Original Article

Sources of dietary iron in urban and provincial 4-year-old children in Iran

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Iron-deficiency anaemia is prevalent in childhood, especially in developing countries. Nutritional deficiency is one of the main causes of iron-deficiency anaemia, although absorption varies considerably between different dietary items. Information on the sources of iron in young children is limited. A study was therefore undertaken to investigate the different dietary sources of iron in 151 healthy children aged 4 years who were selected from two districts of Fars province, Iran. Two 3-day dietary diaries with pre- and post-interview were used to record the dietary intake of the children. Food and drinks were categorised into four groups (animal, plant, drinks and other) to measure the relative importance of different sources of iron. Sixty-eight percent of the children completed the 3-day dietary diaries in both summer and winter. The results showed no statistically significant differences in total daily iron intake between the two seasons or between genders. However, the difference in the total daily iron intake between children in the city and the provincial district was significant: 7.73 ± 1.75 mg/day and 10.33 ± 2.9 mg/day, respectively ($P < 0.001$). About 75 and 60% of iron intake came from plant sources in the provincial district and city, respectively. The three most important sources of iron for children of the provincial district were bread (51%), fruit and vegetables (12%) and meat (7%). This pattern was also observed for children living in the city, but with different percentages: 27%, 16% and 16%, respectively. In conclusion, total iron intakes were similar to those recorded in European countries, but little of the intake came from animal sources and substantial differences between city and provincial children were recorded.

Key words: children, diet, Fars province, food sources, Iran, iron.

Introduction

Anaemia is estimated to affect one-half of children in developing countries, and more than three billion of the world's population have iron-deficiency anaemia.[1] According to the World Health Statistic Report,[2] the percentage of children under 6 years of age who were anaemic in six middle south Asian countries (including Iran) ranged from seven to 97%. In Iran, anaemia has been reported to affect 11% of children aged 2–14 years.[3] The major cause of anaemia in most countries is iron deficiency, with nutritional iron deficiency and intestinal infestations of hookworms being the two main reasons in many countries. The consequences of anaemia in children are serious and consist of reduced work capacity, reduced school performance, decreased growth rate and impaired motor development.[4]

Foods of animal origin such as meat, poultry and fish are the main sources of haem iron, while the main sources of non-haem iron are cereals, pulses, fruits and vegetables. Absorption of iron from animal sources, with the exception of eggs, is three to five times higher than from foods in the non-haem iron group.[5] However, many factors influence dietary iron absorption, and a sufficient dietary intake of iron depends on the bioavailability of iron from the diet. Factors such as calcium, phytate, iron-binding phenolic compounds and soy protein reduce the bioavailability of iron from meals, while ascorbic acid enhances the bioavailability of iron.[4] Based on Western diets of high availability, for children aged 4–6 years, the UK Reference Nutrient Intake (RNI) for iron is 6.1 mg/day[6] while the Dietary Reference Intakes (DRI) in the United States[7] and Swedish Nutrition Recommendations (SNR) for the same age group[8] are somewhat higher at 10 mg/day.

Most investigations on iron intake and iron deficiency have been focused on infants, adolescents and pregnant women, and there have been few studies on children. The mean total iron intake of British children aged 3½–4½ years was found to be 6.1 for boys and 5.6 mg/day for girls.[9] The mean daily iron intake, for 4–6-year-old children from a number of mainly European countries, ranged from 6.1 to 13.0 mg for boys and from 5.6 to 13.4 mg for girls.[10] Some of these results were obtained from large national surveys[9]

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while others were from smaller, more local studies.[10] No published information on dietary intake of iron of Iranian children aged about 4 years was found in the literature.

Two studies of dietary intake of iron in adolescents and young adults in Iran have been reported. In a nutritional survey of 12–14-year-old boys in rural areas of Fars province and Shiraz, the mean total dietary iron intake was reported to be 44 mg/day,[11] while Amin-por and Ferdosian[12] reported mean dietary iron intakes of 16 and 20 mg/day for 19–21-year-old Iranian girls and boys, respectively. These figures are much higher than those reported elsewhere. For example, in Europe, Adamson and coworkers[13] reported that the mean iron intake of 379 English adolescent boys and girls was 11–12 mg/day, while the mean daily iron intake of Scottish 12-year-olds was reported to average 10 mg.[14]

Measuring the total daily dietary iron is a relatively poor indicator of the adequacy of the diet because of differences in absorption from different dietary sources. In a survey of health and nutrition in rural areas of southern Iran, it was found that the total amount of iron in children's diets was more than the recommended dietary allowance, while the prevalence of iron-deficiency anaemia in children was 30%.[15] Iron-deficiency anaemia is also prevalent in India, despite a high dietary-iron intake[16] — maybe due to intestinal infestation. Therefore, it is quite possible to develop iron-deficiency anaemia while ingesting a large amount of iron in food from which it is poorly absorbed and, conversely, iron-deficiency anaemia appears to be absent in populations where intake is far less than the recommended amount but it is in forms that are well-absorbed. Few studies have reported the percentage contribution of different food groups to total iron intake in children; although, from the above, this would appear to be a relevant issue. In one study, Moynihan and coworkers[17] reported that meat and meat dishes were the main contributors of iron (19%) for English adolescents, four times the contribution of vegetables (5%).

Because of the importance of dietary sources to the absorption of iron and the shortage of such information in children, an age group at risk of anaemia, a study was undertaken to investigate the different dietary sources of iron intake in children living in different circumstances in a middle-eastern country. It was impossible to investigate the pattern of iron intake for all age groups of preschool children because of financial constraints. Children in Iran start at kindergarten and primary school at the end of their fourth year and it was therefore decided to examine this age group of children, who were just beginning their career in school.

Materials and methods

This study took place in two districts of Fars province, south-west Iran, between May 1995 and March 1996, and has been described by Zohouri and Rugg-Gunn.[18,19] In brief, the districts chosen were a big city (Shiraz) and a provincial town (Darab) together with its surrounding rural area. In the city, a high socioeconomic area was chosen, while in the provincial district, all areas were included. Lists of all kindergartens and health centres were obtained and 151 healthy 4-year-old children of both genders were selected by random sampling of these units.

A record of the dietary intake of these children was obtained using two 3-day dietary diaries with pre- and post-interviews. The second interview took place in the child's home on the day after completion of the diaries. The first diary was collected during June to August, and the second diary after six months, to allow for any seasonal variation and to increase the reliability of the survey data. The average maximum temperature in this region is 40°C in summer and the average minimum temperature is – 5°C in winter.

The validity of the dietary assessment method and the reliability of the data have been discussed previously.[19] In brief, validity was estimated by (i) calculating the physical activity level (PAL), and (ii) comparing the energy intakes of the children with those obtained in other studies and reference values.

In order to obtain a quantitative record of food, the weights and volumes of foods and drinks served with household utensils, such as glasses, cups and spoons, were measured. The Iranian food composition tables[20] were used for those food items, which were analysed in the Iranian laboratories. However, because of the limitation of those tables, most information on the nutrient content of foods was derived from the computerised version of McCance and Widdowson's food composition tables.[21] Also, the immigrant Food Supplement[22] and the Near East Food tables[23] were employed for just a few cooked dishes for which no code was to be found in other tables. Age, height and weight were recorded.

To determine the relative importance of different sources of iron, foods and drinks were categorised into four groups: (i) animal sources, such as meat, egg and fish; (ii) plant sources, such as fruit and vegetables, bread, rice, cereals and legumes; (iii) drinks, such as water, tea, carbonated beverages and soft drinks; and (iv) other sources, such as snacks (mainly corn), non-dairy ice creams, chocolate and chocolate spreads, sweets, cookies, honey, sugar, jam and other preserves. No iron supplement was taken by the children.

Data analysis using SPSS provided descriptive statistics, and analysis of variance for repeated measures was used to detect effects of gender, district (city or provincial) and season (summer or winter) on iron intake.

Results

One hundred and three children, 68% of the 151 children sampled and invited to participate, completed the 3-day dietary diaries in both seasons in all areas. The number of boys (50) and girls (53) were approximately equal. The mean age was 4.05 years and the mean height and weight of the children was 99 cm and 14 kg, respectively. The mean energy intakes for boys and girls were 1347 and 1306 kcal/day, respectively, which were below the RNI of 1608 kcal/day for boys and 1463 kcal/day for girls, but higher than those reported for British children (1273 kcal/day for boys and 1183 kcal/day for girls). The PAL ratio for these children was 1.7, which is compatible with the standard of 1.8 given by the Department of Health, England, and more than 1.4

obtained for British children.[6] From these results, under-reporting of dietary intake was considered unlikely.

Table 1 shows the different sources of iron intake (mg/day) in boys, girls and average of both genders, as well as the percentage contribution of different food groups to the total intake of iron. A fairly similar iron intake was observed in both genders: 9.40 (± 2.63) for boys and 9.20 (± 3.12) mg/day for girls. The mean total iron intake for all children, in both seasons and genders and from all sources, was 9.28 (± 2.88) mg/day. About 71% of the total intake of iron came from plant sources, while the contribution of animal sources to total iron intake was 23% (Table 1). Almost half of the total dietary iron came from bread (4.21 ± 2.66 mg/day for all children). Other important sources of iron were fruit and vegetables (1.21 ± 0.53 mg/day; 13%), meat (0.87 ± 0.77 mg/day; 9%), egg (0.69 ± 0.48 mg/day; 7%) and cereals (0.57 ± 0.32 mg/day; 6%) (Table 1).

The daily iron intake (mg) for these children in summer and winter and for the children living in the city and provincial districts is presented in Table 2. No statistically significant difference was found in total daily iron intake between the two seasons. However, the difference in the total daily iron intake between the city and the provincial district was considerable: 7.73 ± 1.75 mg/day and 10.33 ± 2.90 mg/day, respectively ($P < 0.001$). While the plant sources (Table 2) were the main source of dietary iron in both areas, the contribution of this group to total daily iron intake for children living in the provincial district was higher (75%) than those living in the city (60%; $P < 0.001$). Although total iron intake was lower in the city, the absolute intake from meat, and percentage contribution of meat to total iron, were higher in the city (1.24 mg/day; 16%) than in the provincial district (0.73 mg/day; 7%; $P < 0.001$).

Iron intake from meat, for all children in both areas ranged from 0 to 3.43 mg/day. However, the substantial difference in the distribution of intakes between the urban and provincial children can be seen in Fig. 1. The intake of iron from meat for about half of the provincial children (47%) was below 0.5 mg/day, and 21% of children did not consume any kind of meat, while in the city, the intake of iron from meat ranged from 1.00 to 1.49 mg/day for 31% of children.

In contrast to the importance of meat as a source of iron in the city children, bread, and to a lesser extent dairy products, were more important sources (in absolute and percentage terms) in the provincial children compared with those in the city. The contribution of rice in the total iron intake in the city was almost twice that in the provincial district – 7% compared with 3%. No interaction was found between gender, season of year and sources of iron intake in the statistical analysis.

Discussion

No recommendations have yet been made for dietary iron intake in Iran. Using the figure of 10 mg/day of iron for 4–6-year-old children, based on Western diets of high bioavailability,[7,8] the absolute mean iron intakes of 4-year-old Iranian children in the provincial district fulfilled the above recommendation, but in the city, the intake of iron was 20% lower than this RDA. The iron intakes of these Iranian children (9.4 for boys and 9.2 mg/day for girls) were higher than those for 3½–4½-year-old British children (6.1 for boys and 5.6 mg/day girls)[9] but were lower than those for Swedish children aged 4 years (12 and 10 mg/day for boys and girls, respectively)[10] and for 6-year-old Finnish boys and girls (13 and 11 mg/day, respectively).[24] Firm recommendations are difficult because of the uncertainty of the bioavailability of

Table 1. Mean ± SD and percentage of dietary iron intake (mg/day) in 103 4-year-old Iranian children

Food group	Iron intake (mg/day) Boys (n = 50)	Girls (n = 53)	All children (n = 103)
Animal sources	2.11 ± 0.94 (22)	2.05 ± 0.98 (22)	2.10 ± 0.95 (23)
Meat, poultry, fish	0.84 ± 0.79 (9)	0.90 ± 0.75 (10)	0.87 ± 0.77 (9)
Egg	0.70 ± 0.58 (7)	0.67 ± 0.59 (7)	0.69 ± 0.48 (7)
Dairy products			
Cheese, dairy cream, yoghurt	0.54 ± 0.48 (6)	0.48 ± 0.54 (5)	0.51 ± 0.51 (5)
Milk	0.03 ± 0.04 (<1)	0.03 ± 0.04 (<1)	0.03 ± 0.04 (<1)
Plant sources	6.62 ± 2.67 (70)	6.60 ± 3.07 (71)	6.62 ± 2.88 (71)
Fruits and vegetables	1.29 ± 0.55 (14)	1.12 ± 0.50 (12)	1.21 ± 0.53 (13)
Bread	4.21 ± 2.64 (45)	4.23 ± 2.84 (46)	4.21 ± 2.66 (45)
Rice	0.36 ± 0.50 (4)	0.40 ± 0.53 (4)	0.38 ± 0.51 (4)
Cereals	0.50 ± 0.30 (5)	0.64 ± 0.33 (7)	0.57 ± 0.32 (6)
Legumes			
Beans, lentils, peas, etc.	0.26 ± 0.29 (3)	0.21 ± 0.45 (2)	0.25 ± 0.38 (3)
Drinks			
Water, tea, carbonated beverages, soft drinks and other beverages	0.08 ± 0.11 (<1)	0.06 ± 0.08 (<1)	0.07 ± 0.10 (<1)
Others sources†	0.59 ± 0.57 (6)	0.53 ± 0.51 (6)	0.56 ± 0.54 (6)
All sources	9.40 ± 2.63 (100)	9.20 ± 3.12 (100)	9.28 ± 2.88 (100)

†Such as snacks (mainly corn), non-dairy ice-creams, chocolate and chocolate spreads, sweets, cookies, honey, sugar, jam and other preserves. Values for each subject were the mean of 6 days. Figures in parentheses represent percentage values.

Table 2. Mean ± SD and percentage of dietary iron intake (mg/day) in 103 4-year-old Iranian children

Food group	Iron intake (mg/day)			
	Summer (n = 103)	Winter (n = 103)	City (n = 32)	Provincial (n = 71)
Animal sources	2.36 ± 1.38 (25)	1.82 ± 1.26 (20)	2.31 ± 0.82 (30)	2.02 ± 0.99 (19)
Meat, poultry, fish	0.98 ± 1.09 (10)	0.84 ± 0.93 (9)	1.24 ± 0.73 (16)	0.73 ± 0.73 (7)
Egg	0.67 ± 0.53 (7)	0.62 ± 0.60 (7)	0.72 ± 0.69 (9)	0.67 ± 0.61 (6)
Dairy products				
Cheese, dairy cream, yoghurt	0.67 ± 0.88 (7)	0.34 ± 0.51 (4)	0.26 ± 0.21 (3)	0.60 ± 0.55 (6)
Milk	0.03 ± 0.06 (<1)	0.03 ± 0.06 (<1)	0.06 ± 0.05 (<1)	0.02 ± 0.03 (<1)
Plant sources	6.46 ± 2.93 (69)	6.63 ± 3.46 (72)	4.64 ± 1.52 (60)	7.73 ± 2.80 (75)
Fruits and vegetables	1.34 ± 0.84 (14)	1.07 ± 0.70 (12)	1.21 ± 0.56 (16)	1.21 ± 0.53 (12)
Bread	3.94 ± 2.75 (42)	4.32 ± 3.06 (47)	2.12 ± 1.05 (27)	5.31 ± 2.66 (51)
Rice	0.42 ± 0.89 (4)	0.33 ± 0.49 (3)	0.56 ± 0.88 (7)	0.31 ± 0.26 (3)
Cereals	0.57 ± 0.48 (6)	0.59 ± 0.42 (6)	0.51 ± 0.26 (7)	0.60 ± 0.34 (6)
Legumes				
Beans, lentils, peas, etc.	0.18 ± 0.31 (2)	0.31 ± 0.63 (3)	0.23 ± 0.24 (3)	0.25 ± 0.42 (2)
Drinks				
Water, tea, carbonated beverages, soft drinks and other beverages	0.12 ± 0.18 (1)	0.02 ± 0.06 (<1)	0.12 ± 0.13 (1)	0.05 ± 0.08 (<1)
Others sources†	0.39 ± 0.68 (4)	0.72 ± 0.89 (8)	0.66 ± 0.41 (8)	0.52 ± 0.58 (5)
All sources	9.33 ± 3.24 (100)	9.19 ± 3.53 (100)	7.73 ± 1.75 (100)	10.33 ± 2.90 (100)

†Such as snacks (mainly corn), non-dairy ice-creams, chocolate and chocolate spreads, sweets, cookies, honey, sugar, jam and other preserves. Values for each subject were the mean of three days for summer and winter, and a mean of six days for city and provincial. Figures in parentheses represent percentage values.

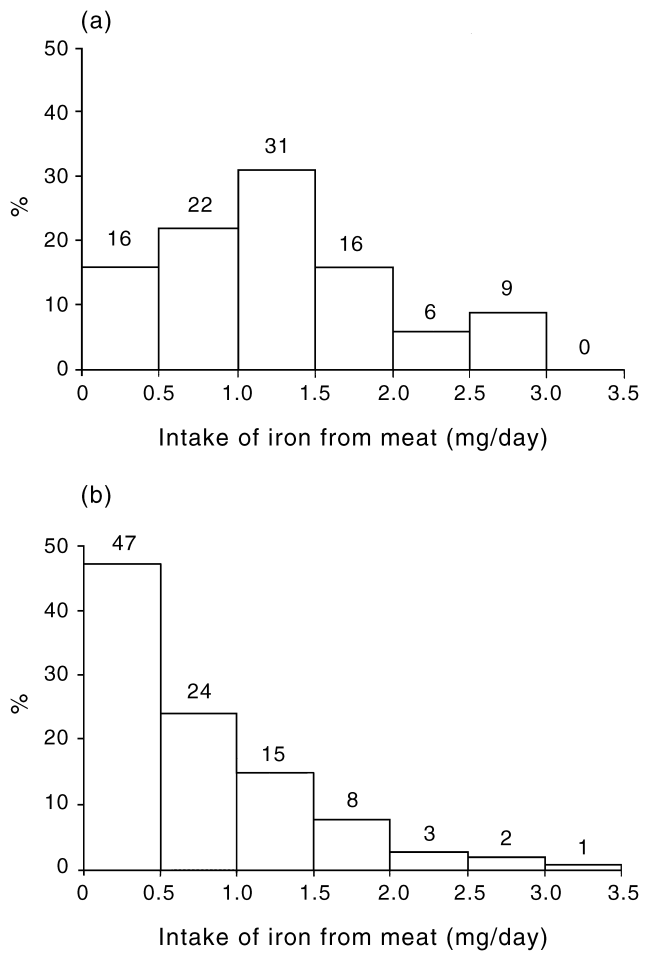

Figure 1. Percentage frequency distribution of 4-year-old children according to mean daily iron intake (mg/day) from meat for children in (a) city (n = 32) and (b) provincial (n = 71) areas. Data presented are the mean of 6 days/subject.

dietary iron in such a population where the majority of iron comes from plants.

Even though there have been several reports of total iron intake for children in this age group, sources of iron intake have rarely been investigated, nor has this been studied in communities of differing lifestyles. Neither gender nor season was significantly related to the iron intake in this study, but there was a significant difference in total iron intake and sources of iron intake between children living in either the city or the provincial district.

Although meat is recognized as a good source of iron, only 7% of total iron intake in the provincial children, and 16% in the city children, came from meat (including fish), whereas the contribution of meat to total iron intake has been reported as 29% for 4-year-old Swedish children[10] and 17% for British children.[9] Because meat is relatively expensive in Iran, consumption is less than other food groups. Rice is a major source of food for children in the city, while bread is the most important source for those living in the provincial district because rice is more expensive than bread. This is reflected in the different contributions of bread and rice to total iron intake, which were 51 and 3%, respectively, in the provincial district and 27 and 7%, respectively, in the city. In general, the three most important sources of iron for the Iranian children in the city were bread (27%), meat (16%) and fruits and vegetables (16%), while the two main sources for the provincial children were bread (51%) and fruits and vegetables (12%). In contrast, the three most important sources

of iron for British children were breakfast cereals (20%), meat (15%) and vegetables, potatoes and savoury snacks (15%), while breakfast cereals (39%) and the meat group (29%) were the main sources of iron intake for 4-year-old Swedish children. Cereal products were reported as the most important source of iron intake (53%) in the Finnish diet in all age groups, and next in terms of importance was meat and meat products (including fish; 22%).[24] Grains (mainly wheat and rye) provided 35% of the Russian population's total iron consumption, followed by beef, potatoes, roots and tubers.[25]

The principal inhibitors of iron absorption are phytates, contained in cereals and legumes, and polyphenols, which are highly concentrated in tea and coffee. More than 50% of iron intake for Iranian children living in the provincial district came from bread, and about half of this was consumed as phytate-rich unleavened bread. The concentration of phytate in such unleavened homemade bread is 630 mg/100 g dry bread, which is more than twice as much phytate (301 mg/100 g dry bread) as bread made in commercial bakeries in the city.[26]

Tea is a popular drink in Iran, especially in rural areas. The consumption of tea was found to be 63 mL/day/child (almost one ordinary Iranian tea cup) in the city, but varied from a mean of 110 (almost two cups) to 238 mL/day/child (almost four cups) in different communities in the provincial district.[27] Because of its iron inhibitory capacity, tea should be given 1–2 h after mealtime. Almost all of the provincial children and most city children had drunk tea with their breakfast, immediately after lunch, or sometimes after dinner.

This was the first study of sources of iron intakes of children aged 4 years in Iran. Dietary intake of iron was lower than in some European countries but similar to intakes in the UK. Little difference was observed between genders or between summer or winter. However, substantial differences were found in iron intake and sources of iron intake between children living in a high class area of a city and children living in provincial districts. High intakes of unleavened bread and tea were also recorded, especially in the provincial district. There is now a need to link these findings to the occurrence of anaemia in these communities and to make recommendations for dietary intake for Iranian children.

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