table 3).

Distribution of female and male adolescents by age and various cut-off levels of serum ferritin concentration are shown in table 4. Highest proportion of females with severe depletion of iron store (serum ferritin<12 microgram/L) was found in the age group 18-19 years, while in males it was found in the age group 14-15 years. None of the males older than 15 years had severe depletion of iron store. Significant association between age and serum ferritin concentration level was found in males only.

Distribution of adolescents by gender and serum ferritin concentration cut-off levels is shown in table 5. The proportion of females who had severe depletion of iron store was higher than males. Significant association was found between serum ferritin level and gender (p<0.001).

Table 2: The means* and standard deviation (SD) of serum ferritin concentration in menstruating females by number of years since menarche.

		Serum ferritin conc. (microg/L)		
	Number of years since menarche	**Mean**	**SD**	**N**
	< 1	11.0	2.0	17
	1-2	18.2	2.0	59
	3-4	14.9	2.0	40
	5-7	18.2	1.5	8
	Total	16.4	2.0	124

P (ANOVA) = 0.01
*Geometric mean

Table3: The Mean* serum ferritin concentration in menstruating and not menstruating females.

	Serum ferritin conc.(microg/L)		
	Mean	**SD**	**N**
Not menstruating	22.2	1.8	28
Menstruating	16.4	2.0	124

P (t-test) = 0.04
*Geometric mean

Table: 4 Distribution of female and male adolescents by age and various cut-off levels of serum ferritin concentration.

	Serum ferritin concentration (microgram/L)									
	<12		12-18		18-24		24+		Total	
	N	%	N	%	N	%	N	%	N	%
Age in years										
Female										
<14	12	27.3	4	9.1	9	20.5	19	43.2	44	100
14-15	20	38.5	10	19.2	7	13.5	15	28.8	52	100
16-17	19	41.3	7	15.2	10	21.7	10	21.7	46	100
18-19	5	50	1	10	2	20	2	20	10	100
P (χ^2)= 0.13[NS]										
Male										
Age in years										
<14	5	13.2	7	18.4	5	13.2	21	55.3	38	100
14-15	6	25	2	8.3	5	20.8	11	45.8	24	100
16-17	0	0	4	20	0	0	16	80	20	100
18-19	0	0	0	0	0	0	7	100	7	100
P (χ^2)=0.01										

Note: For statistical analysis; in both genders, individuals with serum ferritin concentration<24microgram/L were consider as one group.

Table 5: Distribution of adolescents by gender and serum ferritin concentration.

	Serum ferritin concentration (microgram/L)									
	<12		12-18		18-24		24+		Total	
	N	%	N	%	N	%	N	%	N	%
Gender										
Female	56	36.8	22	14.5	28	18.4	46	30.3	152	100
Male	11	12.4	13	14.6	10	11.2	55	61.8	89	100

P (χ^2) <0.001

Table 6 Shows the distribution of adolescents by their intake of various iron bioavailability diet and their serum ferritin concentration. Highest proportion of adolescents with severe depletion of iron store was found in those consuming low iron bioavailability diets. Significant association was found between serum ferritin concentration levels and iron bioavailability of the dietary intake (p<0.001).

Among the studied sample, 64 adolescents were identified to be anemic depending on their Hb levels and according to the cut-off values suggested by the WHO. Distribution of anemic and non-anemic adolescents by their serum ferritin concentration levels is shown in table.7. High proportion of anemic adolescents have severe depletion of iron stores (47/64 = 73.4%). Only 5% of anemic adolescents have adequate iron stores. Calculation of Odds ratio (OR) shows that the risk of anemia increases with the increase in severity of depletion of iron stores. Moreover, adolescents with severe depletion of iron stores have 45.1 times the risk of having anemia compared with those who have adequate iron stores.

The relationships between serum ferritin concentration and some independent variables are shown in table 8. Serum ferritin concentration shows significant positive correlations with dietary intake of calorie, protein and iron and with iron bioavailability of the diet in female. In males, however, significant positive correlations are noticed between serum ferritin concentration and age, dietary intake of iron and iron bioavailability of the diet. On the other hand, in females, significant negative correlation exists between serum ferritin concentration and number of pad used during the menstrual period.

Multiple regression analysis model used in this study (table 9) shows that the only variables which show significant positive correlation with serum ferritin concentration are; gender, age – gender interaction and iron bioavailability of the diet. Significant negative correlation is noticed (in females) between serum ferritin concentration and number of pad used.

Table 6: Distribution of adolescents by iron bioavailability of the diet consumed and serum ferritin concentration levels.

	Serum ferritin concentration (microgram/L)									
	<12		12-18		18-24		24+		Total	
	N	%	N	%	N	%	N	%	N	%
Iron bioavailability of the diet.										
Low	32	40.5	12	15.2	12	15.2	23	29.1	79	100
Intermediate	19	21.8	19	21.8	16	18.4	33	37.9	87	100
High	16	21.3	4	5.3	10	13.3	45	60	75	100

P (χ^2) <0.001

Table 7: Distribution of anemic and non- anemic adolescents by their serum ferritin concentration.

	Non anemic		Anemic		
Serum ferritin conc. (microgram/L)	**N**	**%**	**N**	**%**	**OR***
<12	20	29.9	47	70.1	45.1
12-18	28	80	7	20	4.8
18-24	33	86.8	5	13.2	2.9
24+	96	95	5	5	Reference
Total	**177**	**73.4**	**64**	**26.6**	

P (χ^2) <0.001
* Odds Ratio.

Table 8: Pearson's correlation coefficient for the relationship between the natural logarithmic transformation of serum ferritin and some independent variables.

Independent variables	Female	Male
Age	-0.084	.334**
Calories intake	.167*	0.131
Total protein intake	.285**	0.175
Iron intake	.189*	.221*
Iron bioavailability of the diet#	0.33**	0.27**
BMI	-0.134	0.184
Crowding index	0.029	-0.105
Number of pads	-.230*	

calculated by Spearman's rank correlation coefficient
*P < 0.05
**P<0.01

Table 9: Multiple regression models for the relationship between serum ferritin concentration and variables studied.

Independent variables	β	Standardized (β)	P	partial r
Age (accurate)	0.629	0.047	0.56	0.039
Calories intake	-0.002	-0.062	0.425	-0.053
Total protein intake	0.005	0.042	0.661	0.029
Iron intake	0.266	0.034	0.696	0.026
BMI	-0.423	-0.055	0.419	-0.054
Bioavailability of iron supply	5.87	0.186	0.006	0.179
Gender(male compared to female)	58.8	1.127	0.023	0.149
Age – gender interaction	5.13	1.474	<0.001	0.196
Crowding index	0.02	0.002	0.98	0.002

$R^2 = 0.20$
P model < 0.001

Discussion:

The clinical roles of serum ferritin assay lie in its tendency to parallel the size of iron stores during normal development as well as in iron deficiency and overload[13]. In the present study, serum ferritin was used as a survey tool in assessing iron stores of Iraqi adolescents.

In this study, distribution of serum ferritin concentration was skewed to the right in both males and females. Similar observation was reported in other studies[14,15].

The mean serum ferritin concentration of Iraqi adolescents showed in this study is much lower than that reported for adolescents in the UK (16). However, the higher mean serum ferritin concentration observed in males compared with females is in agreement with the previous study (16). In the studied adolescents, the lowest mean serum ferritin concentration in males and females was found in the age group 14-15 and 18-19 years respectively. High prevalence of severe depletion of iron store (in both genders) was also observed in these age groups. A study on serum ferritin in Danish children and adolescents[17], reported that the lowest mean serum ferritin concentration in the studied boys and girls was at the age of 14 and 16 years respectively followed by gradual increase in both genders.

Our results regard serum ferritin concentrations in female adolescents are alarming, since they show that half of girls who are at the end of their adolescence (18-19 year age group) have severe depletion of iron store, further deterioration in their iron status is anticipated when the demand for iron is increased as in pregnancy. In Iraq, like other countries in the Eastern Mediterranean Region, most of women get married at young age, and the mean age at marriage ranges from 15.9 -20.2 years (18). Thus, optimum nutritional and iron status of female adolescents is of particular importance. Another study in Sri Lanka [19] stress on ensuring adequate iron stores in female adolescents to prepare them to meet the nutritional and physiological stress of pregnancy in later life.

In the present study, the mean serum ferritin concentration in females was studied in relation to the number of years since menarche, the lowest value was found in the first year after menarche. A longitudinal study of serum ferritin concentration during female adolescent growth spurt in Japan [20] found that the mean serum ferritin concentration declined significantly due to the occurrence of menarche and showed lowest level at third year after menarche. In the studied girls, it is possible that marginal iron stores existed during childhood may have been further depleted during the period of accelerated growth and increased demand occurring in puberty coupled with blood loss during menstruation to bring down the serum ferritin concentration in many of them. All these factors might have been operating to bring about the sharp decrease in mean serum ferritin concentration observed in the first year after menarche. After the first year, in spite of the significant increase in mean serum ferritin concentration observed, however, all means were lower than that before commencement of menstruation.

In the present study, menstrual blood loss was found to be a significant determinant of serum ferritin concentration in female adolescents. This has been proved by the significant difference noticed between the mean serum ferritin concentration of menstruating and non-menstruating females and by the persistent significant negative correlation observed between serum ferritin concentration and numbers of pad used (which has been used as indicator of blood loss) after controlling of other variables.

Results of this study confirm that iron deficiency is an important risk factor for anemia in adolescents, since only 5% of anemic adolescents have normal iron stores. The importance of iron deficiency as a contributor factor for anemia was reported in other study [21].

Existing dietary findings confirm the importance of iron bioavailability of the diet in determining serum ferritin concentration in adolescents, since it showed significant association and persistent significant positive correlation with serum ferritin concentration after controlling of other variables studied. Another study[22] showed that dietary factors influencing iron availability were better predictor of iron status than total iron intake. Similar finding was noticed in this study, since statistically no significant correlation was observed between serum ferritin concentration and dietary iron intake after controlling of the other variables. This finding is of concern, since it indicate the importance of and the needs for dietary modification program to improve iron availability of the diet thus to improve iron status of our adolescents.

Results of the present study show that the interaction of age- gender is the most important determinant of serum ferritin concentration, since it is associated with the greatest change in serum ferritin concentration, when adjusted for all other variables. No similar finding is available to compare with.

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