SUJMS
Sana'a University Journal of Medical Sciences

Original Article

Anemia and iron deficiency anemia among 10-19 years schoolgirls of Alwehda district in the municipality of Sana'a

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Abstract

Background: Worldwide attention over iron deficiency anemia in pregnancy has shifted recently from providing supplements during pregnancy to attempting to ensure that women, especially adolescentsa, have adequate iron stores prior to conception. Objective: The aims of this study was screening the prevalence of anemia and iron deficiency among 10-19 schoolgirls in Alwehda area in the municipality of Sana'a, and study the association between levels of hemoglobin and serum firritin with age, class level, menstrual and anthropometric status. Method: The study was conducted in a representative school that was selected randomly from five public schools for girls that existed in Al-wehda district. Schoolgirls (n=115) aged 10-19 years were selected using stratified systematic sampling technique from the 4th-12th grades. The relevant information was collected with anthropometric measurements and hemoglobin and serum ferritin estimations. Results: The means for age, hemoglobin levels (Hb) and serum ferritin (SF) were 14.36, 13.99g/dL, and 52.80 µg/L respectively. The overall prevalence of anemia according to the WHO cutoff limits (Hb<12) was 4.4% and according to the altitude adjusted cut off values (Hb<13) was 7.9%. Among the entire group, 5.4% of the girls were iron depleted (SF<16), 23.7% had small iron store (SF 16-32), and 71.0% had sufficient iron stores (SF>32). Iron deficiency anemia and iron deficiency erythropoiesis were found in 2.2% (n=2) and 3.3% (n=3) respectively. Age was negatively correlated with serum ferritin and positively correlated with hemoglobin, and class level was negatively correlated with the serum levels of ferritin. Younger girls had higher prevalence of anemia and lower prevalence of iron deficiency and small iron stores. Post menarcheal girls had higher prevalence of iron deficiency erythropoiesis (6.5%) than the pre menarcheal girls (0%). Conclusion: This study predicted that the prevalence of anemia and functional iron deficiency is low among the Yemeni schoolgirls in Alwehda district. Further evaluations are recommended on different parts of the country, especially in the rural areas, to investigate anemia and iron deficiency, and to study the other correlations of nutritional anemia.

Introduction:

Anemia is a major public health issue. It affects about a billion people in the world [1] and approximately half of the anemia worldwide is due to nutritional iron deficiency [2]. Iron deficiency anemia is the most common nutritional deficiency worldwide. It

decreases working capacity, cognitive performance, and immunological defense

aWHO has defined "adolescents" as people in the 10-19 years age range against infections. Girls at the age of 10-19 years are considered a vulnerable group due to significant physiological growth and maturation, iron losses at menstruation, and pregnancy; particularly in developing countries where they are married at an early age. They become exposed to greater risk of reproductive morbidity and mortality.

Women of fertile age have a delicate iron balance and display a high prevalence of small body iron stores and iron deficiency [3-6]. Most pregnant women who begin their pregnancy with decreased iron stores and/or with an insufficient iron supply undergo a high risk of becoming either iron deficient or anemic. Existing data suggest that

***** Corresponding Author: Dr. Rabaa Jumaan/ Department of Biochemistry/ Faculty of Medicine and Health Sciences, Sana'a UniversityaWHO has defined "adolescents" as people in the 10-19 years age range***

iron deficiency during pregnancy affects both the health of the mother and that of the newborn [7]. In the mothers, anemia, even mild anemia, is associated with an increase in their death rate. If the anemia is more serious, it causes one of every five maternal deaths. Studies also show a correlation between anemia and an increase of the incidence of heart insufficiency during labor, a smaller tolerance to blood loss during childbirth, a decreased resistance to infections [7, 8].

Concerning the newborn's health, it has been demonstrated that if the mother has anemia, the risk of premature childbirth increases 2.7 times; in the same way, newborns from anemic mothers weigh less than normal 3.1 times more frequently than from normal mothers. It has also been shown that serious anemia is responsible of the death of approx 30% of the hospitalized anemic children if they don't get immediate blood transfusion, and if the transfusion is carried out, they suffer other risks. On the other hand, another study demonstrated that those children born from mothers having anemia during their pregnancy showed a significantly decreased immune response [9-12].

METHODS

SUBJECTS AND RESEARCH DESIGN

The study area, Al-wehda district, is one of 10 districts that exist in the municipality of Sana'a. It is located in the south west of the capital city of Yemen, Sana'a, and has a population of approximately 99,596.

The studied subjects consisted of 115 apparently healthy girls aged 10-19y. They were students in grades 4th-12th in a representative public school, randomly selected from a total of 5 public schools for girls that existed in this area. Twenty girls were chosen from each class using the school records by systematic sampling technique. From the 180 students selected, girls who were not in the age range of 10-19y were excluded. The purpose of the study was explained to the school administration and the parents of the students and girls who did not obtain parental written consent were excluded. Finally, 115 schoolgirls were enrolled in this study.

QUESTIONNAIRE AND ANTHROPOMETRIC MEASUREMENT

A face-to-face interview was done to record information regarding age, class level, health problems, any supplements or medications used, and menarcheal status. Anthropometric measurements were taken in school. The students were asked to remove heavy clothing and shoes Weight was taking in kilograms using electronic scale. Height was measured using standiometer. The students were asked to stand still bare-footed, with heal, buttock, and back touching the wall. Measurement was taken in centimeters then converted to meters. Height and weight results were compared to the international reference values of the National Center for Health Statistics/Center for Disease Control and prevention (NCHS/CDC). Body mass index (BMI) was calculated by dividing the weight (Kg) by square of height (m2).Under weight was defined as the CDC BMI<18. Overweight was defined as BMI>25 and those fell between 18 and 25 were considered to be at risk of overweight. Stunting was defined as the CDC stature-for-age<3rd percentile, short stature<5th percentile, and long stature>75th percentile [13]

SAMPLE COLLECTION AND BIOCHEMICAL MEASUREMENT

The girls were taken to Althawra General Hospital by bus in the early morning in groups of 15-30 girls each day for 5 days, in April 2007. Fasting blood samples (approx.5ml) were collected at the laboratory department. Blood samples were drawn by venipuncture into two different vacutainers tubes, one with EDTA for hematology indices determination and the other was immediately centrifuged after clotting. The serum obtained was kept in freeze at -20 C until it was analyzed 4 months later for serum ferritin (SF). The EDTA blood samples were analyzed immediately in the hematology department using stromatoanalyzer-WH reagent from sysmex europ GMBH (organic quaternary ammonium, 8.5g/l and salt and

sodium chloride, 0.6g/l) using Sysmex Automated Hematology Analyzer. Serum ferritin was analyzed by electrochemiluminescence immunoassay (Eclia) from Roche using Elecsys and Cobas e immunoassay analyzer.

Serum ferritin reagent was sufficient for only 100 tests.

DEFINITION OF ABNORMAL HEMOGLOBIN AND SERUM FERRITIN CUT OFF LIMITS

According to the world health organization (WHO) Hb<12g/dl in non pregnant females was defined as anemia[14].Because the study was performed in the city of Sana'a which is elevated 2250m above sea level, anemia cutoff limits was adjusted for altitude to Hb<13 g/dl [15, 16]. WHO altitude adjusted classification for levels of anemia was severe (Hb<8), moderate (Hb 8-10.9), and mild (Hb 11-12.9) [17, 18].

Screening for iron deficiency was examined by measuring serum ferritin (SF) and hemoglobin (Hb) as a combination measures. By combining hemoglobin measurement and serum ferritin, the sensitivity and the specificity of the screening method for iron deficiency are greatly improved [19]. It was argued that the use of multiple criteria for defining iron deficiency leads to an underestimation of the true prevalence of iron deficiency (20). Serum ferritin is the most specific indicator available of depleted iron stores. Actually, Iron deficiency could be defined by SF < 16, because signs of iron deficient erythropoiesis (IDE) were already present at this level of SF [20]. As SF levels decreased, a marked and statistically significant reduction occurred in all of the hematological parameters; Hemoglobin (Hb), Mean Cell Volume (MCV), Mean Cell Hemoglobin (MCH), and Transferrin Saturation (TS). (20). Therefore, SF can be validly used as a single criterion of iron deficiency [21]. Iron status was classified as absence of iron stores SF<16µg/L, small iron stores SF 16-32 µg/L, and normal iron stores as SF>32 µg/L.

The stages of negative iron balance with the respective cutoff limits for the hemoglobin and serum ferritin, as was used in this study, are shown in Table 1.

Table 1: Stages of negative iron balance with the respective cutoff limits.

Stages	Hemoglobin (g/dL)	Serum ferritin (µg/L)
Normal iron status	≥13	>16
Anemia	<13	
Depleted iron stores (ID)		<16
Iron deficient erythropoiesis (IDE)	≥13	<16
Iron deficiency anemia (IDA)	<13	<16

MENSTRUAL STATUS ASSESSMENT

Menstrual status was assessed by recording if the girl attained menarche or not, the age at menarche, the girl's self assessment of the intensity of the menstruation and if they have the period at the time of blood drawing.

STATISTICAL ANALYSIS

Data were analyzed using SPSS statistical package software, version 15.0. The hemoglobin (Hb) and serum ferritin (SF) were not normally distributed as tested by the Kolmogorov Smirnov test .The means, standard deviations and prevalence were obtained by descriptive statistics. The correlation was tested using the pearson's r coefficient.

RESULTS

GENERAL CHARACTERISTICS OF THE SUBJECTS

The study included 115 schoolgirls residing in Alwehda district, aged 10-19 years old of which 34 girls (30.1%) were in the age of 10-12 yrs and 49 girls (43.4%) in the age of 13-16yrs and 30 girls (26.5%) in the age of 17-19y. Among the entire group 42 (40.4%) of the girls did not attain menarche and 62 (59.6%) of the girls attained menarche. The general characteristics of the girls were presented in Table 2.

Table 2: The general characteristics of the schoolgirls aged 10-19 years.

Variables	N (%)	Mean ± Std. Deviation	Range
Hemoglobin (g/dL) (n=114)[1]		**13.9991 ± 1.0175**	**8.00-16.00**
Anemic (Hb<13)	**9 (7.8)**		
Normal (Hb≥13)	**105 (91.3)**		
Ferritin (µg/L) (n=93)[2]		**52.7999 ± 31.0782**	**11.21-191.00**
Abnormal iron store (SF≤32)	**27 (29%)**		
Normal iron store (SF>32)	**66 (71%)**		
Age at menarche	**60**	**13.20 ± 1.205**	**9-15**
Age of the girls (n=113)[3]		**14.36 ± 2.653**	**10-19**
10-12y	**34 (30.1)**		
13-16y	**49 (43.4)**		
17-19y	**30 (26.5)**		
Class level (n=115)		**8.17 ± 2.666**	**4-12**
4th-6th grade	**41 (35.7)**		
7th-9th grade	**33 (28.7)**		
10th-12th grade	**41 (35.7)**		
Menstrual status (n=104)[4]			
Not attained menarche	**42 (40.4)**		
Attained Menarche	**62 (59.6)**		
Menstrual bleeding intensity (n=64)			
Light	**1 (1.6)**		
Moderate bleeding	**58 (90.6)**		
Heavy bleeding	**5 (7.8)**		
Menstruating at blood drawing (n=68)			
No	**52 (76.5)**		
Yes	**16 (23.5)**		
BMI category (n=107)[5]			
<18	**48 (44.9)**		
18-25	**52 (48.6)**		
>25	**7 (6.5)**		
Stature-for-age percentile (n=110)[6]			
<3rd	**23 (20.9%)**		
<5th	**32 (29.1)**		
5th-10th	**45 (40.9)**		
25th-50th	**32 (29.1)**		
75th	**0**		
90th	**1 (0.9)**		

[1] one of the 115 girls did not have sufficient blood sample for hematological analysis.
[2] 93 girls were randomly selected for serum ferritin evaluation because the reagents in the kit was for 100 tests including controls
[3] two students did not know their exact date of birth.
[4] information regarding the menstrual status of 11 girls were not recorded
[5] eight students did not respond when they were called for weight measurement.
[6] 5 girls were absent during height measurement.

Although the girls in this study were apparently healthy, there was no information regarding concurrent sub clinical infection. **Table 3** provided the hematological characteristics of the girls

Table 3: Hematological and biochemical characteristics* of the schoolgirls aged 10-19 years in Alwehda district

Indicators	Reference Range	Mean	Std. Deviation	Minimum	Maximum
RBC(106/uL	4.00-5.00	5.3124	.42072	3.68	6.62
Hb(g/dL)	11.5-16.5	13.9991	1.01750	8.00	16.00
HCT (%)	37.0-47.0	44.0298	2.76114	26.80	50.10
MCV (%)	76.0-94.0	83.2614	6.44489	61.90	93.20
MCH(pg)	26.0-31.0	26.4702	2.34453	19.00	30.50
MCHC(g/dl)	32.0-36.0	31.7754	.80050	29.90	34.30
RDWCV(%)	11.6-15.6	13.6518	1.75289	12.10	27.90
RDWSD(fL)	37.0-54.0	40.2912	3.47386	32.50	65.30
WBC103/uL	4.00-10.0	5.9251	2.00872	2.34	12.82
LYMPH (%)	20.0-40.0	45.5272	11.84719	15.40	71.20
MONO (%)	2.00-10.0	8.4500	2.15223	4.70	17.10
NEUT (%)	40.0-80.0	42.5632	12.87346	17.30	77.10
EO (%)	1.00-6.00	2.8912	2.30473	.20	15.80
BASO (%)	0.00-1.00	.5947	.49185	.00	4.00
FERRITIN(µg/L)	12.0-150	52.7999	31.07819	11.21	191.00

*****number of cases for hematological parameters values=114, and number of cases for serum ferritin=93

PREVALENCE OF ANEMIA AND IRON DEFICIENCY

For the entire cohort, the mean ± SD for hemoglobin and serum ferritin were 13.99 ± 1.017 g/dl, and 52.79± 31.078µg/L respectively.

The over all prevalence of anemiab according to the WHO cutoff limit (Hb<12)

was 4.4% and according to the altitude adjusted cut off values (Hb<13) was 7.9%. The prevalence of moderate and mild anemia was presented in Table 4. No sever anemia was found among the girls participating in this study neither by any of the two cutoff criteria

Table 4: Prevalence of anemia and Iron deficiency* among 10-19 years schoolgirls

prevalence of anemia according to hemoglobin who cutoff limits	N	%
Moderate anemia (Hb=7-9.99)	1	.9
Mild anemia (Hb=10-11.99)	4	3.5
Total anemic (Hb<12)	5	4.4
prevalence of anemia according to the altitude adjusted hemoglobin cutoff limits	N	%
Moderate (Hb=8-10.99)	1	.9
Mild (Hb=11-12.99)	8	7.0
Total anemic (Hb<13)	9	7.9
prevalence of iron deficiency anemia	N	%
Iron depleted(SF<16)	5	5.4
Iron depleted-adjusted cut off point (SF<20)	12	12.9
Small iron store (SF=16-32)	22	23.7
Iron sufficient (SF>32)	66	71.0
Iron deficiency anemia (SF<16 , Hb<13)	2	2.2 %
Iron deficiency erythropoiesis (SF<16 , Hb≥13)	3	3.3

It was found that 5.4% of the girls were iron depleted (SF<16), 23.7% had small iron store (SF 16-32), and 71.0% had sufficient iron store. Iron deficiency anemia and iron deficiency erythropoiesis were found in 2.2% (n=2) and 3.3% (n=3) respectively.

Using adjusted higher cut off point (SF<20) for possible mild infection, the prevalence of iron depleted girls was 12.9%. Prevalence of iron deficiency was presented in Table 4.

When the hematological parameters values were studied in relation to iron deficiency erythropoises, it was found that this stage of iron deficiency was accompanied by a slight decrease in the RBC count, and a slight increase in MCV and MCH. Table 5

Table 5: The hematological parameters values for girls with iron deficiency erythropoises. (Number of cases=3)

Indicators	Mean	Std. Deviation
RBC (106/uL)	4.8800	.32787
Hb (g/dL)	14.1000	1.01489
HCT (%)	44.6333	2.75015
MCV (%)	91.5000	1.00000
MCH (pg)	28.5667	.51316
MCHC (g/dl)	31.5667	.55076
RDWCV (%)	13.3333	.56862
RDWSD (fL)	43.5333	2.33524
WBC (103/uL)	6.2200	1.22503
LYMPH (%)	45.4667	.60277
MONO (%)	10.4333	2.37136
NEUT (%)	41.7667	1.30128
EO (%)	1.9667	.55076
BASO (%)	.3667	.05774
Ferritin (μg/L)	14.1467	2.56788

The hematological parameters values for girls with iron deficiency anemia are presented in Table 6. This stage of iron deficiency was accompanied by a decrease in HCT, MCV, and MCH.

Table 6: The values for hematological parameters for girls with iron deficiency anemia (Number of cases=2)

Indicators	Mean	Std. Deviation
RBC (106/uL)	5.2850	.86974
Hb (g/dL)	12.0000	.56569
HCT (%)	38.9500	.91924
MCV (%)	76.4000	7.91960
MCH (pg)	23.5000	1.83848
MCHC (g/dl)	30.8000	.70711
RDWCV (%)	14.6000	.42426
RDWSD (fL)	39.4000	2.96985
WBC (103/uL)	6.0500	.65054
LYMPH (%)	38.1000	9.33381
MONO (%)	8.3000	2.12132
NEUT (%)	51.2500	11.66726
EO (%)	1.6500	.49497
BASO (%)	.7000	.28284
Ferritin (μg/L)	13.9250	2.67993

and in the case of low serum ferritin, the mean values for MCV and MCH were not affected. The mean values for hematological indices were provided in Table 7. Therefore, it was found that the MCV and MCH levels decreased only at the stage of iron deficiency anemia while they increased slightly at the stage of iron deficiency erythropoises.

In fact, correlation results indicated that there were no statistically significant correlation between the levels of serum ferritin and the levels of MCV and MCH.

Table 7: The values for hematological parameters for girls with iron deficiency (SF<16, and Number of cases=5)

Indicators	Mean	Std. Deviation
RBC (106/uL)	5.3660	.39042
Hb (g/dL)	14.1600	.88769
HCT (%)	45.3000	2.66458
MCV (%)	84.6000	5.22733
MCH (pg)	26.2800	1.65892
MCHC (g/dl)	31.2400	.35777
RDWCV (%)	13.7400	.48270
RDWSD (fL)	41.5800	2.62145
WBC (103/uL)	6.1340	1.03828
LYMPH (%)	40.3600	11.48490
MONO (%)	9.3000	1.99374
NEUT (%)	48.5800	12.98796
EO (%)	1.4000	.65192
BASO (%)	.3600	.15166
Ferritin(μG/L)	14.0580	2.25993

HEMOGLOBIN AND SERUM FERRITIN IN ASSOCIATION WITH AGE, AND ANTHROPOMETRIC MEASUREMENT

There was a statistically significant negative correlation between the girls age and the levels serum ferritin (r = –0.251, p=0.017), whereas, no statistically significant correlation between the girls age and hemoglobin (p=0.071).

When the age of the girls was divided into three categories, A statistically significant positive correlation was found between the age category and hemoglobin levels (r = 0.219, p=0.021), but no significant correlation was found with levels of serum ferritin (p=0.052). The mean levels of hemoglobin and serum ferritin were provided in Table 8, and graphically represented in Figure1 Although there was a negative association between the levels of Serum ferritin and the age category, this relationship was not statistically significant (r = -0.204, p=0.052). Table 8, Figure 2

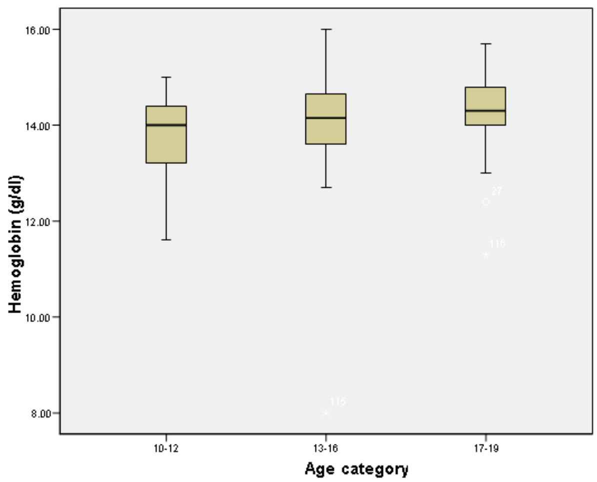

Figure 1- categories Comparison mean levels of hemoglobin in different age

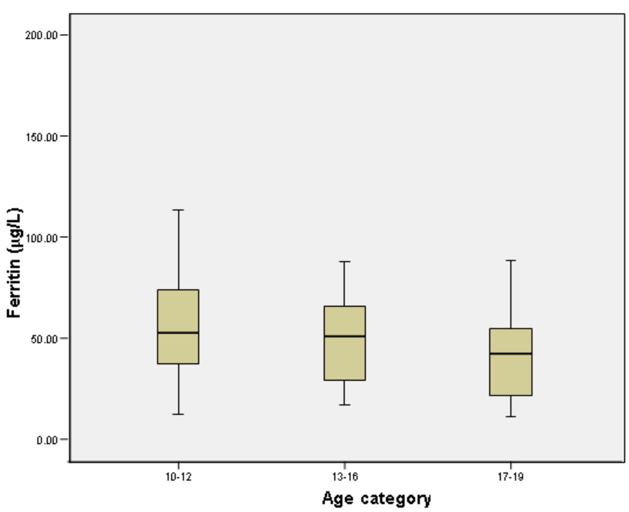

Figure 2- Comparison mean levels of hemoglobin in different age categories

Table 8: Levels of hemoglobin and serum ferritin according to the age category

Age category	Mean	p-value
Hemoglobin (g/dL)		0.021
10-12 yrs	13.74	
13-16 yrs	13.75	
17-19 yrs	14.24	
Serum ferritin (µg/L)		0.052
10-12 yrs	56.17	
13-16 yrs	52.43	
17-19 yrs	48.24	

There was a negative association between the levels of serum ferritin with BMI and with stature-for-age, and there was a positive association between levels of hemoglobin with BMI and with stature for age, however, these associations were not statistically significant.

Table 9: Prevalence of anemia and iron deficiency according to the age category.

Age category		N	%
Anemia(HB<13)			
	10-12	5	14.7%
	13-16	2	4.2%
	17-19	2	6.7%
	Total	9	8.0%
Iron depleted (SF<16)			
	10-12	1	3.0%
	13-16	0	.0%
	17-19	4	13.3%
	Total	5	5.5%
Small Iron Stores(SF 16-32)			
	10-12	6	18.2%
	13-16	9	32.1%
	17-19	7	23.3%
	Total	22	24.2%
IDE(Hb>13,SF<16)			
	10-12	0	.0%
	13-16	0	.0%
	17-19	3	10.0%
	Total	3	3.3%

IDA (Hb<13,SF<16)			
	10-12	1	3.0%
	13-16	0	.0%
	17-19	1	3.3%
	Total	2	2.2%

Anemia was more prevalent in the girls at younger age (10-12y) whereas iron deficiency and iron deficiency erythropoises was more prevalent in 17-19 years girls, Table 9.

HEMOGLOBIN AND SERUM FERRITIN IN ASSOCIATION WITH THE CLASS LEVEL

A statistically significant negative correlation was found between the girls class level and the levels of serum ferritin (r = – 0.250, p=0.016), whereas no correlation was found with the hemoglobin levels.

The girls were then divided into three categories according to the school class levels; girls in the elementary school (4th-6th grades), girls in the secondary school (7th-9th grades), and girls in the high school (10th-12th grades). Further studies revealed significant correlations between the class categories and the levels of both hemoglobin and serum ferritin.

There was a statistically significant positive correlation between the levels of hemoglobin and the class category (r = 0.197, p= 0.035). However, the trend of increasing hemoglobin with increasing class level category was marginal. The mean levels of hemoglobin according to the class category were provided in Table 10, and represented by Figure 3.

Table 10: Levels of hemoglobin and serum ferritin according to class category.

Class level category	Mean	P – value
Hemoglobin (g/dl)		0.035
Elementary	13.62	
Secondary	13.94	
High school	14.19	
Serum ferritin (µg/L)		0.006
Elementary	61.03	
Secondary	48.07	
High school	46.57	

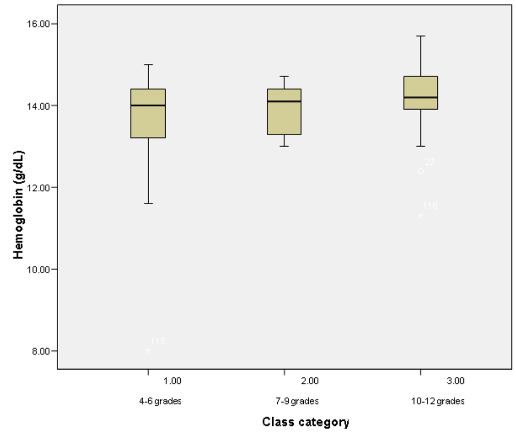

Figure 3- Compareson of the mean levels of hemoglobin according to the class category

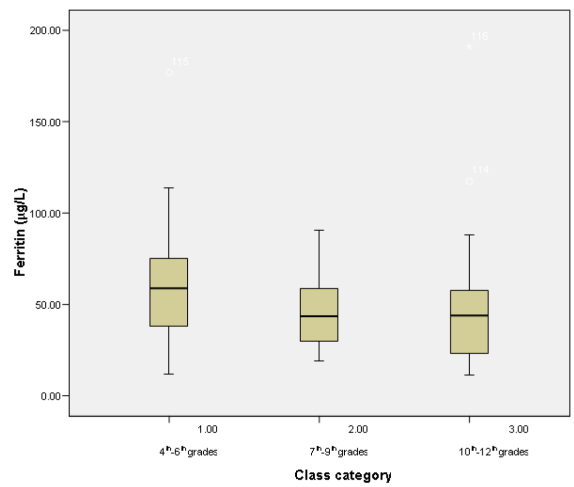

Figure 4- Comparison of the mean levels of serum ferritin according to the class category

There was a stronger relationship between the levels of serum ferritin and the class category than the one found between the levels of serum ferritin and the age category. Correlation studies revealed a statistically significant negative correlation between the levels of serum ferritin and the class category (r = – 0.281, p= 0.006), and no statistically significant correlation was revealed between serum ferritin and the age category (r = -0.204, p=0.052). The mean levels of serum ferritin according to the class category are provided in Table 10, and represented by Figure 4.

HEMOGLOBIN AND SERUM FERRITIN IN ASSOCIATION WITH ATTAINMENT OF MENARCHE

From a total of 104 girls, 62(0.9%) of the girls attained menarche of which one girl had light menstrual bleeding, 56 girls (90.3%) had moderate menstrual bleeding, and only 5 girls (8.1%) had heavy menstrual bleeding.

There was a statistically significant negative correlation between the attainment of menarche and the levels of SF (r= –0.223, p= 0.040).Girls who attained menarche had lower

levels of serum ferritin than girls who did not attain menarche. Table11, Fig. 5 Table 11: Levels of hemoglobin and serum ferritin according to the attainment of menarche

Table 11: Levels of hemoglobin and serum ferritin according to the attainment of menarche

Attainment of menarche	Mean	p-value
Hemoglobin (g/dL)		0.063
Not attained	13.78	
Attained	14.02	
Serum ferritin (μg/L)		0.04
Not attained	55.52	
Attained	46.49	

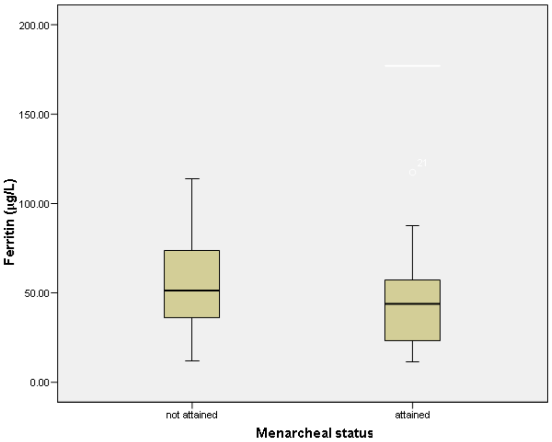

Figure 5- Comparison between the mean levels of serum ferritin according to attainment of menarche

The levels of hemoglobin were lower in girls who did not attain menarche than girls who did attain menarche, however, this increase was not statistically significant (p=0.063).

This followed the trend that girls at younger age have lower hemoglobin levels and higher anemia prevalence Table 11, Figure 6.

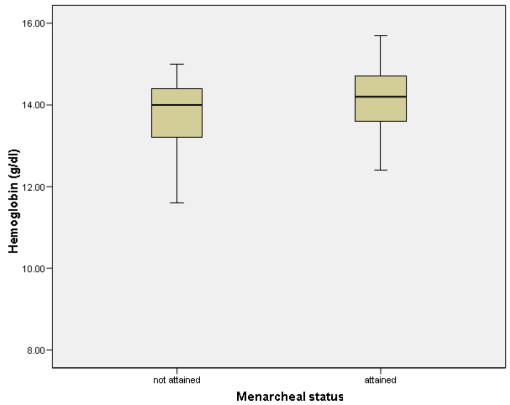

Figure 6- Comparison of the mean levels of hemoglobin according to the attainment of menarche

Girls who attained menarche had a higher prevalence of iron deficiency than girls who did not. The prevalence of iron deficiency and small iron stores according to the attainment of menarche were given in Table 12, and represented by Figure 7.

Table 12- Number and percentage of girls with different stages of iron deficiency according to the attainment of menarche

Iron status (Serum ferritin (μg/L)	Mensarcheal status	
	Not attained N (%)	Attained N (%)
Iron depleted (SF<16)	1 (2.6%)	4 (8.7%)
Iron deficiency erythropoiesis (SF=16-32)	8 (20.5%)	14 (30.4%)
Iron sufficient (SF>32)	30 (76.9%)	28 (60.9%)

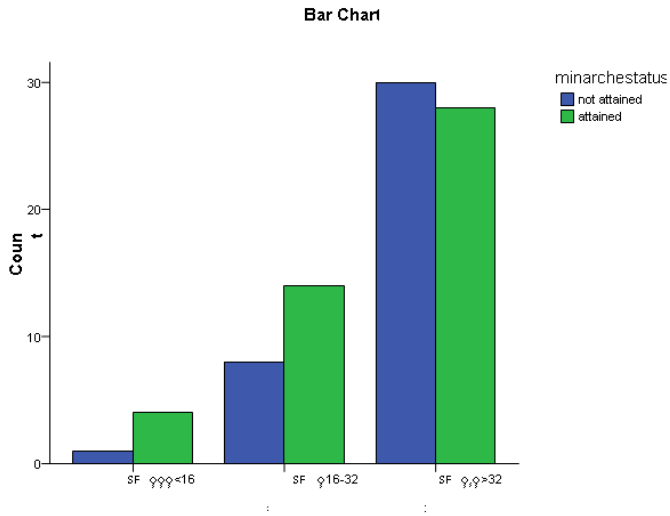

Figure 7- comparison of different stages of iron deficiency among girls according to attainment of menarche

Table 13: Prevalence of anemia, and iron deficiency among girls according to attainment of menarche.

Menarcheal status		N	%
Not attained			
	IDA	1	2.2
	IDE	0	0
	Anemic	5	10.9
	Normal	40	87.0
	Total	46	100.0
Attained		N	%
	IDA	1	2.2
	IDE	3	6.5
	Anemic	2	4.3
	Normal	40	87.0
	Total	46	100.0

HEMOGLOBIN AND SERUM FERRITIN IN ASSOCIATION WITH MENSTRUATING AT THE TIME OF BLOOD DRAWING, AND THE AGE AT MENARCHE

We found no correlation between the intensity of menstrual bleeding (light, moderate and heavy bleeding) and the levels of hemoglobin and serum ferritin (p=0.569, and p=0.908 respectively). Neither there was a correlation between the levels of hemoglobin and serum ferritin in association with menstruating at the time of blood drawing (p=0.22, p=0.580). There was also no correlation between the levels of hemoglobin and serum ferritin in association with the age at menarche (p=0.542, p=0.808)

DISCUSSION:

The schoolgirls involved in this study (aged 10-19 years) ranged between pre-menarcheal and post-menarcheal age. Among the studied group, 42 girls (40.4%) did not attain menarche and 62 girls (59.6%) attained menarche. 44.9% of the girls were under weight (BMI<18) and 50% had short stature (stature-for-age<5th percentile). The mean for hemoglobin for the entire cohort was 13.99g/dL, and the mean for serum ferritin was 52.79µg/L. Except for RBC count and % of lymphocytes, all the hematological means was normal. The mean for RBC count was high (5.27x106/µL) and this was considered normal for people living at high altitudes. The shift in the mean for lymphocytes was very small (44.90%) and this might suggest the existence of slight infection [22].

The over all prevalence of anemia in Alwehda area according to the WHO cutoff limit (Hb<12) was 4.4% and according to the altitude adjusted cut off value (Hb<13) was 7.9% ranging from moderate to mild anemia, while sever anemia was not found. Following the Who cutoff point, it was found that anemia was not a public health problem (because prevalence of anemia was<5%) when the criteria for anemia was not adjusted for altitude. With altitude adjusted cutoff point anemia prevalence became a mild public health problem (since the prevalence was between 5-19.9%). The prevalence of anemia in Alwehda was low compared to other studies. Nelson et al. [23] documented 10.5% anemia prevalence among white adolescent girls aged between 12-14 years in a South West London suburb. Nelson et al [24] also recorded that 20% of 111 girls (11-14 years) had Hb <12 g/dl in Wembley. Agarwal [25] had documented that the prevalence of anemia was 46.6% in premenarcheal girls as compared to 48.4% in post menarcheal girls in the urban slums of North East Delhi. Vasanthi et al [26] observed a

prevalence of 27% and 22% in the rural and urban premenarcheal girls and 24.2% and 27.8% in the rural and urban post menarcheal girls in the age group 11-16 years, respectively in Hyderabad. Mehta [27] found out an anemia prevalence of 63.8% in urban slums of Bombay among 10-18 years adolescent girls.

The overall prevalence of iron deficiency and small iron stores were 5.4% and 23.7% respectively. Evaluation of the iron status of the girls revealed that a small percentage of the girls were iron depleted (5.4%), however, higher percentage of the girls had small iron stores (23.7%). Anemia of iron deficiency was found in only 2.2% and iron deficiency erythropoiesis was found in only 3.3% of the girls. The low prevalence for iron deficiency could be due to the fact that the study was in a relatively privileged area and did not cover poor areas in the capital Sana'a. Also there was the possibility of previous undetected mild infections, which increased serum ferritin, and decreased the prevalence of iron deficiency using serum ferritin measurement [22]. It had been suggested that a higher cutoff value for serum ferritin (SF<20µg/l) be used in populations where infections and/or inflammatory diseases were highly prevalent to assess risk of iron deficiency [28]. Using this higher cut off value, the prevalence of iron depleted was 12.9%. Definitely, these prevalence figures for anemia and iron deficiency were expected to increase substantially if a larger study was done that included the entire municipality of Sana'a; and yet, if a national screening for anemia and iron deficiency included districts where malaria and other chronic diseases were more prevalent than the capital city, Sana'a.

Serum ferritin had a statistically negative association with the age and tended to decrease with increasing age; while hemoglobin had a statistically positive association with the age category and appeared to be lower in younger age (10-12y) than in older age (17-19y). These results were in accordance with the anemia prevalence which was higher in younger girls (10-12y) while iron deficiency prevalence was higher in older girls (17-19y).

There was no significant association between serum ferritin with BMI and with stature-for-age, and neither there was a significant association between levels of Hb with BMI and with stature-for-age. This was in accordance to other studies [29].

It was interesting to find a stronger relationship between the levels of serum ferritin with the class category than the age category. Correlation studies showed statistically significant correlation between the serum levels of ferritin and the class category($r = -0.281$, $p= 0.006$) while revealed no statistically significant correlation between the levels of ferritin and the age category ($r = -0.251$, $p=0.017$), These results indicated that the distribution of girls in the classes seemed to be more dependent on the serum ferritin levels of the girls than the age of the girls. This supported the findings that iron status of the school children affects their cognitive achievement including those who have iron deficiency without anemia.[30] On the other hand, the correlation was stronger between the age category and the levels of hemoglobin($r = 0.219$, $p=0.021$) than between the class category and hemoglobin which showed no correlation.

A statistically significant correlation was found between the levels of serum ferritin and the attainment of menarche, with lower serum ferritin levels in the post menstruating girls than in pre menstruating girls. No correlation was found between the levels of hemoglobin and attainment of menarche. Also, the prevalence of iron deficiency and the prevalence of small iron stores were increasing among girls who attained menarche than girls who did not attain menarche. One logical reason for this, besides other possible reasons that were not investigated in this study, was the loss of blood and thus iron during menstruation. This was supported by the findings that iron deficiency is the most prevalent nutritional deficiency in fertile women, because of menstrual bleeding, and yet this problem is rare among men and postmenopausal women [31, 32].

In this study, it was surprising to find no positive correlation between the intensity of the menstrual bleeding and the levels of serum ferritin. It was postulated by a previous study that women were unable to give a qualified subjective evaluation of their blood losses at menstruation [33]. There was also the probability of insufficient data because there were a small number of girls who judged their menstrual bleeding as light (only one girl), and as heavy (only 5 girls) compared to girls who judged their menstrual bleeding as moderate.

As was expected, there was no correlation between the levels of hemoglobin and serum ferritin and the age of menstruation or having period at the time of blood drawing.

CONCLUSION

The primary purpose of this study was to estimate the prevalence of anemia in general, and iron deficiency anemia in particular, among schoolgirls aged 10-19 years. Adolescent girls were neglected by previous studies despite the fact that they are considered a high risk group. As a matter of fact, adolescence may be an optimal time in which to build iron stores before pregnancy. Physiological needs are high at this stage of life because of increased requirements for the expansion of the blood volume associated with the adolescent growth spurt and the onset of menstruation [34]. The results revealed that the prevalence, of both, anemia and iron deficiency among schoolgirls in the Alwehda district was low. Nevertheless, further studies are recommended to confirm these results and to study other correlates of nutritional anemia.

ACKNOWLEDGMENTS

This work was financially supported by the National Trade Company (NATCO). The authors would like to thank the authorities at the NATCO company represented by Mr. Mohamed Abdullkawi. Special thanks are extended to both Dr. Ahmed Al Ansi and Dr AbdulKhalek Al Nunu at the Althawra General Hospital for their kind help, and to the principal of Alqods School and all the teachers and students who actively participated in this study.

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