Prevalence of iron deficiency, anaemia, and iron-deficiency anaemia in high-school students in Jolfa, East Azerbaijan

B. Pourghassem, G. S. M. Kimiagar, A. A. Abolfathi, N. Vallaii, and M. Ghaffarpour

Abstract

Iron deficiency is the most prevalent nutritional problem in the world. We determined the prevalence of iron deficiency, anaemia, and iron-deficiency anaemia in 652 high-school students (340 girls and 312 boys) who were selected by stepwise random sampling from 16 high schools in Jolfa, East Azerbaijan. Iron deficiency was defined as having transferrin saturation and/or serum ferritin values below normal. Anaemia was defined as having haemoglobin levels below normal. Iron-deficiency anaemia was taken to be the combination of both. The prevalences of iron deficiency, anaemia, and iron-deficiency anaemia were 60.7%, 12.6%, and 11.5%, respectively. The respective prevalences of these conditions were 66.5%, 13.6%, and 13% in girls and 54.5%, 11.6%, and 10.3% in boys. The prevalences of these conditions were higher among 15- and 16-year-old boys than among girls. Among boys, age was inversely related to the prevalence of iron deficiency ($r = -0.88$, $p < .05$) and anaemia ($r = -0.79$, $p < .07$). Among girls, age was directly related to the prevalence of anaemia ($r = 0.96$, $p < .001$) and iron-deficiency anaemia ($r = 0.99$, $p < .001$).

Introduction

Iron deficiency is the most prevalent nutritional problem in the world. About two billion people suffer from iron deficiency, half of whom have clinical signs of anaemia [1, 2]. Iron deficiency and iron-deficiency anaemia adversely affect physical and intellectual performance, the immune system, and body temperature regulation [3, 4]. It is well known that adolescents are at risk for iron deficiency and iron-deficiency anaemia [2]. Limited data exist in Iran on the prevalence of iron deficiency, anaemia, and iron-deficiency anaemia in adolescent girls, and virtually no information is available on adolescent boys [5–8]. We looked at the prevalence of iron deficiency, anaemia, and iron-deficiency anaemia in 14- to 20-year-old high-school students in Jolfa, East Azerbaijan. This district is north of Azerbaijan Province, 120 km from Tabriz and 750 metres above sea level [9].

Materials and methods

High-school students (340 girls and 312 boys) were selected by stepwise random sampling from 16 high schools in Jolfa. The sample size was based on an estimated 11.5% prevalence of anaemia in East Azerbaijan, 95% confidence interval, and 2.5% error [10]. The proposal was approved by the Research Council of the National Nutrition Institute, and written consent was secured from the subjects’ parents. Students who had hepatic or neural chronic diseases, had received blood transfusions, or had been blood donors within the previous two weeks were excluded, because these conditions change iron status indicators in the body [3]. About 10 ml of fasting venous blood was taken from each subject, 2 ml for haemoglobin and the remainder for serum tests. Serum was stored at $-20^\circ$C. Serum iron (SI) and total iron-binding capacity (TIBC) were measured with manual kits (Zeist) by spectrophotometry, and serum ferritin was assayed by IRMA kit (Kavoshyar) on a gamma counter. The transferrin saturation (TS) percentage was calculated as follows:

$$\text{% TS} = \frac{\text{SI}}{\text{TIBC}} \times 100$$

Iron deficiency was defined as serum ferritin below...
15 µg/L and/or transferrin saturation below 16% in both boys and girls. Anaemia was defined as haemoglobin values below 11.5 g/dl in girls under 15 years of age and below 12 g/dl in girls 15 years of age and older, as well as for boys under 15 years of age. In boys over 15 years of age, the cut-off point was 13 g/dl. Iron-deficiency anaemia was defined as the occurrence of iron deficiency together with anaemia [11–15]. About 10% of the tests were done in duplicate.

**Results**

The mean ages were 16.9 ± 1.3 years for girls and 17 ± 1.4 years for boys. In 25 students (24 girls and 1 boy), haemoglobin could not be tested because of sample coagulation and haemolysis. The age and sex distribution of the students surveyed in Jolfa are shown in table 1. Table 2 shows the distribution of iron deficiency, anaemia, and iron-deficiency anaemia.

Among girls, the 95% confidence intervals were 61.5% to 71.5% for the prevalence of iron deficiency, 9.8% to 17.4% for the prevalence of anaemia, and 9.3% to 16.7% for the prevalence of iron-deficiency anaemia. Among boys, the respective confidence intervals were 49% to 60%, 8% to 15.2%, and 6.9% to 13.7%. The age distributions of iron deficiency, anaemia, and iron-deficiency anaemia are shown in figs. 1, 2, and 3.

**Discussion**

Our study showed that three out of every five girls and half of the boys were iron deficient. Studies in Islamabad and Karachi, Pakistan [16, 17]; Colombo, Sri Lanka [18]; Chartsworth, South Africa [19]; and Sligo, Ireland [20] showed a prevalence of iron deficiency of 30% to 59%. Measurements of serum iron, total iron-binding capacity, and transferrin saturation and assay of serum ferritin concentration are sometimes useful in distinguishing iron deficiency, except when conditions such as inflammatory disorders or malignancies and chronic diseases coexist. We excluded these conditions.

At present, measurement of serum ferritin concentration appears to be the most sensitive, specific, and practical test for the diagnosis of uncomplicated iron deficiency [3].

Studies in other areas of Iran showed a 27% to 39% prevalence of iron deficiency in 14- to 20-year-old girls [5, 6, 8]. The difference is due to the different cut-off points used. Because there is no information on parasitic infection and dietary assessment in our study area, the real causes need to be determined in

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>15</td>
<td>67</td>
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<td>19</td>
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<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>340</td>
<td>312</td>
</tr>
</tbody>
</table>

TABLE 1. Age and sex distribution of the subjects, Jolfa, 1997

<table>
<thead>
<tr>
<th>Sex</th>
<th>Iron deficiency&lt;sup&gt;a&lt;/sup&gt; no. (%)</th>
<th>Anaemia&lt;sup&gt;b&lt;/sup&gt; no. (%)</th>
<th>Iron-deficiency anaemia&lt;sup&gt;c&lt;/sup&gt; no. (%)</th>
<th>% of anaemia due to iron-deficiency anaemia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>Female</td>
<td>226 (66.5)</td>
<td>114 (33.5)</td>
<td>43 (13.6)</td>
<td>273 (86.4)</td>
</tr>
<tr>
<td>Male</td>
<td>170 (54.5)</td>
<td>142 (45.5)</td>
<td>36 (11.6)</td>
<td>275 (88.4)</td>
</tr>
<tr>
<td>Total</td>
<td>396 (60.7)</td>
<td>256 (39.3)</td>
<td>79 (12.6)</td>
<td>548 (87.4)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Iron deficiency in both sexes is defined as serum ferritin below 15 µg/L and/or transferrin saturation below 16%.
<sup>b</sup> Anaemia is defined as haemoglobin values below 11.5 g/dl in girls under 15 years of age and below 12 g/dl in girls 15 years of age and older, as well as for boys under 15 years of age. In boys over 15 years of age, the cut-off point is 13 g/dl.
<sup>c</sup> Iron-deficiency anaemia is a combination of the above two conditions.
future studies. Studies from Europe, North America, and Australia have reported a 2% to 38% prevalence of iron deficiency in male and female adolescents [13–15, 21–24]. Our study found that 13.6% of 14- to 20-year-old girls were anaemic, a figure comparable to those from Zahedan in southern Iran, Islamabad in Pakistan, and Adana in Turkey [6, 16, 25]. Studies in Georgia, USA, Sligo, Ireland, and Val-de-Marne, France, have found a 2.3% to 7% prevalence of anaemia in 14- to 20-year-old girls [14, 20, 23]. The prevalence of anaemia in boys in our study was less than that in Islamabad and Adana. In these studies, 15% to 17.5% of boys were anaemic [16, 25]. Iron-deficiency anaemia was found in 13% and 10.3% of girls and boys, respectively. In high-school girls, a direct relationship between age and the prevalence of anaemia and of iron deficiency was observed, whereas in boys after puberty there was an inverse relationship between age and the prevalence of anaemia and of iron deficiency. Menstruation and puberty both increase body iron needs [3]. Thus, the prevalence of iron-deficiency anaemia increases more in adolescent girls.

Conclusions

The prevalence of anaemia and of iron-deficiency anaemia was in the range found in other studies in Iran (9%–16%), whereas the prevalence of iron deficiency was higher. The high prevalence of iron-deficiency anaemia and iron deficiency in 14- to 17-year-old male high-school students is notable. The high prevalence of iron deficiency and iron-deficiency anaemia in our study was similar to that in neighbouring countries and calls for the fortification of cereals, oral supplementation, and other public health interventions to combat it. These measures have been recently reviewed by a UNICEF/UNU/WHO/MI Technical Workshop [26]. Iron deficiency and iron-deficiency anaemia adversely affect behaviour and intellectual performance, body temperature regulation, immunity and resistance to infections, lead poisoning, and pregnancy outcome. In view of the prevalence of iron deficiency in adolescents and its adverse effects, it is essential to combat iron-deficiency anaemia and iron deficiency in school-age children in Iran.

Acknowledgements

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References