Prevalence of Iron Deficiency Anemia Among Female Elementary School Children in Northern Jeddah-Saudi Arabia

MAMDOOH A. GARI, PhD

*Department of Medical Technology, Faculty of Applied Medical Sciences
and King Fahd Medical Research Center
King Abdulaziz University
Jeddah, Kingdom of Saudi Arabia
mgari@kau.edu.sa*

Abstract. The aim of this study was to assess the prevalence of iron deficiency and iron deficiency anemia in relation to variables such as: age, weight, height, mother's education, number of family members, and nutritional habits among female elementary school children (age 6-12 years) in the western province of Saudi Arabia. A total of 123 female children were selected for this study. Complete blood count, serum iron, ferritin and total iron binding capacity were measured to assess iron deficiency and iron deficiency anemia. Overall, the prevalence of iron deficiency and iron deficiency anemia in this study was 23.0%. Data showed that the majority of anemia cases in this study were normocytic type. Anemia was more prevalent among students of age 10-12 years as compared to younger age group. In addition, there was no relationship between iron deficiency anemia and number of family members or mother's education. Anemic students were not aware of their nutritional habits. It was concluded that iron deficiency anemia is a problem among young girls, especially among those of age 12 years in western region of Saudi Arabia. It is recommended that the iron-folate supplementation program for pregnant women be expanded to non-pregnant women, including young girls.

Keywords: Anemia, Iron deficiency anemia, Nutritional risk factor.

Introduction

Iron is essential for normal human growth. Iron is required for many essential body functions, including oxygen transport, *adenosine triphosphate* (ATP) production, DNA synthesis, mitochondrial function,

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and protection of cells from oxidative damage[1,2]. Iron deficiency

anemia is the most prevalent hematologic disorder in childhood, especially in female children[3]. It is estimated that around 2.15 billion individuals suffer from iron deficiency anemia[4]. In a recent review of the prevalence of iron deficiency anemia in the United States, 9% of toddlers and up to 11% of adolescent girls were iron-deficient[2]. The absorption of dietary iron is assumed to be 5-10%, but it increases 3-5 times when iron storage is depleted[5]. Inadequate dietary iron, iron absorption and intense exercise, along with blood loss and parasitic infections are some etiologies of iron deficiency anemia (IDA). Some consequences of IDA are growth retardation, exercise intolerance, behavioral changes, and abnormal thermogenesis. Although the prevalence of IDA has declined in industrialized countries, there have been few changes globally[6]. According to a UNICEF report, two billion people suffer from anemia worldwide and most of them have IDA, especially in underdeveloped/developing countries, where 40-50% of children under age 5 are iron deficient[7]. It has been reported that 46.5% of Indonesian and 30-60% of Guatemalans under the age of 5 have suffered from IDA[8,9]. In Iran, 30-50% of women and children, especially those in low-income families, are suffering from iron deficiency[10]. Anemia has been shown to affect mental development and learning capacity. In infancy it may cause a permanent loss of IQ later in life, shortened attention span, irritability, fatigue, difficulty with concentration, lethargy, weakness and increased susceptibility to infection. Consequently, anemic children tend to do poorly on vocabulary, reading, and other tests[11]. In Saudi Arabia most of the studies on anemia were based on nutritional status and concentrated on preschool children who were under six years old[12-16], so data on the nutritional status of children and adolescents in the Kingdom are insufficient[17,18].

According to a World Health Organization (WHO) report, IDA is most frequent in children and women around the world, especially in non-industrialized countries. It is the only nutrient deficiency which is also significantly prevalent in virtually all industrialized nations. In addition, there are no current global figures for iron deficiency, but using anemia as an indirect indicator it can be estimated that most female preschool children and pregnant women in non-industrialized countries, and at least 30-40% in industrialized countries, are iron deficient[4,19].

Therefore, the aim of this study was to assess the prevalence of iron deficiency and IDA among female elementary school students and their relation to variables such as: age, weight, height, mother's education, number of family members, and nutritional habits in Jeddah, western province of KSA.

Material and Methods

Sample selection

During the course of this study, a total of 123 female students between the ages of 6 to 12 years old were randomly selected from a governmental school in northern Jeddah. Venous blood samples (5 ml) were drawn from each student into ethylenediamine tetra-acetic acid (EDTA) and an additional 5 ml blood was drawn into tubes without an added anticoagulant. EDTA blood samples were used to analyze complete blood count (CBC), whereas plain tubes were used to measure serum iron and ferritin. In addition, the weight and height of each student was recorded.

Data collection

Data for nutritional status was collected with paternal consent agreement; each student's parent was interviewed to complete a structured questionnaire over the phone, which included information on sociodemographic data, type of food taken, behavioral habits, health status in the family, and nutritional status. The type of food taken was classified into always, rarely and/or never. Mother's breast feeding was classified into natural, artificial or both. Presence of domestic helper in the home was taken to measure the social class status. The working status of the mother was also asked. Students' parents were asked if their children suffered from anemia and if so, it's type as well as other chronic diseases (such as bronchial asthma, skin allergy, *etc*). Data were collected by medical technology intern students trained in interviewing skills and directly supervised by the academic staff. Those reported to having hereditary anemia (such as sickle cell anemia or thalassemia) as diagnosed by a physician were excluded from the study.

Methods

CBC was measured by using Beckman coulter LH750 machine in the hematology laboratory, King Abdulaziz University Hospital, Jeddah to determine CBC (including hemoglobin hematocrit MCV, MCH, MCHC, RBC, RDW, WBC, and platelets). Throughout the study, Beckman coulter LH750 machine was checked and calibrated by using standard quality assurance at the beginning of the experiment.

Serum iron, ferritin and total iron capacity were measured using modular machine (Hitachi) in the Clinical Chemistry Laboratory at King Abdulaziz University Hospital, Jeddah. Throughout the study, Hitachi analyzer was checked and calibrated by using standard quality assurance at the beginning of the experiment.

Iron deficiency was defined as ferritin <10 ng/ml and IDA as ferritin <10 ng/ml with hemoglobin <10.5g/dl[20]

Participants' weight was measured without shoes and with light clothes using standard measuring scale to the nearest 0.1 kg and the height was taken without shoes using standard measuring tape to nearest 0.1 cm. Equipment were recalibrated between each measurement. Body mass index (BMI) was calculated as follows: body weight $(Kg)/height^2$ (M).

Data Entry and Analysis

Data were entered and analyzed using Statistical Package for Social Sciences program (SPSS) for Windows, Version 12. Student's "*t*" test was used to compare the proportions and 95% confidence intervals (95% CI) between anemic and normal students in many parameters such as (height, weight, body mass index, RBCs, hemoglobin, Hct, MCV, MCH, MCHC). Differences between proportions were considered statistically significant if 95% CI did not overlap. In addition, Chi-square test was used to determine the significant difference between IDA and normal group in nutritional habits of the population studied**.**

Results

A total of 123 Saudi female students were enrolled in this study. All students' ages ranged between 6 to 12 years. All student EDTA samples were subjected to CBC analysis to determine the frequency of anemia. Looking at overall CBC results, students were divided into two groups normal and anemic (iron deficiency and IDA) according to their age (6-9 and 10-12 years old). Table 1 summarized the CBC results in

Table 1. Mean and standard deviation for CBC results (Hb, MCV, MCH, MCHC, and RDW) and BMI, serum iron and serum ferritin in female students 6-12 years old in Jeddah.

Age		RBC (10^{12}/l)	Hb (g/dl)	Hct (%)	MCV (fl)	MCH (pg)	MCHC (%)	RDW (%)	BMI	S Irion µmol/l	S Ferritin ng/ml	*p* value
6-9	Mean	4.8	12.1	37.1	80.4	26.3	33.5	14.0	16.1	22.1	146.5	0.441
	SD	0.3	1.3	4.9	6.1	2.1	0.7	1.2	2.6	14.4	121.1	
10-12	Mean	4.7	11.8	37.8	79.7	26.7	33.6	33.5	18.5	21.0	157.1	
	SD	0.4	2.0	3.0	6.0	2.2	0.7	0.7	4.7	13.2	145.5	

Hb= Hemoglobin; Hct= Hematocrit; MCV = mean corpuscular volume; MCHC = mean corpuscular hemoglobin concentration; RDW= Red Cell Distribution Width; BMI= Body Mass Index

 each age group. The mean hemoglobin level for the first group (age 6-9 years) was 12.4 g/dl (±1.3), while the mean hemoglobin level for the

second group was 11.8 g/dl (±2.0). Also, the median MCV was 80.4 fl for the first group and 79.7 fl for the second group. The ferritin levels (mean= 157.1 ng/ml) were higher in female children between the ages of 10-12 (Table 1).

Overall, the prevalence of iron deficiency, and IDA in this small study was 25.2% and 10.6%, respectively (Fig. 1). When the World Health Organization (WHO) cut off value for anemia was considered to be Hb < 11.0 g/dl, the prevalence of anemia increased to about 30%. Iron deficiency and IDA were most frequent among 10-12 year old children and the frequency decreased as age decreased (Table 2); there was significant difference between the two age groups (p=0.024).
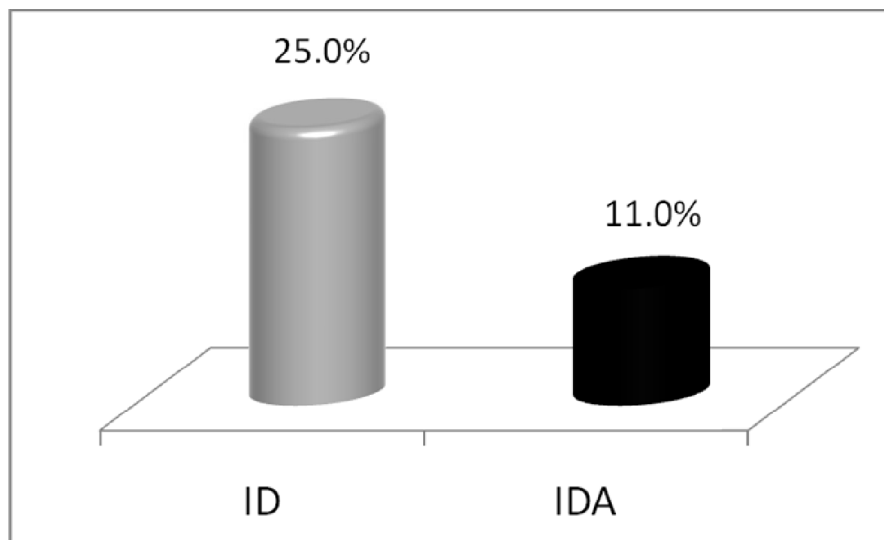

Fig. 1. The frequency of iron deficiency and iron deficiency anemia in female children 6-12 years old. ID= iron deficiency, IDA=iron deficiency anemia (*p Value* >0.05)

Table 2. Distribution of iron deficiency and iron deficiency anemia (%) among anemic female children 6-12 years old.

Age Group	Total Number	Iron Deficiency		Iron Deficiency Anemia	
		Number	Percent	Number	Percent
6-9	64	13	10.6 %	5	4.1%
10-12	59	18	14.6 %	8	6.5%
p-Value		0.024			

Total number= total number of students involved in the study. The percentage shown in the table represents the frequency of iron deficiency and IDA in each age group among female students. The difference between the two groups was estimated according to their hemoglobin and ferritin levels in all anemic students investigated.

General questionnaire included: mother's work status, residence with both parents, family income, domestic helper in the home, sleeping

time, type of feeding (breast or bottle), chronic diseases and student's school grades because these factors may play a significant factor. The majority of anemic students (15.4%) were born to housewife mothers, while 9.8% were born to well-educated mothers. 18.7% of the students lived with both their parents. 13.8% had a domestic helper, while 13.0% were born with a chronic disease (such as asthma and *diabetes mellitus*). About 6.5% of anemic students were from a low income family (S.R. 1000-3000), while 18.7% were from a family of median income (>S.R. 6000). In addition, 8.9% of the students were naturally breast-fed while the rest of the students (16.3%) were fed on artificial milk (Table 3). Overall, all these results had no statistical significant differences (*p*>0.05).

Table 3. Distribution of socio-demographic factors and other related factors among normal and anemic students

		Normal		IDA		*p Value*
		n	*%*	*n*	*%*	
Mother's working status	Yes	48	39.0%	19	15.4%	0.195
	No	44	35.8%	12	9.8%	
Living with parents	Yes	72	58.5%	23	18.7%	0.64
	No	20	16.3%	8	6.5%	
Family income	≤1500 (SR)	3	2.4%	0	0	0.724
	3000 (SR)	27	22.0%	8	6.5%	
	6000 (SR)	55	44.7%	20	16.3%	
	≥9000 (SR)	7	5.7%	3	2.4%	
Domestic helper	Yes	52	42.3%	17	13.8%	0.87
	No	40	32.5%	14	11.4%	
Sleeping time	Early 9:00 p.m.	48	39.0%	14	11.4%	0.50
	Late after 12:00 a.m.	44	35.8%	17	13.8%	
Breast feeding	Yes	40	32.5%	11	8.9%	0.435
	No	52	42.3%	20	16.3%	
Chronic diseases	Yes	49	39.8%	16	13.0%	0.874
	No	43	35.0%	15	12.2%	
Student grade	Best	32	26.0%	8	6.5%	0.60
	Average	39	31.7%	16	13.0%	
	Poor	21	17.1%	7	5.7%	

Data shown in each column normal and IDA student population representing the percentage of each question answered in the questionnaire. The differences between normal and IDA population for each question were calculated by chi-square and there was no statistical significance between the two groups.

Regular daily food intake that included meat, liver, green vegetables and fish were reported by 9.1% of anemic students. There was no statistical difference in regular daily food intake by BMI (*p*>0.05).

IDA was detected among 10.6% of female students studied. Anemia was higher among older age groups (10–12 years) as compared to younger students (6–9 years). Anemia was more prevalent among students who did not eat meat, liver, green vegetables, fish, and who did not drink fresh juice. Anemia results increased among those who ate fast

food and drank soft drinks; however, the results did not reach statistical significance. In addition, anemia was more prevalent with statistical significance in students who did not eat green vegetables on a daily basis (*p*=0.01) and students who fed on artificial milk at infanthood (*p*=0.01).

Discussion

The purpose of this study was to (1) assess the prevalence of iron deficiency anemia and (2) to correlate the anemia with the nutritional habit intake among female elementary school students.

Worldwide, the prevalence of anemia varies according to different conditions. In this study, the prevalence of anemia in Jeddah (iron deficiency and iron deficiency anemia) was 25.2%, when anemia defined as if Hb<10.5 g/dl, but if we use WHO definition for anemia (Hb < 11.0 g/dl), the prevalence of anemia increases to 35.8%. This small research showed that the majority of anemia cases were normocytic anemia.

Previous studies performed in different regions of the Kingdom showed that the overall prevalence of anemia reported among Saudi school students in older age groups ranged from 16.1%[21], 20.5%[18], to 26.4%[17]. The results from other researches in developing countries showed that the prevalence of anemia in African and Southeast Asian countries and India is higher than in Saudi Arabia[22,23]. In addition, the prevalence of anemia (Hb < 11 g/dl) in urban slum areas of India was 76%[24], and it is reported to be 27% in children between the ages of 6 months and 13 years in northern Thailand[25]. Also, the prevalence of anemia in South Cameroon in children younger than 3 years was reported to be 42% and in children between 3-5 years old, it was reported to be 21%[26]. Nicklas *et al.* have reported the prevalence of anemia to be 40% in urban Haitian children (Hb < 10.7 g/dl in children younger than 2 and Hb < 10.9 g/dl in children of ages 3-5 years)[27]. Furthermore, the prevalence of iron deficiency in the United States has been reported to be 9% in children ages 6-16 years[5]. They have assumed serum ferritin < 10 ng/ml is abnormal and consider the student iron deficient when 2 of 3 tests of iron status are abnormal (Protoporphyrin of RBC, transferrin, and serum ferritin). Other groups from Switzerland have demonstrated the prevalence of IDA in school-age children to be 25%[27].

In this study, the prevalence of iron deficiency and IDA was higher among female children ages 10-12 years old, compared to a younger group (Table 2). This result confirms the suggestions from other

studies that food consumed by children ages 6-9 years contain higher iron content than that consumed by older age groups, explaining the higher prevalence of anemia in children 10-12 years[26, 28,29].

There was no relationship between iron deficiency or IDA and BMI, family income, mother's working status (mother's education), breast-feeding or chronic diseases. However, some studies have shown a high prevalence of IDA in families with lower education levels and a high number of family members. Prevalence of IDA in this study was higher in children who did not eat green vegetables. In addition, children who were not breast fed during childhood had a higher chance of developing IDA.

The lack of iron supply for hemoglobin formation that leads to development of anemia and inadequate intake of iron rich foods should be considered as contributing factors. Other factors contributing to nutritional anemia were not explored in this study, such as vitamin A deficiency and other nutrient deficiencies. Several studies have shown that poor vitamin A status is associated with low hemoglobin concentration[29,30]. The high prevalence of anemia among young school girls in the northern area of Jeddah might lead to multiple health problems, such as impaired cognitive function, reduced school performance and poor reproductive health. These in turn would impact the future quality of human resources. The current iron-folate supplementation program for pregnant women should be expanded to non-pregnant women, including young girls. The school health program is a potential strategy to increase the iron status as well as improving the general health and nutritional status of school children. With regards to the possibility of IDA, particularly in the area where the prevalence of anemia is considered to be high, a screening procedure is suggested before an iron supplementation program is launched.

In conclusion, the burden of suffering from iron deficiency anemia in school students appears high especially among those between 10-12 years of age. Unhealthy feeding habits such as eating few vegetables and fruits and more fast foods appear to be prevalent among school students. Screening for iron deficiency anemia should be directed to high-risk groups and school programs should be implemented to improve awareness on healthy dietary habits. However, this project needs to be expanded in other areas of Jeddah, Makkah, Rabigh and other small areas to obtain the exact frequency of IDA in the western region of Saudi Arabia in order to correlate the nutritional habits.

Acknowledgment

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نسبة نقص الحديد في الدم في طالبات
المرحلة الابتدائية في شمال جدة

ممدوح بن عبد الله قاري

المستخلص. تعتبر نسبة نقص الحديد في سكان الولايات المتحدة الامريكية بـ ٣٠% من السكان وتزداد تلك النسبة في بعض اسيا و افريقيا. لذا فإن الهدف الرئيسي لهذا البحث هو تحديد نسبة انيميا نصق الحديد في طلاب المرحلة الابتدائية و اسباب هذا النقص و ما علاقة الانيميا بالنسبة للعادات الغذائية عند هؤلاء الطلاب. تم اخذ عينات عشوائية من احدى المدارس لعدد بلغ ١٢٣ طالبة تتراوح اعمارهن بين ٦ - ١٢ عاما ومن ثم عمل التحاليل مثل عد خلايا الدم و قياس نسبة الهيموجلوبين و نسبة الحديد و الحديد المخزون في الدم وخرجت المحصلة ان ٢٣.٠% من هؤلاء الطالبات مصابات بالانيميا لديهن انيميا نقص الحديد، واشارت النتائج في هذا البحث ان اغلبية الطالبات اللاتي يعانون من نقص في الحديد هم سن ١٠-١٢ عاما بالاضافة الى ان اكثر من ثلث الطالبات لا يأكلن الكبدة والمأكولات البحرية واللحوم واكثر من نصف الطالبات لا يأكلن الخضار، حيث يتوفر في هذه المواد الغذائية عنصر الحديد. ومن التوصيات التي توصي بها نتائج هذا البحث هي الاكثار من الحملات التوعوية لجميع المدارس بالاضافة الى استحداث برنامج طبي لاخذ فيتامينات تحتوي على عنصر الحديد لجميع الطالبات في تلك المرحلة الدراسية.