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Assessment of Iron Nutritional Status in A Group of Jordanian School Children Aged 6-12 Years in Deir Alla District

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Abstract
A cross-sectional study was conducted to assess the nutritional status of iron in a sample of school children aged 6-12 years in a rural area at Deir Alla District in Al-Balqa Governorate, Jordan. A sample of 108 children (54 males, 54 females), aged between 6-12 years, were selected from primary schools of Deir Alla District. A validated and adopted questionnaire was used to collect data for the children families and data about health and life style for children and their parents. A three- day food recall was also used to collect dietary intake data. Height and body weight were measured and Body Mass Index (BMI) was calculated for evaluating the anthropometric status. Hemoglobin, mean corpuscular volume and serum ferritin concentrations were measured. The results showed that 9.26% of children had iron deficiency anemia (IDA), where hemoglobin was <11.5 g/dl, MCV was <80 fl and serum ferritin was <15 µg/l. Anemia (without IDA) was found in 14.81% of children, where hemoglobin was <11.5 g/dl, and iron deficiency was found in 38.9% of children, at ferritin level of <15 µg/l. No significant difference for hemoglobin, MCV, and serum ferritin values existed among different groups. Mean intake of iron was the highest among children at age of 11-12 years. No significant differences were observed between children in any of the anthropometric measurements (P>0.05). Regarding the family awareness of dietary intake, there was significant difference in importance of taking breakfast daily, taking tea with meals, and taking snacks between meals among the children with different iron status. It could be concluded that iron deficiency is common in children in Al-Balqa Governorate, since up to 9.26% of Jordanian children developed iron deficiency anemia (IDA), 14.81% developed anemia, and 38.9% had iron deficiency (ID).

Keywords: Iron status, School children, Jordan, Deir Alla
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1. Introduction

Anemia is one of the most common problems in the world nowadays. It has consequences on humans through affecting socioeconomic status, in addition to morbidity and mortality rate especially in pregnant women and young children (WHO, 2015). Clinically, anemia is characterized by a low level of hemoglobin in the blood, either as a result of a deficiency in red blood cells or a deficiency in hemoglobin within each cell (Sirdah et al., 2013), whereas anemia is described in terms of public health as a condition when the hemoglobin level is below cutoffs. Cutoffs of hemoglobin for children aged 5-11 years and 12-14 years are 11.5 g/dl and 12 g/dl, respectively, (Ramazan et al., 2009; WHO, 2015). At least half of all types of anemia worldwide are due to nutritional iron deficiency anemia (IDA) (Stopler et al., 2014). Additionally, anemia can be caused by other factors, such as blood loss diseases including malaria, hookworm infections or inherited condition, like thalassaemia (Halileh et al., 2005).

WHO estimated that in 2004, IDA resulted in 273000 deaths, 9% of them were in the Eastern Mediterranean region with 97% occurring in low and middle income countries (Pasricha et al., 2013). In children, anemia can result in fatigue, impaired cognitive performance, impaired immunity, impaired motor development, and decreased school achievement (Yewale and Dewan, 2013; Paoletti and Ritchey, 2014).

In the developing countries, the high prevalence of ID has economic costs and substantial health problem such as decreased productivity, poor pregnancy outcome and impaired school achievement (Zimmermann and Hurrell, 2007). Ahankari et al. (2017) stated that if anemia is highly prevalent in the children of a country, it can substantially affect its intellectual, economical potential, cognitive development, and consequently learning achievement. Also, brain development which results in mental retardation, decrease in appetite, low resistance to infection (Hawamdeh et al., 2013), and decreased performance are the most common problems that can be caused by IDA (Kassebaum et al., 2014; Gupta et al., 2016). Furthermore, ID individuals have increased absorption capacity of divalent heavy metals, such as lead and cadmium, which increases metal poisoning (Desalegn et al., 2014).

IDA is the most common type of nutritional anemia in the world and significantly affects individuals of all ages and economic groups in both developing and developed countries (Sirdah et al., 2014). The prevalence of IDA in the countries of the Eastern Mediterranean is high (Pasricha et al., 2013), and was reported to be more prevalent in the rural than urban regions (MOH, 2021). The school age children are among the groups of the population who are affected by IDA. The prevalence in this group is up to 9% in developed countries, while in developing countries it reaches 45-84% of population (Hawamdeh et al., 2013). This was in agreement with data from WHO. The prevalence of IDA among school age children in developing countries according to WHO (2001), was 48.1%, and according to WHO and Centers for Disease Control and Prevention (CDC) (2008), the global prevalence of anemia among school children was 25.4% worldwide.

Several studies on anemia in Jordanian children were on pre-school children. According to data from the most recent national Jordan Population and Family Health Survey (JPFHS) conducted in 2017–2018 showed that 32% of children aged 6–59 months were found to have anemia with 21%, 11% and <1% having mild, moderate and severe anemia, respectively (Al-awwad et al., 2022). Previously, two nationwide micronutrient surveys, carried out in 2002 and 2010, assessed the prevalence of anemia, iron deficiency, and iron deficiency anemia in children aged 12-59 months. These surveys showed that the prevalence rates of iron deficiency decreased significantly from 26.2% in 2002 to 13.7% in 2010 and that iron deficiency anemia decreased significantly from 10.1% in 2002 to 4.8% in 2010, while the rates of anemia decreased non-significantly from 20.2% in 2002 to 17% in 2010. According to modeled data, the prevalence of anemia in children between the ages of 6 and 59 months varied, first declining from 32.6% in 2000 to 30.4% in 2010, then rising to 32.7% in 2019. The prevalence in children between the ages of 6 and 59 months in 2017–2018 was categorized as a moderate public health issue. In 2010, anemia and iron deficiency rates among children aged 12-59 months were classified as modest public health issues, whereas iron deficiency anemia rates were regarded normal. The incidence of iron deficiency showed a declining tendency over time, whereas anemia rates did not significantly improve. This trend may have been caused by the national wheat flour fortification program, which added various micronutrients, including iron (Al-awwad et al., 2022)

According to information from the most recent Nutritional Micronutrient Survey in 2019, the prevalence of anemia, ID, and IDA among school-age rural children were 1.2%, 36%, and 0.8% respectively, while in similar study in 2010, the prevalence of anemia, ID, and IDA were 17%, 13.7% and 4.8% respectively (MOH, 2021). Regarding the anthropometric measurement in the previous studies, no significant differences were found in groups of different age, gender, and area. Children in urban areas are less likely to have anemia than rural areas. The aim of this study was 1) to evaluate the nutritional status of iron in a sample of school children aged 6-12 years in Deir Alla District and the occurrence of IDA and nutritional risk factors among them, and 2) to assess dietary intake of energy, carbohydrate, protein, fat, and iron in the subjects recruited in the study.

2. Materials and Methods

2.1 Design and study sample

A cross sectional study using a convenient sample of 108 school children aged 6-12 years were recruited from Princess Iman Hospital and health centers in Deir Alla District. The sample consisted of 54 females and 54 males, 9 boys and 9 girls from each grade. Institutional Review Board (IRB) was obtained from the Ministry of Health and from the Deanship of Academic Research at the University of Jordan. All participants' parents received full information about the objectives, nature, and main method of the study prior to asking them to provide written consent form for blood collection.

The inclusion criteria were self-reported; being Jordanian at the age of 6-12 years old, apparently healthy, who are free from severe illness. They are not using medication recently (including specially treatment for anemia), for the last two weeks and they are free from hemolytic diseases. The exclusion criteria of the children included the presence of severe illness, the recent use of medication for the last two weeks and being free from hemolytic diseases, being younger than 6 years or older than 12 years and non-Jordanian students.

2.2 Data collection

Basic data were obtained about the children, including name, gender, and date of birth.

The questionnaire, which is validated and adopted from a previous study (Mahfouz, 2009), included the information about the personal demographic data, a set of questions used to measure the level of awareness, knowledge, practices and health profile of participants. Data about health status, supplements, and drug use were collected through face to face single interview with the mothers and/or care takers of each participant at clinic or at their home.

2.3. Anthropometric measurement

The weight and height were measured in order to calculate body mass index (BMI) as an indicator of weight status. Child weight was measured to the nearest 0.1 kg using electronic scale balance and length was measured to the nearest 0.1 cm with movable measuring rod attached to platform according to Lee and Nieman, (2013). Body mass index (BMI) was calculated according to the following equation (Litchford, 2017):

BMI (Kg/m^2) = weight (Kg)/ height (m^2).

2.4. Dietary assessment

Data on the current children food practices were collected during the interview with the parents. Food models and standard measuring tools were used to help parents of each participant to estimate portion size. Data about number of meals per day, tea consumption, snacks, food ingredients of meals, and way of preparation were collected. Parents of each participant were also requested to fill a three days food recall for their children about the previous day for three days (two week days and one weekend day). Parents were also instructed on how to write the child's food intake and accurately describe the food portion size, dish composition, food varieties, and preparation methods. Detailed information of all foods and beverages, including amount of ingredients of dishes, brand name, and methods of preparation were also collected.

2.5. Calculation of energy, macronutrients, and micronutrient intakes

Food recall data were used to calculate the intake of nutrients and energy using The Food Processor SQL software (version 10.9.0, 2011 ESHA Research). The intake of energy and nutrients were then compared with DRI which included RDA and AI for each age group.

2.6. Biochemical analysis

At Prince Iman Hospital, a venous blood sample of about 5ml was obtained for every child by a specialist nurse. A 3 ml blood sample was collected utilizing a sterile vacuum tube filled with K3EDTA. These samples were analyzed on the same day by the electronic count to determine complete blood count using, ERMA PCE-210N, Japan 2015 in private laboratory (Hawamdeh et al., 2013). In a separate sterile vacuum tube with a gel that promotes clotting, another blood sample of 2ml of blood was collected, on the same day. Serum for ferritin level determination was done using, Tosoh Immunoassay Analyzer AIA-600 II. All of the tests were done in the same laboratory. Participants were considered as IDA according the following criteria as shown in table 1.

Table 1: Criteria of establishing IDA (WHO, 2011; Hawamdeh *et al.*, 2015)

Age	**Hb (g/dl)**	**MCV (fl)**	**Serum ferritin µg/l**
6-11 years	<11.5	<80	<15
12 years	<12	<80	<15

The following criteria are used to diagnose anemia, ID, and IDA:

1- Children with Hb <11.5 g/dl were considered anemia.

2- Children with Hb within normal value, MCV ≥80fl and serum ferritin <15µg/l were considered ID.

3- Children with Hb <11.5 g/dl, MCV <80fl, and Serum ferritin <15µg/l were considered IDA.

3. Statistical analysis:

The statistical analysis was conducted using the Statistical Package for Social Science, version 20 (SPSS for windows, Rel. 20.0. 201 SPSS Inc.). Variables were compared using the t-test, and categorical variables by chi square. Analysis of variance (ANOVA) was used to determine whether there are any significant differences among the means of continuous variables. All tests were conducted at the significant level (p≤0.05) and were expressed as mean ±S.E.M.

4. Results

4.1. Characteristics of the study sample

Table 2 shows the anthropometric measurements of the study sample regarding weight, height, and Body Mass Index (BMI) in both sexes. Mean age of the children for males and females were 8.8±0.2, and 8.8±0.2, respectively. Mean children height (cm) for male and female children was 130±1.4 cm and 130.4±1.4 cm, respectively. Mean children weight (kg) was 26.8±1.0 kg for male children and 27.2±1.0 kg for female children. Mean BMI for male and female children was 15.5±0.3 and 15.7±0.3, respectively. There were no significant differences in age, height, weight, and BMI between both sexes.

Table 2: Characteristics of the study sample according to age, weight, height, and BMI in both sexes

Variables	male (n=54)	female (n=54)	Total (n=108)	P-value*
	Mean± SEM**			
Age (years)	8.8±0.2	8.8±0.2	8.8±0.2	0.9
Height (cm)	130±1.4	130.4±1.4	130.1±1.0	0.8
Weight (kg)	26.8±1.0	27.2±1.0	27±0.7	0.7
BMI*** (kg/m²)	15.5±0.3	15.7±0.3	16±0.2	0.6

*Differences are considered significant at P<0.05
**SEM: Standard Error of Mean
***BMI: Body Mass Index

4.2. Biochemical indicators (Hemoglobin, MCV, and Serum ferritin) of the study sample

Table 3 shows mean hemoglobin (Hb), mean corpuscular volume (MCV), and mean serum ferritin (S. ferritin) of the children in both sexes. There were no significant differences (p>0.05) in Hb, MCV, and serum ferritin between male and female children. The mean value of Hb was 12.2±0.2 (g/dl) in males, and 12.2±0.1 (g/dl) in females. The mean value of MCV was 82.4±0.7 (fl) in males and 83±0.6 in females. Mean serum ferritin was 21.6±2.1 (μg/l) in males, and 20.7±2.0 in females.

Table 3: Biochemical indicators according to gender

Indicators	male (n=54)	female (n=54)	Total (n=108)	P-value**
Hb	12.2±0.2*	12.2±0.13	12.2±0.1	0.7
MCV	82.4±0.7	83±0.63	82.7±0.5	0.6
Serum Ferritin	21.6±2.1	20.7±1.98	21.2±1.5	0.8

*Data is presented as mean ± SEM
**Differences are considered significant at P<0.05

4.3. Anthropometric characteristics in relation to iron status

The anthropometric measurements for the children according to iron status are shown in the table 4. There were no significant differences in the means height, weight, and BMI between children in different groups of iron status.

Table 4: Anthropometric measurements for the study sample according to iron status

Anthropometric measurements*	Iron status				P-value*
	Normal	Anemia	ID	IDA	
	Mean± SEM				
Height (cm)	132.2±1.45	133.4±2.48	127.6±1.6	127.7±4.1	0.1
weight (kg)	28±1.1	29.3±2.14	25.8±1.0	24.3±2.1	0.2
BMI (kg/m²)	15.8±.4	16±0.6	15.53±0.26	14.36±.6	0.3

*Differences are considered significant at P<0.05

4.4. Dietary intakes of the study sample in relation to sex

Table 5 shows the nutrient intake of males and female subjects. There were no significant differences (p<0.05) in energy intake (kcal/day), CHO intake (g/day), protein intake (g/day), fat intake (g/day), calcium intake (mg/day), vitamin C intake (mg/day) and iron intake (mg/day) between male and female children.

Table 5: Nutrient intake for the study sample in relation to sex

Nutrients	male (n=54)	female (n=54)	Total(n=108)	P-value*
Energy (kcal/d)	1736.2±51.8	1669.8±46.8	1703.0±34.9	0.3
CHO (g/d)	215.3±8.9	209.9±7.6	212.5±5.8	0.7
Protein (g/d)	62.4±2.4	63.4±2.9	62.9±1.9	0.8
Fat (g/d)	66.4±2.6	62.8±2.6	64.6±1.9	0.3
Calcium (mg/d)	485.3±38.5	403.5±31.4	444.4±25.0	0.1
Vitamin C (mg/d)	67.3±6.1	81.6±7.9	74.5±5.0	0.2
Iron (mg/d)	12.3±.5	11.9±.8	12.1±0.5	0.7

*Differences are considered significant at P<0.05

4.5. Dietary intakes of the study groups in relation to iron status

Table 6 shows the nutrient intake (as % of DRI) for the children according to iron status. Among normal children, energy intake (as % of DRI), Carbohydrates (CHO) intake (as % of DRI), protein intake (as % of DRI), and iron intake (as % of DRI) were significantly (p<0.05) higher compared to anemic, ID, and IDA groups. On the other hand, among the children with IDA, calcium intake (as % of DRI) was significantly (p<0.05) lower compared to the children with other iron status (normal, anemia, and ID). There was no significant difference in vitamin C intake (as % of DRI) between the children with different iron status (normal, anemia, ID, and IDA). It is clear that the energy intake and iron intake for the children with IDA are below the recommendation (>80%).

Table 6: Nutrient intake for the study sample (as % of DRI) based on iron status

Nutrients* (%)	Iron status					P-value**
	Normal (n=40)	Anemia (n=16)	ID (n=42)	IDA (n=10)	Total (n=108)	
	Mean ± SEM					
Energy intake %	93±1.9[c,***]	81.6±2.6[b]	83.9±1.9[b]	58.0±3.5[a]	84.5±1.5	**.001**
CHO %	180.2±5.5[b]	178.1±10.7[b]	147.0±7.2[a]	142.6±19.9[a]	163.5±4.5	**.003**
Protein %	277.9±16.1[b]	235.2±24.8[b]	271.2±16.6[b]	154.5±10.3[a]	257.5±10.3	**.006**
Calcium %	42.9±3.6[b]	31.4±4.9[a,b]	44.7±4.1[b]	18.4±6.9[a]	39.6±2.4	**.007**
Vitamin C %	241.2±24.3	191.4±26.9	227.8±27.3	170.1±40.6	222.0±14.9	.498
Iron %	163.6±10.8[c]	145.6±11.9[b,c]	119.5±6.7[b]	74.3±5.0[a]	135.5±5.7	**.001**

*Fat is not determined (ND) in DRI for the age of the study sample
**Differences are considered significant at P<0.05
***Values in rows with different superscripts indicates significant difference

4.6. Iron status in relation to family awareness and dietary habits

Table 7 shows distribution of the children of different iron status with respect to dietary habits. As shown in the table, there were no significant differences in eating chips, spinach, lettuce, hummus and falafel, nuts, milk, and milk products between the children of different iron status. Whereas, in eating liver, meat, soft drink, and natural fruit juice, there were significant differences (p<0.05) between the children of different iron status; 97.9% of the normal children had liver and meat in their usual meals and they were significantly (p<0.05) higher compared to 70% of the children with IDA who had same foods in their usual meals. Whereas, 90% of the children with IDA who had soft drinks (cola, soda…etc) in their usual meals were significantly (p>0.05) higher compared to 82.5% of the normal children who had same foods in their usual meals. Ninety percent of the normal children had natural fruit juice in their usual meals which is significantly (p<0.05) higher compared to 60% of the children with IDA who had same foods in their usual meals.

Table 7: Distribution of the study sample according to iron status and eating habits

Meals ingredient*	**Answer**	**Iron Status**				P value***
		Normal	**Anemia**	**ID**	**IDA**	
Chips	**Yes**	34 (85)**	9 (56)	34 (81)	9 (90)	0.08
	No	6 (15)	7 (43.8)	8 (19)	1 (10)	
Spinach and lettuce	**Yes**	34 (22.5)	14 (87.5)	39 (92.9)	9 (90)	0.72
	No	6 (15)	2 (12.5)	3 (7.1)	1 (10)	
Falafel and hummus	**Yes**	38 (95)	15 (93.7)	41 (97.6)	10 (100)	0.68
	No	2 (5)	1 (6.3)	1 (2.4)	0 (0)	
Liver and meat	**Yes**	39 (97.5)	16 (100)	38 (90.5)	7 (70)	**0.02**
	No	1 (2.5)	0 (0)	4 (9.5)	3 (30)	
Soft drinks (cola, soda)	**Yes**	33 (82.5)	10 (62.5)	39 (92.9)	9 (90)	**0.04**
	No	7 (17.5)	6 (37.5)	3 (7.1)	1 (10)	
Natural fruit juice	**Yes**	36(90)	15 (93.8)	39 (92.9)	6 (60)	**0.02**
	No	4 (10)	1 (6.2)	3 (7.1)	4 (40)	
Nuts	**Yes**	36 (90)	13 (81.2)	37 (88.1)	7 (70)	0.37
	No	4 (10)	3 (18.8)	5 (11.9)	3 (30)	
Milk and milk products	**Yes**	40 (100)	16 (100)	40 (95.2)	10 (100)	0.36
	No	0 (0)	0 (0)	2 (4.8)	0 (0)	

*Care takers and children were asked about the meal's ingredients
**Values are presented as number of children in each meals ingredient group (row) and iron status with its percentage (%) from the total of each iron status group (column)
***Variables are compared by Chi square test; differences are considered significant at $P<0.05$

Iron status in relation to family awareness of dietary intake is shown in table 8. There was significant difference ($p<0.05$) in relation to family awareness on importance of taking breakfast daily among the children with different iron status. Three children with IDA (30%) had breakfast daily in comparison with 85% of normal children, 81.3% of anemic children, and 85.7% of children with ID. Regarding the awareness of the children's families about that breakfast increases ability to concentrate; there was no significant difference between families of the children of different iron status. There were significant differences ($p<0.05$) between the children who had snacks between meals and those who did not; 95% of normal children had snacks between meals compared to 70% of the children with IDA, showing a significant difference between the two groups. Regarding the number of meals during the day, there were no significant differences ($p>0.05$) among children of different iron status.

Table 8: Iron status in relation to family awareness of dietary intake*

Awareness of dietary intake	Answer	Iron Status				P-value***
		Normal** n (%)	Anemia n (%)	ID n (%)	IDA n (%)	
Taking Breakfast daily by children	Yes	34 (85)	13 (81.3)	36 (85.7)	3 (30)	**0.001**
	No	6 (15)	3 (18.8)	6 (14.3)	7 (70)	
Breakfast increases ability to concentrate	Yes	5 (87.5)	15 (93.8)	34 (81)	7 (70)	0.35
	No	5 (12.5)	1 (6.3)	8 (19)	3 (30)	
Taking snack between meals	Yes	38 (95)	15 (93.8)	32 (76.2)	7 (70)	**0.04**
	No	2 (5)	1 (6.3)	10(23.8)	3 (30)	
Number of meals during a day	2	0 (0.0)	1 (6.3)	1 (2.4)	0 (0.0)	0.129
	3	9 (22.5)	4 (25)	12 (18)	7 (70)	
	4	22 (55.0)	9 (56.3)	18 (42.9)	3 (30)	
	5	9 (22.5)	2 (12.5)	11 (26.2)	0 (0.0)	

*Care takers were asked about their awareness on the diet
**Values are presented as the number of children in reference to iron status group (row) with its percentage (%) from the total in each group (column)
***Differences are considered significant at P<0.05

The prevalence of anemia, ID, and IDA in the children in relation to tea consumption is shown in table 9. There was significant difference (p<0.05) in taking tea with meals between children of different iron status; 80% of the children with IDA had tea with meals in comparison with 30% of the normal children who had tea with meals. However, there was no significant difference in taking tea directly or after an hour of meal between the children of different iron status; 30% of the children with IDA had tea directly after meal compared with 17.5 of the normal children had same habit. There was no significant difference with respect to parent's beliefs that tea increases iron absorption between the children of different iron status. Also, there was no significant difference in taking fruit juice between the children of different iron status.

Table 9: Occurrence of anemia, ID, and IDA according to tea consumption

Habits of taking tea*	Answer	Iron Status				P-value***
		Normal n (%)**	Anemia n (%)	ID n (%)	IDA n (%)	
Taking tea with meals	Yes	12 (30)	9 (56.3)	29 (69)	8(80)	**0.001**
	No	28 (70)	7 (43.8)	13 (31)	2 (80)	
Taking tea after meals directly	Yes	7 (17.5)	4 (25)	18 (42.9)	3 (30)	0.09
	No	33 (82.5)	12 (75)	24 (57.1)	7 (70)	
Taking tea after meals one hour or more	Yes	23 (57.5)	6 (37.5)	19 (45.2)	4 (40)	0.47
	No	17 (42.5)	10 (62.5)	23 (54.8)	6 (60)	
Tea with meals increases iron absorption?	Yes	8 (20)	5 (31.3)	10 (23.8)	2 (20)	0.83
	No	32 (80)	11 (68.8)	32 (76.2)	8 (80)	
Taking fruit juice with meals	Yes	10 (25)	1 (6.3)	9 (21.4)	0 (0)	0.16
	No	30 (75)	15 (93.8)	33 (78.6)	10(100)	

* Care takers and children were asked about children's habit
**Values are presented as number of children in each habit group (row) and iron status with its percentage (%) from the total of each iron status group (column)
***Differences are considered significant at P<0.05

5. Discussion

In Jordan, studies on IDA were focused on pregnant women, infants, and preschool children (MOH, 2021). Limited studies were directed to school-age children. IDA remains the most prevalent deficiency worldwide in developing countries, especially in rural areas. In the present study we aimed to highlight the nutritional iron status among school-age children in a rural area (Deir Alla) in relation to dietary intake. Several studies showed that a high prevalence of IDA and ID were common among children at different ages, especially in rural areas (Achouri et al., 2015; Nusair et al., 2011, Desalegn et al., 2014). This could be attributed to socioeconomic status and dietary habits. Jordan population and Family Health survey JPFHS (2018) reported that 29 % of the anemic children of the age of 1-5 years old (with percentage of 32%) were from the central and southern regions. The Ministry of Health (MOH, 2011) reported that children living in rural areas were more likely to have anemia than children in urban areas. In the present study, mean hemoglobin, MCV, and serum ferritin were not different among male and female subject (12.2 ± 0.1 g/dl vs. 12.2 ± 0.2 g/dl), (83.0± 0.6fl vs. 82.4 ± 0.7 fl), and (21.6 ± 2.1 µg/dl vs. 20.7± 1.5µg/dl), respectively. These results do not agree with those of other studies; in which females were reported to have higher hemoglobin and MCV (Demellof et al., 2002; Achouri et al., 2015).

Dewey and Chapparo (2007) attributed this to differences in sex hormone between the two sexes, which can affect the physiological characteristics that differ between males and females. Lack of significant differences in our study could be due to small sample size. Difference between males and females from other studies could be attributed to genetics (Achouri et al., 2015). The findings of this study are consistent with the findings of Desalegn et al. (2014) who conducted a study on a sample of school children in Southwest Ethiopia. The authors found that the means of height, and weight were 131±0.1 cm and 27.3± 5.8 kg, respectively, for children aged 6-15 years. The current study found that no significant differences in height, weight, and BMI, between normal children, anemic children, children with ID, and children with IDA. These findings seem to be consistent with the findings of MOH (2021), in which it is reported that no significant differences were observed according to sex, age, and regions. Also, we found that no significant difference in height, weight, and BMI between children with different iron status (normal, anemia, ID, IDA). This supported the results of Le Nguyen et al. (2016) who reported that ferritin status was not different between stunted and non-stunted children.

The energy intake by most children was 80-120% of DRI of different age groups. Mean energy intake was 1703.0±34.9 kcal/day. The finding of our study seemed to be consistent with adequate intake of energy for children at different age groups. There was a significant difference in CHO intake among children in all of the study groups. Mean CHO intake was 212.6 ± 5.8 g/day for the whole study sample (see Table 5). Mean protein intake was 62.8± 1.9 g/day (257.5±10.3% of DRI) of children of the whole sample. There was a significant difference in protein intake among children of different groups of iron status. High consumption of protein could be due to high consumption of legumes such as hummus and falafel which are higher in protein and could inhibit the absorption of non-heme iron due to high content of phytates (Wong, 2017). Mean fat intake of the whole study sample was 64.6± 1.9 g/day by children of the study sample (see table 5). There was a significant difference in fat intake among children of different groups of iron status. Fat is not specified by DRI for the age groups in the study. Mean calcium intake was 444.4 ± 25.0 mg/day for the children of the study sample. This result is too low as compared with adequate intake (AI) of calcium. This could be due eating a lot of snacks like chips, and empty calorie foods instead of calcium-enriched nutrient foods. Mean vitamin C intake (ascorbic acid) was 74.5± 5.0 mg/day by the whole study sample. This finding is too high as compared with DRI of vitamin C and could be due to consumption of fruits, vegetables, and vitamin C rich juice in this region. Vitamin C is considered an enhancer of iron absorption. It can increase absorption of non-heme iron by 300% (Wong, 2017).

Mean iron intake was 12.1± 0.5 mg/day, and there was a significant difference in iron intake among children of different groups. This result was 135% of DRI, which is higher than what is recommended. Although ID and IDA are still present, it could be due to high consumption of non-heme iron (plant sources) and its inhibitors. It is clear that iron intake was increased with age. Increasing iron intake with age could be due to the increase in energy intakes. Zimmermann et al. (2007) reported that iron intake is directly related to energy intake and the risk of ID is increased when iron requirements are greater than energy needs. Regarding the children with IDA, energy intake, macronutrients intake, and micronutrients intake (including iron, vitamin C, and calcium) were lower as compared to children of other iron status groups. Energy intake was 58% of DRI, and iron intake was 74.3% of DRI. Allen et al. (2006) reported that high consumption of processed high energy foods that are poor in micronutrients is likely to adversely affect micronutrient intake and health status. Energy intake, macronutrient intakes, and micronutrient intakes by normal children were higher when compared in children of different iron status groups. When iron intake is lower than the recommendation, it is expected to be deficient in iron status, and consequently causes IDA. Poor micronutrient intakes adversely affect nutritional status (Allen et al., 2006).

Regarding the family awareness of dietary intake, there was significant difference on importance of taking breakfast daily among the children with different iron status; 30% of children with IDA had breakfast daily in comparison with 85%, 81.3%, and 85.7% of normal, anemic, and children with ID, respectively. This finding supported the result of Abalkhail et al. (2002) who reported that anemia and IDA were highly related to poor dietary habits, such as skipping breakfast; anemia and IDA were prevalent among the children who skipped breakfast. In the current study 90% of children with IDA had chips in their snack's meals. Eating a lot of chips could affect the quantity and quality of nutrients. There were significant differences among the children who had snacks between meals and those who did not; 95% of normal children who had snacks between meals were higher in number as compared to the children with IDA, but there was no significant difference in number of meals among children with different iron status. There was significant difference in eating liver and meat between the children groups with different iron status; 97.5% of normal children had liver and meat in their usual meals in comparison to 70% of children with IDA who had those foods. This result supported the result of Achouri et al. (2015) who reported that the children who consume animal foods more frequently were less likely to developed anemia than those who less frequently consumed these foods. Irregular consumption of meat was found to be correlated with anemia among school-age children (Djokic et al., 2010).

Soft drinks, such as cola and sweetened soda are consumed in large amount in our area; this could contribute to the inhibition of the absorption of dietary iron and will affect the variety of foods (Allen et al., 2006); 90% and 93% of children with ID and IDA, respectively, had soft drinks in their meal in comparison with 82.5% of normal children who had same drinks in their usual meals. Since natural fruit juice is rich in vitamin C, it can enhance the absorption of dietary iron (Musaiger, 2011). Sixty percent of children with IDA had natural fruit juice in their usual meals as compared with 90% of normal children who had same food in their usual meals. Legumes, such as hummus, and nuts contain phytates. 100% of children with IDA had hummus in their usual meal.

Regarding tea consumption and its possible effect on iron status, there was significant difference in taking tea with meals between children with different iron status; 80% of children with IDA had tea with meals in comparison with 30% of normal children who had tea with meals. There was no significant difference in taking tea after meals. This result supported the results of Musaiger et al. (2011) who reported that consumption of tea which is rich in polyphenols may have a role in the etiology of IDA. Its consumption with meals can inhibit iron bioavailability. However, its consumption between meals had almost no effect on the iron bioavailability (Thompson, 2007; Musaiger et al., 2011).

Conclusion

In conclusion, the present study shows that Iron deficiency is common in school age children in Deir Alla district. The high prevalence of nutritional anemia, ID, IDA was associated with low awareness of parents about children's health. It is recommended that there should be early intervention to improve the health status of the children who had depleted iron and IDA. Health education programs for parents, care-takers, and children are needed in order to increase the level of health awareness. The food fortification program of the Ministry of Health seem to be not enough; so the national nutrition programs should be directed toward these age groups (6-12 years) in order to prevent worsening of the problem. A main limitation of the study is the small sample size. Further studies that include larger number of the sample and include other rural areas in Jordan are needed.

Conflict of interest

The authors report no conflict of interest.

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