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A comparison of selected nutrient intakes in anemic and nonanemic adolescent girls in Kuwait

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Abstract

In Kuwait, as elsewhere, little information exists on the nutrition status and diet habits of adolescents. Anemia is a widespread problem among Kuwaiti adolescent girls and is most likely caused by iron (Fe) deficiency. We examined anemia and dietary intake to ascertain whether dietary intake was related to hemoglobin (Hb) and/or Erythrocyte Protoporphyrin (EP) values and if the intake of anemia relevant nutrients differed between anemic and nonanemic girls. We measured the Hb, EP, dietary intake (24 Hour Recall), and obtained various background socio-economic data from 255 high schools girls. Dietary intakes (e.g., of Fe and Folate) were below recommended levels in the majority of the girls. Girls whose intakes of Fe or Folate equaled or exceeded the Recommended Dietary Allowance (RDA) had significantly higher mean Hb values. The results indicate that dietary intake of anemic girls is lower in important hematinics nutrients.

Keywords: Anemia; Iron deficiency; Dietary intake; Kuwait

1. Introduction

There are fewer studies of nutritional status and nutrient intakes of adolescents than there are of adults or young children. Yet studying the nutrition and health status of adolescents provides an opportunity to understand and intervene at a point in the life cycle before potential problems become serious in later life. There are very few published studies of

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adolescent nutrition or health status in Kuwait. There are no studies of relationship of diet intake to nutritional status reported from Kuwait for adolescents.

The State of Kuwait has undergone rapid growth of its Gross National Product since the inception of the oil boom of the 1950s. Increased revenue from oil sales has dramatically changed the landscape and lifestyles of Kuwaitis. One of the more salient changes wrought by economic growth is the change in eating habits (including increased food consumption) and the wide availability of American fast food restaurants [1–2]. Greater affluence has also led to an increase in sedentary lifestyles [3]. However greater food availability does not necessarily equate to better nutrition or health status [2].

Over the last few decades, there have been a number of studies indicating that anemia is a significant public health problem in the State of Kuwait. Most of these studies have been performed on adult women or children. Some studies have included adolescents as a part of a larger sample, however, only a few have concentrated on adolescents as the focal group. Overall, various studies [4–7] have estimated the prevalence of anemia at between 25-37% among young adult women. Most of these studies were based on an examination of Hb concentration. Only recently did Jackson and Al Mousa [7] examine the prevalence of anemia and correlate it with the level of the erythrocyte protoporphyrin (EP) in a sample consisting exclusively of Kuwaiti adolescent girls. In that study of 1051 adolescent schoolgirls, Jackson and Al Mousa [7] found that 30% of the girls were anemic with an even higher percentage having EP values elevated above normal levels. Those results were interpreted as suggesting that Fe deficiency may be a significant contributor to the anemia seen among the girls.

In earlier studies from Kuwait, Hira et al. [8] found that anemia-causing parasites were generally absent due to improved environmental sanitation and high ambient temperatures. Neither genetic traits (such as Hemoglobin S and α- Thalassemia) [9–11], nor high lead (Pb) burdens [12,13] were found to be significant causes of anemia among Kuwaitis.

It has been suggested that studies to determine the prevalence of Fe deficiency should include several biochemical indicators of Fe status, including either serum ferritin, transferrin saturation, and EP or Mean Corpuscular Volume, transferrin saturation (TS) and EP [14]. Few field studies, in poor or developing countries, have included all of these indices.

A thorough nutritional assessment may include several indicators (anthropometric, biochemical, clinical, and dietary). Assessment of diet, in addition to other indicators, can provide confirmatory evidence of a biochemical nutrient deficiency. For example, inadequate dietary intakes of Fe over time will result in lower Fe stores (reduced serum ferritin) and in lower tissue levels of Fe (lower TS and elevated EP). No previous study of anemia in Kuwait has examined the role or contribution to anemia of dietary factors concomitant with biochemical indicators.

The purpose of the present study therefore was to ascertain whether the dietary intake of Kuwaiti adolescent girls was related to their Hb concentrations and/or their EP values. We also wanted to know if the dietary intake of anemia relevant nutrients differed between anemic and nonanemic adolescent Kuwaiti girls?

2. Methods and materials

2.1. Background

Kuwait is an oil-rich, Arab country with an area of 17,818 sq. km located at 30.27°N and 48.46°E. It is bordered on the north and west by the Republic of Iraq, on the east by the Arabian Gulf, and on the south by the Kingdom of Saudi Arabia. The total population is about 2 million, however only about 800,000 of that number are Kuwaiti citizens. The remainder is foreign workers [15]. Kuwait has seen a proliferation of fast food restaurants, leading to increased consumption of fast and high-energy foods, such as potato chips and colas, particularly among adolescents [2,16,17].

Kuwait has a high per capita income (estimated at $15,100 in 2001). Food insecurity is not a problem for Kuwaitis. Its citizens generally enjoy a high standard of living that includes free education, medical care, and other amenities. The life expectancy at birth for women, for example, has been estimated to be 76.4 years [15].

Since our goal was to compare nutrient intake in anemic and non-anemic girls, we selected girls from two high schools previously studied by us in a 1998 national survey [11]. This study was conducted two years later. After identifying the participating schools in 2000, we sought and obtained permission to study human subjects from the both the Kuwait Ministries of Health and Education. All students in the two selected schools were informed of the study. All girls in the selected schools were asked to participate. Only girls who brought back forms signed by their parents, indicating both the girl's and parents consent to participate in the study, were included in the study. Very few girls did not participate in the study. The target sample size ($N = 100$ per group) was chosen to give adequate statistical power ($\alpha = 0.05$, $\beta = .80$, difference of two units in Fe intake) to detect differences in the major end point nutrients, Fe and folic acid. We assumed that the anemia seen in the two schools in 2000 was due to Fe deficiency, since the percent of girls with clinically relevant hemoglobinopathies was very low and none of the girls had parasites normally associated with anemia [11]. Our final sample consisted of 255 single, healthy, adolescent girls.

Dietary information was collected using the 24 Hour Recall method. Dietitians, with long experience in nutrition surveillance and with training by WHO consultants in dietary survey methodology, explained the purpose of the dietary information and instructed the girls on how to report quantities using food models. Nutritionist 4 (N-Square Computing, Inc., Salem, OR, USA) was used to enter and analyze nutrient intakes. Nutrient intakes of the girls were compared with age and gender-appropriate values from the USA RDA reference values [18]. The Fe and folate RDA's used were 15 mg/day and 400 μg/day, respectively. The RDA values were used to allow comparisons with previous diet assessments of Kuwaitis [1,2,16,17]. Weights and heights were measured using established equipment and techniques [7] and BMI values were calculated as WT (in Kg) divided by HT (in meters).^{2} Overweight (i.e., $>$ 95th percentile for age) and underweight (i.e., $<$ 5th percentile for age) were defined by using the age specific percentiles of the Centers for Disease Control and Prevention BMI growth charts [19].

Capillary blood was collected from the finger. Hb was measured in g/L by the HemoCue hemoglobinometer [20]. Calibration of the photometer was checked daily with a control

Table 1
Background and nutritional information on Kuwaiti adolescent girls

	N	Mean	Standard Deviation
AGE (y)	255	16.2863	1.5008
BMI (kg/m^2)	255	23.4431	5.8324
HB (g/L)	255	120.0	16.8
FEP (mg/g Hb)	255	4.832	3.209
Energy (MJ)	255	7.153	2.291
PROT (g)	255	57.327	22.395
FAT (g)	255	54.076	21.769
VITA (μg/day)	255	603.85	1103.85
FE (mg)	255	10.722	5.269
FOLAT (μg/day)	255	166.271	115.697

cuvette supplied with the hemoglobinometer. Fe deficient erythropoiesis was assessed by measurement of Erythrocyte Protoporphyrin (EP) using the ZPP Hematoflurometer (AVIV Biomedical, Incorporated, Lakewood, New Jersey). ZPP levels are known to be elevated in only 4 conditions: in subjects with elevated Pb burdens, in Fe deficiency, in a rare genetic disorder called erythropoietic protoporphyria, and in chronic inflammatory diseases [21].

The WHO definition of anemia (Hb $<$ 120 g/L) [22] for nonpregnant women was used. Normal EP values were below 5 μg/g Hb, a level suggested by AVIV Biomedical, the manufacturer of the ZPP hematofluorometer and used by us in previous Kuwait surveys [7,11]. Standards (high, medium, and low) for EP were obtained from the manufacturer (AVIV Biomedical, Lakewood, New Jersey) and tested daily with the samples.

2.2. Statistical methods

Data were analyzed using descriptive and inferential statistics. Means and frequencies were calculated for Hb, EP, and various socio-demographic variables (such as age). The independent two-sample t-test was used to compare various means between anemic and non-anemic girls. Statistical significance was accepted when a *P*-value was $\leq$ 0.05. The analysis was conducted on a personal computer using version 10.0 of the Statistical Package for the Social Sciences statistical package.

3. Results

3.1. Background

The sample consisted of 255 adolescent schoolgirls between the ages of 14 and 20 years. The mean age of the sample was 16.3 $\pm$ 1.5 yrs. Table 1 provides additional background information on the sample in terms of its hematological status and nutrient intakes. Although the mean BMI was in the normal range, 37 girls were overweight (i.e., $>$95th percentile for age), while 17 girls were underweight ($<$5th percentile). Overweight girls had higher mean

daily intakes of several hematinic nutrients compared to underweight girls (e.g., Iron: 10.4 vs. 9.7 mg; Vitamin C: 93.1 vs. 81.5 mg; Folate: 181.0 vs. 131.5 micrograms). The girls consumed 13.4%, 28.3%, and 58.0% of their energy from protein, fat, and carbohydrates, respectively.

Eighty eight percent (87.5%) of the sample had Fe intakes less than the RDA recommendations. Girls with Fe intakes below the RDA had a slightly lower mean Hb value (120 ± 17 versus 123 ± 16g/L) and a higher mean EP value (4.9 ± 3.3 versus 4.6 ± 2.8 mg/g Hb).

Nearly all (95.7%) of the girls (n = 244) had Folate intakes below the RDA value (400 μg/day). Girls whose intakes of Folate equaled or exceeded the RDA had significantly higher mean Hb values (120 g/L vs. 13.1 g/L). Seventy-six percent (76.1%) of the sample had vitamin A levels below recommended levels. Forty two percent (42.3%) and 88.5% percent, respectively, had vitamin C and vitamin B_{12} levels below the current RDAs.

More than one-half (55%) of the girls had Fe intakes below 70% of RDA, while 49% had Fe intakes between 30 and 69% of the RDA. Eighty seven percent (87%) of the girls had Folate intakes below 70% of RDA and 62% had Folate intakes between 30 and 69% of the RDA. 30.8%, 63.2%, and 51% of the girls consumed tea, cola drinks, and/or chocolates, which inhibit iron absorption, respectively, in the 24 hours prior to the survey.

The correlations between Hb concentration and the intakes of Fe, Folate, Protein, Vitamin A, and Vitamin C were all positive but not significant from zero ($P > 0.05$). There were negative correlations between EP values and the same nutrients. None of the correlations between the nutrients and EP were significant.

3.2. Anemic versus non anemic girls

The overall mean Hb was 120 ± 17 g/L, but ranged between 73 and 159 g/L. Fifty-seven percent (56.9%) of the girls (n = 145) had Hb values <120 g/L; while 43.1% of the girls (n = 110) had Hb values of ≥120 g/L. The mean EP level of those with normal Hb values (≥120 g/L) was significantly less than (3.2 mg/g Hb) in those with Hb values below normal (6.1 mg/g Hb) ($t = 8.02$, $df = 253$, $P = 0.001$). Moreover, Hb concentration was significantly inversely related to EP ($r = -0.564$, $n = 255$, $P = 0.01$).

Table 2 compares the energy and anemia-relevant nutrient intakes of anemic and non-anemic adolescent girls. Girls with normal Hb concentrations had slightly; though not significantly ($P > 0.05$), higher mean intakes of energy and hematinic nutrients (except Cu) studied.

3.3. Body iron status and nutrient intakes

Table 3 compares the nutrient intakes of those with normal and elevated EP values. None of the comparisons were significantly different. However, girls with normal EP values had higher energy, protein, and folate intakes than girls with elevated EP values.

Table 2
Comparison of mean (± SD) energy and nutrient intakes of anemic (n = 145) and nonanemic (n = 110) Kuwaiti adolescent girls

Measure	Anemic Girls (<120 g/L)		Nonanemic Girls (≥120 g/L)	
	Mean	(± SD)	Mean	(± SD)
Energy (MJ)	7.025	(2.209)	7.321	(2.393)
Protein (g)	56.6	(22.4)	58.3	(22.5)
Vitamin A (μg/day)	557.8	(1038.3)	664.5	(1186.8)
Vitamin C (mg)	87.9	(71.2)	89.0	(72.8)
Vitamin B_{12} (μg)	2.5	(10.7)	2.8	(12.4)
Folic Acid (μg)	158.0	(111.8)	177.3	(120.3)
Iron (mg)	10.6	(5.1)	10.8	(5.5)
Copper (mg)	1.3	(1.4)	1.3	(1.6)

4. Discussion

Over the last few decades, there have been a number of studies showing that anemia is a significant public health problem in the State of Kuwait. These studies, based solely on assessing Hb concentration, could not indicate the etiology of the anemia seen. The studies of Jackson et al. [7] assessed anemia and examined EP. Studies of children under 6 years of age (n = 1225) and of adolescent girls (n = 1051) both indicated that a high percentage of Kuwaitis were anemic and also had higher than normal levels of EP. These findings were interpreted as indicating that Fe deficiency was highly probable in this population, since infection, parasites, and hemoglobinopathies were generally rare [7]. However in the absence of a battery of tests and dietary confirmation of low Fe and/or other nutrient intakes, those results could not be interpreted unambiguously. So still the question remained whether the majority of girls who were anemic and who had high EP values really had subnormal dietary intakes of Fe.

A battery of tests (including ferritin or MCV, EP, and TS) has been recommended to assess the prevalence of anemia in a population. However, in field situations in most

Table 3
Comparison of mean (± SD) energy and nutrient intakes of Kuwaiti adolescent girls with low (n = 174) and high (n = 81) erythrocyte protoporphyrin values

Measure	Low EP Girls (<5 mg/g Hb)		High EP Girls (≥5 mg/g Hb)	
	Mean	(± SD)	Mean	(± SD)
Energy (MJ)	7.163	(2.372)	7.130	(2.121)
Protein (g)	58.0	(23.4)	55.9	(20.1)
Vitamin A (μg/day)	584.6	(975.3)	645.3	(1335.1)
Vitamin C (mg)	85.6	(70.9)	94.2	(73.6)
Vitamin B_{12} (μg)	2.3	(9.9)	3.2	(14.3)
Folic Acid (μg)	167.6	(112.7)	163.5	(122.6)
Iron (mg)	10.7	(5.3)	10.8	(5.2)
Copper (mg)	1.3	(1.4)	1.3	(1.6)

developing countries it is not usually possible (due mainly to lack of trained personnel and lab facilities) to assess Fe deficiency using the recommended battery of lab measures recommended by Expert groups [14], although ideally this would be highly desirable. Differentiating between anemia due to Fe deficiency (the most common cause of anemia worldwide) and anemia of infection (frequently assumed to be high) is difficult based on a single Fe status measure. EP, serum ferritin, TS, and other anemia and Fe status indicators are influenced by infection and pregnancy states. Thus without biochemical or clinical evidence ruling out the presence of infection, interpretation of any one of Fe status indicators may be complicated.

There are a number of reports to suggest that EP responds in the anticipated manner (i.e., is lowered) when Fe deficient and anemic individuals are given Fe supplementation over a number of weeks [23–29]. In most of these controlled supplementation trials, where EP has been compared with other hematological indicators, Hb concentration and SF levels have increased and EP decreased significantly in supplemented, but not in the placebo groups. Zanella et al. [28] compared the sensitivity and specificity of serum ferritin and erythrocyte protoporphyrin for detecting Fe deficiency in women with uncomplicated Fe deficiency, using response to Fe supplements as evidence of Fe deficiency. They concluded that the sensitivity of EP and SF were 60% and 79%, respectively in women, at a specificity of 95%. However, the sensitivity varied as a function of the Hb level. In the absence of anemia, the sensitivity dropped to 70% and $<$50% for SF and EP, respectively.

Given the low sensitivity of individual measures, nutrition assessment has to rely on several lines of evidence, including diet, to corroborate laboratory assessment measures that lack high sensitivity.

This is the first study of anemia in Kuwait to examine Hb concentrations, EP values and dietary intake simultaneously. Our dietary results suggest that the impairment in hemopoesis may indeed be due largely to inadequate Fe intake.

The results of the present study are similar to those of previous studies, and revealed that a large percentage of Kuwaiti adolescent girls are anemic and an even larger percent have elevated EP values. The current study not only affirms the high percentage of elevated EP values but also shows that these abnormalities are associated with poor dietary intakes of several hematinic nutrients, especially Fe and Folic acid. The low Hb concentrations are also associated with poor dietary intake of hematinic nutrients.

These data indicate that the intakes of energy and important hematinic nutrients (such as Protein, Vitamin A, Vitamin C, Iron, Vitamin B12, and Folate) were consumed at levels less than the RDA in a significant percentage of these adolescent Kuwaiti girls. Moreover, girls with below normal Hb concentrations displayed greater relative deficits in these nutrient intakes. Girls who were above the 95th percentile of the Centers for Disease Control and Prevention BMI charts had higher mean intakes of selected nutrients (and had higher Hb values) than did girls who had lower BMI values.

Our diet findings are consistent with previous dietary studies conducted in Kuwait by Kamel and Martinez in 1983 [17] and by Al-Shawi in 1992 [16]. Both studies found that significant percentages of Kuwaiti women consumed lower than adequate amounts of several recommended nutrients. For example, Al Shawi studied 202 female college students using a three-day diet record. She found that “specific nutritional inadequacies, in relation to the

RDAs, existed for many individuals." Al Shawi showed that college aged women consumed only 87% of the RDA energy recommended (i.e., on average 1799 Kcal per day). Our finding in adolescent girls of low energy intakes is remarkably similar, i.e., 1706 Kcal intake per day. Over one-half of Al-Shawi's college aged women had Fe intakes below two-thirds of the RDA. Nearly 90% of our adolescent sample had Fe intakes below the RDA. In our sample, girls with lower intakes of Fe also had lower mean Hb and higher mean EP values.

Thus the dietary intake data support the Hb and EP data, buttressing the impression that Fe deficiency is a major contributor to anemia in this sample. Since we did not examine biochemical parameters other than EP, we cannot comment on the potential role that other nutrients, especially folic acid, may have played in anemia causation. However, it is clear from our dietary data, with the low overall mean intake and the high percentage of girls with intakes below the RDAs, that folic acid may have also played a role in their low Hb values.

Although the 24 Hour Recall does not represent an individual's usual dietary intake, this technique has been shown to generally reflective of average population intake. The 24 Hour Recall has been used in several surveys, and is generally recognized to provide a good reflection of group level intake. Though these data do not reveal a single dietary deficiency responsible for the low Hb concentrations, they do raise concern that there is a need for the public health community to increase awareness among adolescents of the need to consume adequate amounts of Fe and other hematinic nutrients.

More than one-half of these adolescent girls were anemic, an even larger percentage had elevated EP values, and larger percentages had Fe intake below the RDA. It is reasonable to assume that Fe was a significant contributor to the anemia and probable iron Fe deficiency of these adolescent girls. To improve the health and anemia status of adolescent girls in Kuwait requires increased emphasis on public health education and/or the preventive supplementation [22].

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