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Prevalence of iron deficiency among schoolchildren of different socio-economic status in urban Turkey

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Objective: To investigate the prevalence of iron deficiency among schoolchildren of different socio-economic status (SES), living in the three largest cities of Turkey.
Design: Cross-sectional study.
Settings: Primary schools of Istanbul, Ankara and Izmir.
Subjects: Schoolchildren aged 12 and 13 y (males: 504; females: 510) from nine primary schools. Inclusion of subjects in the study was on a voluntary basis.
Methods: Data were obtained on children SES, anthropometry, haematological and biochemical indices of iron status and consumption of food items related to dietary iron bioavailability. One-way analysis of variance was mainly applied, for the evaluation of the tested hypotheses, using Bonferroni correction in order to take into account the inflation of Type I error.
Results: Iron deficiency (serum ferritin <15 μg/l) prevalence was 17.5% among boys and 20.8% among girls. Furthermore, iron deficiency was significantly more prevalent among boys of lower SES, who were also found to have significantly lower levels of serum iron, serum ferritin, transferrin saturation, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration compared to those of higher SES. In terms of dietary factors affecting iron bioavailability, low SES boys exhibited significantly higher frequency of tea consumption and lower frequency of citrus fruit, red meat and fish consumption, compared to their higher SES counterparts.
Conclusion: The prevalence of iron deficiency was relatively high, particularly among lower SES schoolboys. Higher tea and lower citrus fruits, red meat and fish consumption by boys of lower SES may provide an indication about the possible role of certain dietary patterns in the different manifestation of this medical condition among the socio-economic groups. However, further research is needed.
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Introduction

Iron deficiency is probably the most prevalent and common micronutrient deficiency in the developing world today (Tatala *et al*, 1998; Asobayire *et al*, 2001; Abalkhail & Shawky, 2002; Hashizume *et al*, 2003). The detrimental public health effects of iron deficiency include anaemia, decreased intellectual and work performance as well as functional alterations of the small bowel (Oski, 1993). Besides other vulnerable age groups, such as infancy and early childhood, adolescence is placed at a high risk level for developing iron deficiency, due to a combination of menstrual iron losses in girls and a rapid physical growth, especially in boys (Fomon *et al*, 2003).

Poor diet quality and low dietary iron bioavailability are the principal factors that contribute to the increased

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incidence of iron deficiency (Tatala *et al*, 1998). The bioavailability of haem iron, present in animal products, is high with absorption rates of 20–30%, whereas the bioavailability of nonhaem iron is determined by the presence of enhancing or inhibiting factors (Hurrell, 1997). The main enhancers of nonhaem iron absorption are meat (haem iron) and vitamin C (Cook & Reddy, 2001). Inhibitors include phytate (nuts, bran and oat products, whole-wheat and brown flour), polyphenols (tea, coffee, cocoa, some spices and vegetables) and calcium (milk products) (Reddy *et al*, 2000).

In developing countries, low standards of living, low socio-economic conditions, restricted access to food and a lack of knowledge for good dietary practices and personal hygiene contribute even more to a high occurrence of iron deficiency and hence anaemia (Hall *et al*, 2001; Islam *et al*, 2001; Soekarjo *et al*, 2001). Intestinal parasitic infection, due to poor hygienic conditions, interferes with iron absorption by reducing it, thus expanding the prevalence of iron deficiency anaemia in the developing world (Olivares *et al*, 1999; Musaiger, 2002).

Turkey is an emerging market economy located between Europe and Asia and bordering the Mediterranean, Aegean and Black Seas. Over 73% of its 65 million people live in urban areas, whereas 31.5% of the total population are under the age of 15 y (Kisa *et al*, 2002). Turkey's poorest were hit hard by the economic crisis of 2001, leaving many unable to afford food, school fees and heating in winter (World Bank Report). It is apparent that the existing socio-economic inequalities in Turkey may directly reflect everyday habits with a major impact on people's dietary choices (Dedeoglu, 1990).

The results from limited studies conducted in different provinces within the Turkish territory showed that iron deficiency is the most important cause of anaemia (Kocak *et al*, 1995; Aydinok *et al*, 1998; Koc *et al*, 2000; Kilinc *et al*, 2002). However, no data exist for schoolchildren of different socio-economic levels, living in the three most densely populated cities of Turkey, namely Istanbul, Ankara and Izmir. Due to this knowledge gap, combined with an absence of concerted national surveillance or intervention programmes for the prevention of iron deficiency in Turkey, the objective of the current study was primarily to expand our knowledge on the prevalence of this medical condition. The information gathered was also intended to produce estimates of iron deficiency and provide indications of the possible role of certain dietary patterns in the manifestation of the disorder, so as to guide the public health policy to a better understanding of the problem and consequently the development of appropriate intervention strategies, in order to tackle efficiently these issues early in life.

Subjects and methods

Sampling

This cross-sectional study was carried out from November 2001 to May 2002. The study population consisted of primary schoolchildren aged 12 and 13 y old, living in the three largest urban areas of Turkey, namely Istanbul, Ankara and Izmir. Inclusion of subjects was on a voluntary basis; prior to acceptance, children's parents or guardians were fully informed about the objectives and methods of the study and they signed a consent form. However, since only volunteers were entered into the study and as there was no available information on those who refused to participate, a selection bias may exist. Still the relatively high participation rate in the current study secured, up to a certain extent, representation of the population sample. Out of a total of 1320 primary schoolchildren registered in the selected schools, data were collected from 1044 subjects, whose parents gave written informed consent (79.1%), whereas 30 children who reported any acute illness or inflammation over the past 2 weeks were excluded because this could affect their haematological status (504 from Istanbul, 289 from Ankara, 220 from Izmir; 504 males and 510 females).

The study population was selected from nine primary schools (three from each city) using the multistage sampling method. Schools were selected taking into consideration the available records of the Ministry of National Education and the National Statistical Center of Turkey, in an attempt to obtain a representative sample from the overall population of the three largest urban areas in Turkey. In the case of Ankara and Izmir data were collected from three public schools, from each area, while in the case of Istanbul the subjects came from one private and two public schools.

All children in the same class were invited to participate in the study to avoid ethical problems.

Approval to conduct the survey was granted by the Ethical Committee of Marmara University and the Turkish Ministry of National Education.

Socio-economic status (SES) assessment

A coded questionnaire was developed and administered to the study participants, in order to obtain information on their socio-economic position and personal characteristics. Data on family size, parental academic qualifications, occupation and financial holdings were gathered. SES classification was a statistical composite comprising (a) the educational level of the head of the household, that is, the member whose financial contribution to the common budget covers the major part of the family's expenses and (b) the ownership of a car by the family. More specifically, the characterization of 'Low SES' was attributed to those children whose families did not own a car and whose guardians had a primary school or an inferior educational level. Likewise, children whose guardians had a high school or a university diploma but their families did not own a car plus those children whose guardians had a primary school or a lower education and their family owned a car were characterized as 'Medium SES'. Finally, 'High SES' children were those whose families owned a car and whose guardians were high school or university graduates.

Anthropometric measures

Body weight was measured by a digital scale (Seca) with an accuracy of ± 100 g. Subjects were weighed without shoes, in the minimum clothing possible, that is, underwear. Standing height was measured without shoes to the nearest 0.5 cm with the use of a commercial stadiometer, keeping the shoulders in relaxed position and arms hanging freely (Lohman *et al*, 1991). Body mass index (BMI) was calculated by dividing weight (kg) by height squared (m^2). Left triceps skinfold (TSF) thickness was measured with a Lange skinfold calliper.

Biochemical and haematological measures

Early-morning venous blood samples were obtained from each child for biochemical and haematological screening tests, following a 12-h overnight fast. Professional staff performed venipuncture, using two types of vacutainers, one of which contained EDTA, to obtain a maximum of 10 ml blood. EDTA-containing vacutainers were used for the collection of whole-blood samples, which were analysed by a haematologic autoanalyser ('MS4' device), for the determination of haemoglobin (Hgb), haematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC). The remaining blood was collected in vacutainers with no added anticoagulant and was kept at room temperature for 2 h, where it was allowed to clot, as this was designated for serum separation. Centrifugation for serum separation was conducted at the local laboratories of each city and 1.5 ml aliquots were pipetted into plastic Eppendorf tubes and stored at $-80°$C. Serum samples from each city were transported in dry ice to Marmara University, Faculty of Health Education, where further analysis took place. Serum iron and total iron binding capacity (TIBC) were measured with a 'Colorimetric, Endpoint, Increasing reaction' method and by the use of 'DIAPACK' liquid reagents. Transferrin saturation (TS) was calculated by dividing serum iron by TIBC. Finally, serum ferritin was measured by using a MicroELISA method.

Definition of overweight and iron deficiency

Participants were classified as overweight and obese according to the International Obesity Task Force age and sex-specific BMI cutoff points (Cole *et al*, 2000). Iron deficiency and iron deficiency anaemia were defined using the following age- and sex-specific thresholds proposed by the UNICEF and WHO (2001): iron deficiency was defined as serum ferritin concentration <15 μg/l, indicating depleted iron stores; iron deficiency anaemia was defined as iron deficiency with Hgb concentration <12 g/dl, which is the cutoff point for anaemia for children aged 12–14 y old.

Dietary assessment

Dietary patterns of the study subjects and the frequency of consumption of certain food items over a period of the last 12 months were assessed via the Food Frequency Questionnaire (FFQ) method. The questionnaire used was a semi-quantitative valid one (Willett *et al*, 1985), which was completed by the participants in the presence and assistance of a trained dietitian. The FFQ included questions on the average consumption frequency during the previous year (never or rarely; times per month, week or day). Participants were asked to describe the serving size for each food item as multiples and proportions of common standard measures (eg tea and table spoons, cups of tea, etc). Food models and cup size portions were used to assist in volume estimation. The data obtained from the analysis of the FFQ records were used to estimate the weekly mean consumption frequency of meat, fish, poultry, citrus fruits and tea, all necessary for the assessment of iron bioavailability.

Statistical analysis

The statistical analysis was carried out using the SPSS 10.0 statistical software package for Windows. Statistical power analysis showed that the used sample size was adequate to evaluate two-sided standardized differences greater than 0.5 achieving a statistical power greater than 0.90 at $a=0.05$. Descriptive statistics of continuous variables were expressed as mean $\pm$ standard deviation (s.d.) as well as median and 25th and 75th percentiles for not normally distributed variables. The two-sample *Z*-test was used to compare proportions, regarding the prevalence of overweight and obesity, iron deficiency and iron deficiency anaemia, among genders and socio-economic groups. One-way analysis of variance (ANOVA), with Bonferroni correction for *post hoc* multiple comparisons, was conducted to determine whether differences among the socio-economic groups were statistically significant. However, for not normally distributed variables (even though several transformations were made), the non-parametric univariate Mann–Whitney test was used to verify the statistical significance of the differences among the three socio-economic groups. In all analyses, a 5% significance level was used.

Results

The mean age of the children surveyed was 12.4 ± 0.5 y. The mean values (mean $\pm$ s.d.) of certain anthropometrical characteristics of the study participants are presented in Table 1. Weight and TSF were found to be higher for girls compared to boys (42.4 ± 9.5 *vs* 41.1 ± 9.6, $P=0.040$ and 12.2 ± 4.6 *vs* 11.1 ± 4.7, $P<0.001$). Moreover, TSF was found to be higher for High SES boys compared to those of Low SES (11.7 ± 5.2 *vs* 9.9 ± 3.6, $P=0.012$), and for High SES girls compared to those of Medium and Low SES, respectively (13.1 ± 5.1 *vs* 11.8 ± 4.7 and 10.9 ± 2.4, $P<0.001$). Additionally, High and Medium SES boys were found to have higher

Table 1 Mean values (±s.d.) of anthropometric measures and prevalence of overweight/obesity, iron deficiency and iron deficiency anaemia by gender and socio-economic group

Subjects	Weight (kg)	Height (cm)	TSF (mm)	Overweight/Obesity[a]		Iron deficiency[b]		Iron deficiency anaemia[c]	
	Mean±s.d	Mean±s.d	Mean±s.d	n	%	n	%	n	%
All subjects (n=1014)	41.8±9.5	150.0±8.0	11.7±4.7	143	14.1	194	19.1	40	3.9
Males (n=504)	41.1±9.6	149.6±8.5	11.1±4.7	76	15.1	88	17.5	19	3.8
Females (n=510)	42.4±9.5	150.3±7.4	12.2±4.6	67	13.3	106	20.8	21	4.1
P-value[d]	0.040	0.182	<0.001						
Males									
Low SES (n=85)	38.3±9.3	147.3±8.6	9.9±3.6	10	11.8	29	34.1	6	7.1
Medium SES (n=204)	41.9±9.8*	150.4±8.6*	11.0±4.5	34	16.7	24	11.8[†]	7	3.4
High SES (n=215)	41.6±9.4**	149.9±8.2**	11.7±5.2**	32	15.0	35	16.3[‡]	6	2.8
P-value[d]	0.012	0.016	0.012						
Females									
Low SES (n=90)	41.6±9.1	149.8±7.1	10.9±2.4	8	8.9	24	26.7	2	2.2
Medium SES (n=210)	42.3±9.8	150.4±7.6	11.8±4.7	28	13.3	41	19.5	11	5.2
High SES (n=208)	42.9±9.1	150.5±7.3	13.1±5.1**,***	31	14.9	40	19.2	8	3.8
P-value[d]	0.556	0.732	<0.001						

[a]Overweight and obesity as defined by IOTF (Cole et al, 2000): overweight: 21.20<BMI<26.05 kg/m² (females), 20.89<BMI<25.58 kg/m² (males); obese: BMI>26.05 kg/m² (females), BMI>25.58 kg/m² (males).
[b]Serum ferritin <15 μg/l.
[c]Hgb<12 g/dl and serum ferritin<15 μg/l.
[d]Based on one-way ANOVA with Bonferroni correction for *post hoc* multiple comparisons.
*P≤0.05 Medium SES *vs* Low SES.
**P≤0.05 High SES *vs* Low SES.
***P≤0.05 High SES *vs* Medium SES.
[†]P<0.0001 Medium SES *vs* Low SES (based on two-sample Z-test).
[‡]P=0.0007 High SES *vs* Low SES (based on two-sample Z-test).

values of weight (41.6±9.4 and 41.9±9.8 *vs* 38.3±9.3, $P=0.012$) and height (149.9±8.2 and 150.4±8.6 *vs* 147.3±8.6, $P=0.016$) compared to their Low SES peers. As for overweight and obesity, it was found to be more prevalent among High and Medium SES boys (15 and 16.7 *vs* 11.8%) and girls (14.9 and 13.3 *vs* 8.9%) compared to those of Low SES. However, these differerences were not statistically significant.

As shown in Table 1 the overall prevalence of iron deficiency and iron deficiency anaemia (regardless of SES) was 19.1 and 3.9%, respectively. Regarding gender distribution of these two systemic conditions, girls were found to be more iron deficient (20.8 *vs* 17.5%) and anaemic (4.1 *vs* 3.8%) than boys. However, these differences were not statistically significant. The comparison between the socio-economic groups in the case of boys revealed that the percentage of iron deficiency was higher for Low SES boys compared to their Medium (34.1 *vs* 11.8%, $P<0.0001$) and High SES (34.1 *vs* 16.3%, $P=0.0007$) counterparts. No significant differences were found among the socio-economic groups of girls, regarding the prevalence of iron deficiency. Similarly, the prevalence of iron deficiency anaemia was not found to differentiate significantly among the three socio-economic groups, neither for boys nor for girls.

The mean values (mean±s.d.) of the biochemical and haematological indices determined in the present study are summarized in Table 2. A pattern of significantly lower levels of serum iron ($P=0.01$), serum ferritin ($P=0.004$), TS ($P=0.015$), MCH ($P=0.003$) and MCHC ($P=0.003$) was apparent for lower SES boys compared to their upper SES counterparts. More specifically, Low SES boys, when compared to those of Medium SES, were found to have significantly lower levels of serum ferritin (26.3±18.4 *vs* 34.5±20.5); whereas when compared to those of High SES, they were found to have significantly lower levels of MCH (28.7±2.4 *vs* 29.5±2.9) and MCHC (32.2±1.9 *vs* 32.9±2.3). In addition, Medium SES boys were found to have significantly lower levels of serum iron (72.2±27.1 *vs* 80.8±32.9), TS (21.4±9.2 *vs* 24.0±10.9), MCH (28.7±2.8 *vs* 29.5±2.9) and MCHC (32.2±2.4 *vs* 32.9±2.3) compared to their High SES peers. Regarding girls, there were no significant differences among the three socio-economic groups for any of these indices.

Table 3 presents the mean (±s.d.) and median frequency (times per week) of weekly consumption of certain food items related to the enhancement (citrus fruits, red meat, poultry, fish) or inhibition (tea) of dietary iron absorption. A tendency of significantly higher frequency of consumption of tea was noticed for Low SES boys compared to those of Medium and High SES (8.5±6.2 *vs* 5.9±5.2 and 4.8±4.9, $P<0.05$). Low SES boys were also found to have lower consumption of citrus fruit (4.0±3.4 *vs* 5.7±4.9 and 6.1±4.8, $P<0.05$), red meat (1.2±1.4 *vs* 1.8±2.5 and 1.6±2.1, $P<0.05$) and fish (0.9±2.0 *vs* 1.2±1.9 and 1.2±1.7, $P<0.05$) than those of Medium and High SES, respectively. On the contrary, no significant differences among the three socio-economic groups were observed for girls, with the only exception of poultry consumption,

Table 2 Mean concentrations (±s.d.) of certain biochemical and haematological indices of iron status by gender and socio-economic group

	Males				*Females*			
	Low SES (n = *85)*	*Medium SES* (n = *204)*	*High SES* (n = *215)*		*Low SES* (n = *90)*	*Medium SES* (n = *210)*	*High SES* (n = *208)*	
Variable	*Mean ± s.d*	*Mean ± s.d*	*Mean ± s.d*	P-*value*[a]	*Mean ± s.d*	*Mean ± s.d*	*Mean ± s.d*	P-*value*[a]
Serum iron (μg/dl)	73.6 ± 28.9	72.2 ± 27.1	80.8 ± 32.9***	0.010	73.1 ± 27.7	72.2 ± 30.0	71.6 ± 30.3	0.915
Ferritin (μg/l)	26.3 ± 18.4	34.5 ± 20.5*	30.7 ± 18.9	0.004	29.8 ± 22.6	31.2 ± 19.3	33.6 ± 22.3	0.283
TS (%)	21.4 ± 9.5	21.4 ± 9.2	24.0 ± 10.9***	0.015	22.4 ± 11.9	20.9 ± 9.7	21.0 ± 9.5	0.446
RBC ($10^6/mm^3$)	4.56 ± 0.28	4.58 ± 0.34	4.51 ± 0.36	0.082	4.56 ± 0.37	4.50 ± 0.36	4.53 ± 0.39	0.329
Hgb (g/dl)	13.0 ± 1.0	13.1 ± 1.0	13.3 ± 1.1	0.078	13.2 ± 0.9	13.0 ± 1.1	13.2 ± 1.0	0.136
Hct (%)	40.4 ± 2.1	40.5 ± 2.4	40.5 ± 2.7	0.920	40.6 ± 2.1	40.3 ± 2.5	40.6 ± 2.6	0.366
MCV (fl)	88.9 ± 4.3	88.7 ± 4.8	89.8 ± 5.2	0.052	89.4 ± 5.1	89.8 ± 4.7	90.1 ± 5.7	0.531
MCH (pg)	28.7 ± 2.4	28.7 ± 2.8	29.5 ± 2.9 **,***	0.003	29.0 ± 2.6	29.1 ± 2.7	29.4 ± 3.1	0.393
MCHC (g/dl)	32.2 ± 1.9	32.2 ± 2.4	32.9 ± 2.3 **,***	0.003	32.4 ± 1.9	32.3 ± 2.2	32.5 ± 2.2	0.586

[a]Based on one-way ANOVA with Bonferroni correction for *post hoc* multiple comparisons.
**P*≤0.05 Medium SES *vs* Low SES.
***P*≤0.05 High SES *vs* Low SES.
****P*≤0.05 High SES *vs* Medium SES.

Table 3 Mean (±s.d.) and median weekly consumption frequency of food items, related to the inhibition or the enhancement of iron absorption

	Males			*Females*		
Food Items	*Low SES* (n = *85)*	*Medium SES* (n = *204)*	*High SES* (n = *215)*	*Low SES* (n = *90)*	*Medium SES* (n = *210)*	*High SES* (n = *208)*
Inhibitors (times/week)						
Tea						
Mean ± s.d.	8.5 ± 6.2	5.9 ± 5.2*	4.8 ± 4.9**,***	6.4 ± 4.7	5.9 ± 4.8	5.6 ± 4.9
Median (25th, 75th percentile)	7.0 (3.0, 7.0)	7.0 (1.0, 7.0)	7.0 (1.0, 7.0)	7.0 (5.7, 17.5)	7.0 (1.0, 7.0)	4.5 (0.5, 7.0)
Enhancers (times/week)						
Citrus fruits						
Mean ± s.d.	4.0 ± 3.4	5.7 ± 4.9*	6.1 ± 4.8**	5.8 ± 4.9	6.5 ± 4.8	6.8 ± 5.1
Median (25th, 75th percentile)	2.5 (1.0, 7.0)	7.0 (2.5, 7.0)	7.0 (2.5, 7.0)	4.5 (2.5, 7.0)	7.0 (2.5, 7.0)	7.0 (4.5, 7.0)
Red meat						
Mean ± s.d.	1.2 ± 1.4	1.8 ± 2.5*	1.6 ± 2.1**	1.8 ± 2.4	2.0 ± 2.4	1.8 ± 2.7
Median (25th, 75th percentile)	1.0 (0.0, 2.5)	1.0 (0.5, 2.5)	1.0 (0.5, 2.5)	1.0 (0.5, 2.5)	1.0 (0.5, 2.5)	1.0 (0.5, 2.5)
Poultry						
Mean ± s.d.	1.7 ± 2.3	2.2 ± 3.3	1.9 ± 2.7	2.0 ± 2.8	2.0 ± 2.5	2.6 ± 3.3***
Median (25th, 75th percentile)	1.0 (0.5, 2.5)	1.0 (0.5, 2.5)	1.0 (0.5, 2.5)	1.0 (0.9, 2.5)	1.0 (0.7, 2.5)	1.0 (1.0, 2.5)
Fish						
Mean ± s.d.	0.9 ± 2.0	1.2 ± 1.9*	1.2 ± 1.7**	1.3 ± 2.3	1.0 ± 1.9	1.3 ± 2.6
Median (25th, 75th percentile)	0.5 (0.0, 1.0)	0.5 (0.5, 1.0)	1.0 (0.5, 1.0)	1.0 (0.0, 1.0)	0.5 (0.0, 1.0)	0.5 (0.0, 1.0)

Significant differences among the socio-economic groups (Mann–Whitney test: *P*≤0.05).
**P*≤0.05 Medium SES *vs* Low SES.
***P*≤0.05 High SES *vs* Low SES.
****P*≤0.05 High SES *vs* Medium SES.

which was found to be more frequent in the High SES girls compared to the Medium SES group (2.6±3.3 *vs* 2.0±2.5, $P<0.05$).

Discussion

The primary purpose of the present study was to estimate the prevalence of iron deficiency and iron deficiency anaemia among urban schoolchildren of different SES in Turkey. Direct comparison of the prevalence rates recorded in the current study with those found in other populations is a difficult task, due to the utilization of different thresholds in the various studies. Additionally, false positive or negative results of iron-related parameters, due to infections and acute inflammatory conditions, which are usually endemic in the developing world, set some extra barriers. Therefore, the intention of the current study was not to focus on comparisons with the prevalence rates reported for other developing or developed countries, but to record and understand the differences in the prevalence of this medical condition among different SES groups and dietary patterns.

Iron deficiency is the most common micronutrient deficiency in Turkey, with prevalence ranging from 6.5% among adolescents living in an urban area of the west

(Aydinok *et al*, 1998) to 33% for a community of a rural south province (Kocak *et al*, 1995). To a further extent, the prevalence of iron deficiency anaemia ranged from 3.2 to 14.2% for children and adolescents of urban and rural residence, in south and east regions of the country (Koc *et al*, 2000; Kilinc *et al*, 2002). Likewise, the corresponding frequencies of iron deficiency and iron deficiency anaemia among schoolchildren of other developing countries have been reported to vary from 16.1 to 21.6% (Al-Othaimeen *et al*, 1999; Ahmed *et al*, 2000; Hashizume *et al*, 2003) and from 8.6 to 14.2% (Ahmed *et al*, 2000; Hashizume *et al*, 2003), respectively. In the present study, the percentage observed for iron deficiency (19.1%) was within the ranges reported not only for Turkey but for other countries as well. As for the prevalence of iron deficiency anaemia, the proportion (3.9%) was much lower than the frequencies reported by other investigators.

SES, either defined by the type of school attended (ie public *vs* private), by the region of residence (ie rural *vs* urban) or by the level of parental education (primary school *vs* University), has been pointed out by many investigators, as an important determinant of the elevated prevalence of iron deficiency and iron deficiency anaemia among the less privileged school-aged children in developing countries (Soekarjo *et al*, 2001; Abalkhail & Shawky, 2002; Kilinc *et al*, 2002; Musaiger, 2002; Hashizume *et al*, 2003). Furthermore, the higher incidence of iron deficiency reported for adolescent schoolgirls, compared to boys (Tatala *et al*, 1998; Abalkhail & Shawky, 2002; Kilinc *et al*, 2002; Musaiger, 2002; Hashizume *et al*, 2004), shows that female gender exerts an extra effect on the prevalence of this medical condition, probably due to accessional iron losses through menstruation. The findings of the current study indicated that both SES and gender might need closer surveillance, in order to better understand the factors associated with the high prevalence of iron deficiency among urban schoolchildren in Turkey. Indeed, although the differences were statistically significant only in the case of boys, iron deficiency was found to be more prevalent among Low SES subjects, who were also found to have lower values of certain anaemia and iron status-related indices, compared to subjects of higher socio-economic level (Tables 1 and 2). Regarding gender differences, both iron deficiency and iron deficiency anaemia were more prevalent among females compared to male subjects.

The absence of significant differences among the socioeconomic groups of female participants could be attributed to the possible role of the age menarche or/and of the duration of menstruation. Besides the genetic determination of menarcheal age, several other parameters, such as higher SES (Khan *et al*, 1995), better nutritional status (Chowdhury *et al*, 2000), higher values of TSF thickness and level of premenarcheal obesity (Freedman *et al*, 2003), have been strongly associated to an earlier dawn of menstruation in adolescent girls. In a recent survey conducted among urban Turkish female students, the duration of menses was significantly longer in girls of higher SES (Ersoy *et al*, 2004). According to the findings of the current study, the mean values of TSF and the prevalence of overweight and obesity were significantly higher for Medium and High SES girls, compared to those of Low SES. Taking these data into consideration, earlier age of menarche and longer menstrual bleeding are more likely for the more privileged socioeconomic groups of girls, thus also partly explaining the high prevalence rates of iron deficiency and iron deficiency anaemia among them (Table 1).

Any serious attempt to examine the role of diet in the aetiology of iron deficiency must take into account the factors that inhibit or enhance iron absorption. Polyphenol-containing beverages, such as tea, are known to reduce nonhaeme iron bioavailability by the formation of insoluble complexes (Reddy *et al*, 2000). Tea is a very popular dietary custom in Turkey as well as in other Muslim countries (Al-Othaimeen *et al*, 1999; Musaiger, 2002), usually served before and after each meal. According to the findings of the current study, tea drinking was very frequent among Turkish boys and especially among those of Low SES. The implication of this observation is that higher tea consumption could be associated with lower iron bioavailability by children of lower social class.

Meat products such as red meat, poultry and fish represent excellent sources of haem iron. However, the cost of these products often restricts access to the poorest in developing countries (Bhargava *et al*, 2001). The limited economic potentiality of Low SES households could probably explain why boys of poor families were found to have lower consumption of red meat and fish in the current study and hence lower intake of highly bioavailable iron.

Citrus fruits have a high content of vitamin C, which is a dietary constituent other than animal tissue that has been reported to augment the absorption of nonhaeme iron in humans (Cook & Reddy, 2001). The analysis of the FFQ records in the present study showed that citrus fruit consumption was more frequent among Medium and High SES boys. This consumption pattern in conjunction with high prices of fresh citrus fruits outside the harvest season, as well as poor nutritional knowledge and practices of the underprivileged population groups, indicates that the enhancing effects of vitamin C on iron bioavailability may be more applicable to the wealthier socio-economic groups and not to those most likely to be iron deficient.

The findings of the current study (Table 3) showed that the mean consumption of certain food items is higher for Low SES girls, compared to male subjects of the same socioeconomic strata. This finding could be primarily attributed to a misrepresentation of the Low SES female subjects, than to actual differences in food intake between girls and boys of this socio-economic group. Based on a recent study conducted in Turkey, girls from the poorest families are likely to drop out of school at an early age, due to cultural and economic reasons (Ulukanligil & Seyrek, 2003). Therefore, the mean food consumption recorded in the current study may not be fully representative of the Low SES girls, since girls of the poorest families and lowest socio-economic groups were probably not included.

Advice to reduce the risk of low iron intake and poor iron status in Turkish youth should target mainly at the poorest by promoting rich sources of iron in the diet (eg red meat/poultry/fish) and also by controlling the consumption of dietary components that may improve (eg vitamin C rich foods) or may deteriorate (eg polyphenol-rich foods and beverages, such as tea) iron bioavailability. In order for this to be accomplished, practical low cost strategies may be required for increasing the accessibility of poor households to dietary sources of highly bioavailable iron. Further initiation of strategies, such as nutrition education programmes or iron fortification of staple foods (ie flour) (Trowbridge & Martorell, 2002), could also be proved as important tools for the management of iron deficiency in Turkey.

In conclusion, the current study showed that iron deficiency was highly prevalent among schoolchildren and especially among boys of Low SES. Different consumption patterns of certain iron bioavailability modifiers, such as tea, citrus fruits and meat products by children of different socio-economic level, could probably provide an indication about the underlying mechanism for the manifestation of this medical condition. However, this cross-sectional study could not establish causal relationships, but could only generate a hypothesis about the possible role of SES and certain dietary patterns in the prevalence of iron deficiency and anaemia among urban Turkish schoolchildren. Nonetheless, much more research in this field is needed, as the present study paves the way for future prospective randomized trials, in order to better understand and develop an effective public health policy, which will efficiently tackle these social and health issues early in life.

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