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Full Length Research Paper

Prevalence of iron deficiency and iron deficiency anemia among females at university stage

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Iron deficiency is the most prevalent nutritional problem in many parts of the world and the most common cause of anemia in Saudi Arabia especially among female. Accordingly, this study was designed to determine the prevalence of iron deficiency and iron deficiency anemia among apparently healthy Saudi young female university students studying at King Abdulaziz University in Jeddah province. Three hundred ten blood samples were collected from the students. Their ages ranged between (18 and 23) years. The data collected consisted of two sections: (A) included socio-demographic data on students such as age, height, weight, social habits, diseases symptoms, menstrual, dietary, and medical history and (B) consisted of laboratory results carried out on each subject. 50.2% of students were normal and hence considered as control group. 25.9% of students had deficient iron store and 23.9% of students had iron deficiency anemia. There was a significant correlation between iron deficiency and iron deficiency anemia with inadequate meat intake and impaired exercise capacity. Furthermore, pallor and past medical history of iron deficiency anemia were statically significant variables. Therefore, it is recommended to use screening and educational programs for iron deficiency anemia among female as high risk groups. Iron supplement and food iron fortification are required in order to overcome this simple but common health problem.

Key words: Iron deficiency anemia, deficiency, female at university stage, socio demographic data.

INTRODUCTION

Iron, in the form of various combined ores, is one of the most common elements, constituting about 5% of the earth's crust (Aisen, 1994). Iron is biometal that is essential for life, mainly because of its ability to accept and release electrons readily by switching between ferrous (Fe^{2+}) and ferric (Fe^{3+}) ions. This shift of electron between iron and donor/recipient molecules leads to several vital functions in the body. It serves as an oxygen carrier to the tissues, as a transport medium for electrons within cells, and as an integrated part of important enzyme systems in various tissues (Hallberg, 1982; Shander et al., 2009).

Anemia is a global public health problem affecting both developing and developed countries with major consequences for human health as well as social and economic development. It occurs at all stages of the life cycle, but is more prevalent in pregnant women and young children. In 2002, iron deficiency anemia (IDA) was considered to be among the most important contributing factors to the global burden of anemia (WHO Report, 2002). It is estimated that around 2.15 billion individuals suffer from iron deficiency anemia (FAO/WHO, 1992). 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 (McCann and Ames, 2007). The absorption of dietary iron is assumed to be 5-10%, but it increases 3 to

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5 times when iron storage is depleted (Halterman, 2001). 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 (Shinton, 1998). 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 to 50% of children under age 5 are iron deficient (Cook et al., 1994). It has been reported that 46.5% of Indonesian and 30 to 60% of Guatemalans under the age of 5 have suffered from IDA (Soewondo, 1995; Ross and Horton, 1998). In Iran, 30 to 50% of women and children, especially those in low-income families, are suffering from iron deficiency (Yip, 1995).

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 (Kordas et al., 2004).

In women of childbearing age, the anemia prevalence is 30.2%; Overall, 468.4 million women of childbearing age are anemic. The highest prevalence is found in Africa (47.5%) and in South-East Asia (35.7%). It is 17.8% in the Americas (WHO Report, 2008)[8] 14% in the United Arab Emirates; and from a low of 11% in Egypt to over 40% in the Syrian Arab Republic and Oman among women of childbearing age (Al-Buhairan and Oluboyede, 2001; Al-Quaiz, 2001; Djazayery et al., 2001; Bagchi, 2004). 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 (Sebai et al., 1981; Serenius and Fourgerson, 1981; Sebai, 1988; Al-Othaimeen et al., 1988; Rasheed et al., 1989), so data on the nutritional status of children and adolescents in the Kingdom are insufficient (El-Hazmi and Warsy, 1999; Abalkhail and Shawky, 2002).

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 to 40% in industrialized countries, are iron deficient (FAO/WHO, 1992; Gleason et al., 1998).

Therefore, the aim of this study was to determine the prevalence of iron deficiency and iron deficiency anemia among apparently healthy Saudi young female university students studying at King Abdulaziz University in Jeddah province and to correlate their relation to variables such as: weight, height, nutritional habits and menstrual history.

MATERIALS AND METHODS

Samples selection

Between February and June 2007, a total of 310 female students between the ages of 18 to 23 years were selected from King Abdulaziz University, Faculty of Medicine, female section after an informed consent agreement. This study was designed to include female only due to high frequency among female according to WHO report. Venous blood samples (4 to 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), high performance liquid chromatography (HPLC) and hemoglobin electrophoresis. Whereas plain tubes were used to measure serum iron (SI) and ferritin (SF).

Data collection

Data for nutritional status and other parameters were collected with informed consent agreement; each student was interviewed to complete a structured questionnaire, which included information on sociodemographic data, age, height, weight, social habits, and symptoms, menstrual history, dietary, medical history, and nutritional habits. The type of food taken was classified into No, Infrequently (<2 servings/week) and frequently (>2 servings/week). Each student was asked if their family history of anemia and if so, it's type as well as other chronic diseases (such as bronchial asthma, diabetes mellitus, cardiac diseases etc). Data were collected by medical technology intern students trained in interviewing skills and directly supervised by the academic staff. Those reported of having hereditary anemias (such as sickle cell anemia or thalassemia) as diagnosed by a physician were excluded from the study.

Methods

Complete blood count was measured by using Beckman coulter LH750 machine in the hematology laboratory at King Abdulaziz University Hospital; Jeddah hematological parameters included hemoglobin, hematocrit, mean corpascula volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red blood cell count (RBC), white blood cell count (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.

High performance chromatography (HPLC) Biorad Varinat II and Sebia Hydrasys Electrophoresis System were used to diagnose hemoglobin disorders.

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 as was used to calibrate and check checked and calibrated by using standard quality assurance at the beginning of the experiment.

Iron deficiency was defined as ferritin <15 ng/ml and IDA as ferritin <15 ng/ml with hemoglobin <12 g/dl (WHO/UNICEF/UNU, 2001).Body mass index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in meters Kg/m^2. Body mass index was calculated as follows: body weight (Kg)/height (m^2).

Statistical analysis

Data were entered and analyzed using Statistical Package for

Table 1. Comparisons between Normal (n=158) iron deficiency (n =79) and iron deficiency anemia (n =73) in the investigated hematological and biochemical parameters as mean, standard deviation (SD) and P-value.

	Normal		ID		IDA		P-value
	Mean	SD	Mean	SD	Mean	SD	
RBC (10^{12}/l)	4.8	0.52	4.57	0.297	4.30	0.36	0.001
Hb (g/dl)	14.3	0.42	12.94	0.67	10.91	0.98	0.047
Hct (%)	42.0	1.76	38.33	1.81	33.19	2.35	0.000
MCV (fl)	87.1	5.87	84.13	4.81	76.27	7.95	0.000
MCH (pg)	29.7	2.42	28.41	1.86	25.12	3.16	0.000
MCHC (%)	34.0	0.54	33.75	0.58	32.84	0.99	0.019
RDW (%)	13.2	0.95	14.13	1.23	16.31	2.19	0.000
Plts (10^9/l)	248.8	15.43	328.62	86.17	335.55	68.42	0.586
WBC (10^9/l)	6.2	1.48	7.16	1.81	6.67	1.76	0.091
S I (µmol/l)	18.8	8.49	12.11	5.93	7.81	5.190	0.000
S F (ng/ml)	45.4	32.61	9.57	2.84	6.08	2.90	0.000
BMI	22.6	4.5	22.19	3.79	21.64	4.35	0.406

RBCs=Red blood cells; Hb=hemoglobin Hct=hematocrit; MCV= mean corpuscular volume; MCH= mean corpuscular hemoglobin; MCHC= mean corpuscular hemoglobin concentration; Plts= platelets; WBCs= white blood cells; RDW= red blood cells distribution width; SI= serum iron; SF= serum ferritin; BMI= body mass index; SD= standard deviation, ID=Iron deficiency, IDA=Iron deficiency anemia.

Social Sciences program (SPSS) Version 12. Student's "*t*" test was used to compare the proportions and 95% confidence intervals (95% CI) between ID, IDA 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 ID, IDA and normal group in nutritional habits of the population studied.

RESULTS

A total of 310 Saudi female students were enrolled in this study. All students' ages ranged between 18 to 23 years.

EDTA samples were subjected to CBC analysis, HPLC and hemoglobin electrophoresis to classify the type of anemia and to exclude hereditary type. Five students were excluded from this study. One of these students had sickle cell anemia and four had β-thalassemia trait. Overall CBC and serum iron profile results divided participants into three groups' normal, ID and IDA. Table 1 summarizes CBC, SI, SF and BMI results in each group.The mean hemoglobin level for the first group (normal) was 14.3 g/dl (±0.42), while the mean hemoglobin level of the second group (ID) was 12.9 g/dl (±0.67), whereas the mean hemoglobin level for the third group was 10.9 g/dl (±0.98). Also, the median MCV was 81.4 fl for ID group and 75.3 fl for the IDA group. The whereas the mean ferritin level in IDA group was 6.1 mean ferritin level in ID group was mean= 9.57 ng/ml ng/ml. (Table 1). The body mass index of students did not show any statistical significant differences between ID and IDA. The prevalence of ID, and IDA in this small study was 24 and 26%, respectively.

Results out of questionnaire were divided into two groups. Group A includes: marital status, exercise, and smoking, dietary history (eating red meat, eating vegetables, drinking coffee, cocoa, brown tea and menstrual history (heavy period and clot with period). The majority of anemic students (28%) were infrequent or did not eat red meat (P = 0.024), while 27% were not performing exercises (P = 0.004). These two factors showed statistically significance correlation while other factors in this group have no statistical significant correlations (p > 0.05) Table 2.

Group B questionnaire includes; chronic diseases (such as asthma and *diabetes mellitus*), blood disorders, past history of IDA, medication (antacid or non steroidal anti-inflammatory drugs), symptoms (headache or pallor) and lack of concentration.

The chronic diseases, blood disorders, antacids and non steroidal anti-inflammatory drugs (NSAID) did not show any significant differences between ID, IDA and the controls. Significant differences were detected between ID, IDA and the controls in regards to past history of IDA (P = 0.000).The headache and lack of concentration did not show any significant differences between ID, IDA and the controls. Significant difference was detected between ID, IDA and the controls in regards to pallor as subjective complaint of the female students (P = 0.004).

DISCUSSION

Iron deficiency anemia is the most common nutritional

Table 2. Distribution of students with iron deficiency (ID), Iron deficiency anemia (IDA) and their controls according to Social Habits Menstrual Cycle.

		Control n =153		ID n =79		IDA n =73		P value
		n	%	n	%	n	%	
Exercises	Yes	41	26.8	38	48.1	29	39.7	0.004
	No	112	73.2	41	51.9	44	60.3	
Smoking	Yes	4	2.6	5	6.3	3	4.1	0.385
	No	149	97.4	74	93.7	70	95.9	
Eating red meat	No	12	7.8	9	11.4	13	17.8	0.024
	Infrequently	73	47.7	44	55.7	42	57.5	
	Frequently	68	44.4	26	32.9	18	24.7	
Eating vegetables	No	9	5.9	7	8.9	1	1.4	0.381
	Infrequently	61	39.9	30	38.0	29	39.7	
	Frequently	83	54.2	42	53.2	43	58.9	
Drinking coffee/ Cocoa directly after meal	No	66	43.1	29	36.7	29	39.7	0.909
	Infrequently	39	25.5	23	29.1	19	26.0	
	Frequently	48	31.4	27	34.2	25	34.2	
Drinking brown Tea	No	61	39.9	32	40.5	32	43.8	0.208
	Within meal	20	13.1	15	19.0	17	23.3	
	After meal	72	47.1	32	40.5	24	32.9	
Menstrual history	Heavy period							
	Yes	42	27.5	27	34.2	27	37	0.295
	No	111	72.5	52	65.8	46	63	
	Clots with period							
	Yes	71	46.4	44	55.7	40	54.8	0.300
	No	82	53.6	35	44.3	33	45.2	
Dieting	Yes	27	17.6	8	10.1	8	11.0	0.200
	No	126	82.4	71	89.9	65	89.0	

deficiency worldwide. The negative consequences of IDA on the cognitive and physical development of children and on the work productivity of adults are of major concern (Verdon et al., 2003).

In our study exercise capacity reveled statistical significant difference (P= 0.004) in students with ID and IDA compared to control. In concordance Roland and Kelleher (1989) showed that treadmill endurance times improved significantly in the iron-treated runners.

Cigarette smoking causes elevation of hemoglobin and hematocrit which is explained by elevation of carbon monoxide a major component of cigarette smoke which reduces oxygen tension in the body. This reduction increases production, maturity and release of erythrocytes from blood forming organs and thus elevates hemoglobin and hematocrit levels while serum ferritin may be low (Van Liere and Stickney, 1963). In this study, 10.4% of the female students were tobacco smokers which include 6.3% ID and 4.1% IDA. However, the correlation between tobacco smoking, ID and IDA did not showed statically differences (P = 0.385).

Students consuming no or infrequent amount of red meat were demonstrated to have ID (55.7%) and IDA (57.5%) compared to control (47.7%), (p = 0.024), while vegetables as dietary variable was not statistically significant compared to control. Dietary factors such as low consumption of red meat, vegetables, cereals and fruits have been reported to be associated with IDA (Galan et al., 1998). Heme iron (from meat) provides 10 to 20% of iron intake while non-heme iron (from

Table 3. Distribution of students with iron deficiency (ID), iron deficiency anemia (IDA) and their controls according to medical and drug history.

		Control		ID		IDA		P-value
		n	%	n	%	n	%	
Chronic diseases	Yes	8	5.2	7	8.9	3	4.1	0.408
	No	145	94.8	72	91.1	70	95.9	
Blood disorders	Yes	3	2.0	2	2.5	0	0	0.426
	No	150	98	77	97.5	73	100	
Past history of IDA	Yes	27	17.6	8	10.1	28	38.4	0.000
	No	126	82.4	71	89.9	45	61.6	
Medication	Yes	7	4.6	7	8.9	4	5.5	0.416
Antacid	No	146	95.4	72	91.1	69	94.5	
*NSAID	Yes	23	15.0	10	12.7	6	8.2	0.357
	No	130	85.0	69	87.3	67	91.8	
Headache	Yes	90	58.8	38	48.1	38	52.1	0.268
	No	63	41.2	41	51.9	35	47.9	
Lack of concentration	Yes	74	48.4	28	35.4	37	50.7	0.104
	No	79	51.6	51	64.6	36	49.3	
Pallor	Yes	49	32.0	16	20.3	33	45.2	0.004
	No	104	68.0	63	79.7	40	54.8	

vegetables, fruits, and cereals) provides 80 to 90%. However, non-heme iron absorption is influenced by the iron status of subjects and the balance between enhancers and inhibitors present in the food, much more than heme iron (Tseng et al., 1997). Other study revealed similar results that female subjects infrequently consuming red meat and vegetables (less than two servings of red meat and vegetables per week) were at increased risk to develop ID and IDA (Al-Quaiz, 2001). Heavy menstrual blood loss is an important risk factor for iron deficiency anemia among women of childbearing age. Total body iron stores contain about 2 to 4 g, with substantial differences between the sexes. Males and non-menstruating females average a 1 mg loss of iron per day. A typical 60-kg woman may lose an additional 10 mg of iron per day during menstruation. Iron loss of 42 mg per menstrual cycle has been reported in females with heavy blood flow (Roland and Kelleher, 1989). In our study, ID (8.8%) and IDA (8.8%) female students were demonstrated to have a heavy period compared to control, which was not statistically significant. In addition, 27.5% students with ID and IDA had history of clots with menstrual cycle, but it was not statistically significant (P = 0.300). Other study among females of childbearing age considered to have heavy menstrual cycle and duration of ≥ 8 days as one of the important risk factors moreover, history of clots and flooding increased the risk of having IDA (Al-Quaiz, 2001) (Table 3).

A past medical history of IDA had been reported to be a risk factor for a subsequent recurrence. Iron deficiency anemia is usually resolved after eight weeks to six months of treatment. Inadequate response may be related to continued blood loss (e.g., heavy menses or analgesic use), inflammation, ineffective absorption, or poor compliance. After the hemoglobin has returned to normal, continuing to take a low dosage of iron (e.g., 30 mg/day) for an additional one to two months will replace iron stores and decrease the likelihood of recurrence of anemia (Cook, 1999). Lack of compliance as well as premature discontinuation of iron tablets are the likelihood of recurrence of anemia. Moreover, dietary habits within a family should be properly investigated to identify the inhibitors and enhancers of iron absorption. In our study there was highly statistical significant correlation between past medical history of ID and IDA (P = 0.000).

Iron deficiency usually develops slowly and insidiously. Many patients have no specific complaints; others have vague symptoms of tiring easily, headache, irritability, or depression (Andrews, 1999). Probably the single most important clinical clue to anemia is the symptom of chronic fatigue. The physical examination reveals usually a range of symptoms such as tachycardia, shortness of breath, poor capillary refilling, fatigue, and pallor of the conjunctiva and skin (Roland and Kelleher, 1989). We reported pallor as subjective complaint by female students to be significant correlation (P = 0.004).

In conclusion, this study revealed the prevalence of ID (25.9%) and IDA (23.9%) among Saudi young females apparently healthy at University stage, in Jeddah provence. This frequency is, however, higher than what have been reported previously in other region. Infrequent or no consumption of red meat impairs exercise capacity and past medical history of IDA was correlated with ID and IDA. Pallor was the most statistically significant complaint. The high prevalence of anemia in an affluent country calls for an in-depth study for the determination of factors associated with IDA. Intervention action programs to combat ID and IDA in Saudi Arabia should be given a high priority.

Recommendations

Educational programs to improve public awareness of this problem and its causes. Nutrition education programs should be conducted especially for the women of child bearing age to advocate healthy dietary habits.

1. Screening for iron deficiency in high risk groups should be considered.
2. Primary physician education is needed to ensure a greater awareness of ID and IDA and the testing needed to establish diagnosis as well as underlying causes.
3. Fortification of some foods such as salts, flour and juices can help to reduce this common problem. Future research is needed to evaluate dietary iron adequacy in Saudi diet.

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