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# Nutritional status of schoolchildren in rural Iran

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The present study compared the nutritional status of schoolchildren from recently settled, ethnic minority tribespeople with those from a Persian village in southern Iran. Height and weight were measured and blood was collected from school children at three time points over 1·5 years. Supplemental Fe was provided to children with low Hb after the first screening. Twenty-one per cent of the children were wasted, 57 % were stunted and 23 % were anaemic. No statistically significant difference in the prevalence of wasting, stunting and anaemia was found between gender or ethnic groups. Children over the age of 12 years had a higher prevalence of wasting than children aged below 12 years. In a sub-sample of forty-one children the average BMI-for-age decreased. Fe supplementation increased Hb levels to normal in most children, but did not increase Fe level in a few children. Dietary deficiency of micronutrients, especially Zn and Fe, probably accounts for the high prevalence of stunting and anaemia in these children. Infection with *Helicobacter pylori* is another possible explanation for the Fe-deficiency anaemia. Further investigation is in progress to determine the cause(s) of the observed deficiencies.

**Iran: Qashqa'i: Schoolchildren's health status**

Iran is located in the Middle East, bordering the Gulf of Oman, the Persian Gulf and the Caspian Sea, between Iraq and Pakistan. It shares borders with Afghanistan, Armenia, Azerbaijan, Iraq, Pakistan, Turkey and Turkmenistan. Iran is divided into twenty-eight provinces (Fig. 1). The population is young, with a median age of 22·9 years, and about 29 % are under the age of 15 years (CIA, 2003).

Iran faces several public health challenges. The infant mortality rate is 44·17 per 1000 live births (CIA, 2003). Malnutrition is not uncommon especially in rural and southern Iran. According to a 1998 nationwide study of children $<5$ years of age, approximately 15 % are moderately or severely stunted ($<-2$ SD weight-for-age) and about 5 % moderately or severely wasted ($<-2$ SD weight-for-height; Ministry of Health and Medical Education, 1998). Substantial differences exist between rural and urban provinces. Twenty-two per cent of rural children aged $<5$ years are stunted compared with 11·0 % of urban children. The highest rate of stunting is 38·1 % in Sistan va Baluchestan in the south east and the lowest is 6·8 % in Gilan in the north east. The difference in the prevalence of wasting between rural and urban areas is small, with 5·6 % of urban and 4·6 % of rural children meeting the criteria for wasting. However, the difference between provinces is large. The highest rate of wasting is 11·3 % in Harmozgan in the south west and the lowest rate is 1·1 % in Golestan in the north west (Ministry of Health and Medical Education, 1998).

The same study revealed that only 14 % of children had their weight recorded regularly on their growth card, with 69 % having two or fewer weights recorded (Ministry of Health and Medical Education, 1998). During the week preceding the interview, protein-rich foods (meat, eggs and legumes) were offered about twelve times, vegetables about twelve times, fruit about more than seventeen times and dairy products about fourteen times to toddlers aged 12–23 months. Given the marginal intake of Fe-rich foods, it is noteworthy that only 74 % of children aged 6–23 months were receiving Fe supplements on a regular basis.

Factors that contribute to the malnutrition are low socio-economic status, low health and nutritional awareness, inadequate access to health services, availability of a limited variety of foods, food insecurity in rural areas, recurrent diarrhoea and respiratory infections (Ministry of Health and Medical Education, 1998).

On the other hand, Tehran and other urban areas are beginning to experience the onset of the diseases of development, such as obesity and CVD (Azizi *et al.* 2001*a*,*b*). A 2001 study of 10–19-year-olds in Tehran (*n* 421) found that 10·7 % and 5·1 % of boys were overweight and obese, respectively, while 18·4 % and 2·8 % of girls were overweight and obese (Azizi *et al.* 2001*a*). This Tehran lipid and glucose study also reported that 16 % of children aged 3–19 years (*n* 3148) had a total cholesterol level of 200 mg/dl or greater and 17 % had LDL-cholesterol level of 170 mg/dl or greater (Azizi *et al.* 2001*b*). The American Academy of Pediatrics considers total cholesterol of 200 mg/dl or

**Abbreviation:** NHANES III, Third National Health and Nutrition Examination Survey.

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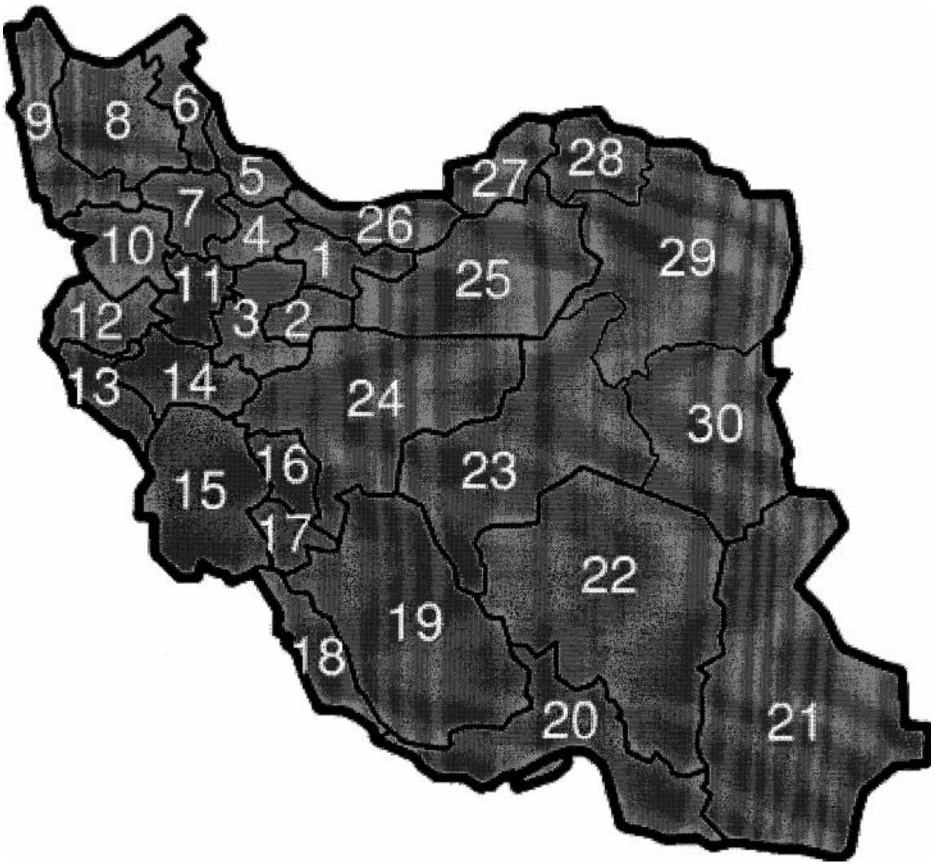


**Fig. 1.** Map of Iran showing the twenty-eight provinces. 1) Tehran; 2) Qom; 3) Markazi; 4) Qazvin; 5) Gilan; 6) Ardabil; 7) Zanjan; 8) East Azarbaijan; 9) West Azarbaijan; 10) Kurdistan; 11) Hamadan; 12) Kermanshah; 13) Ilam; 14) Lorestan; 15) Khuzestan; 16) Chahar Mahaal and bakhtiari; 17) Kohkiluyeh and Buyer Ahmad; 18) Busheher; 19) Fars; 20) Hormozgan; 21) Sistand and Baluchistan; 22) Kerman; 23) Yazd; 24) Esfahan; 25) Semnan; 26) Mazandaran; 27) Golestan; 28) North Khorasan; 29) Razavi Khorasan; 30) South Khorasam.

greater and LDL-cholesterol levels 130 mg/dl or greater high (American Academy of Pediatrics Committee on Nutrition, 1998).

Fe deficiency is another nutritional concern in Iran. A study of 583 children aged $<5$ years in Fars province reported a prevalence of Fe-deficiency anaemia of 18·7 % (Kadivar *et al.* 2003). Another study of pregnant women at 16 weeks' gestation in southern Iran reported that 28·5 % had low ferritin values and 16·7 % had low Hb (Karimi *et al.* 2002). Fe-deficiency anaemia impacted negatively on performance in school examinations in a study of 800 school children in Saudi Arabia (Abalkhail & Shawky, 2002). Fe deficiency is due to a combination of dietary factors: low Fe intake and high consumption of whole grains rich in phytates, and frequent consumption of tea, which inhibits absorption of Fe. Additionally, high birth rates, short pregnancy intervals and parasitic infections, which increase losses, contribute to anaemia (World Health Organization Regional Office for the Eastern Mediterranean, 2001; Dickey, 2002).

Little information is known regarding the nutritional status of school-aged children, especially among ethnic minority and 'hard-to-reach' populations such as the Qashqa'i tribespeople (Zohouri & Rugg-Gunn, 2002). The Qashqa'i are a Turkish-speaking minority ethnic group of more than a half a million people residing in southern Iran. Some live a nomadic lifestyle and others have settled in small villages. They are considered a high-risk population in terms of their health status (Zohouri & Rugg-Gunn, 2002). The infant mortality rate among the Qashqa'i was reported as 84·3 per 1000 live births (Keshavarz & Sarraf, 1997), compared with the national level of 44·17 per 1000 live births. Fars province, where most Qashqa'i live, ranks number 10 (16·7 %) in stunting and number 13 in wasting (11·3 %) among children aged $<5$ years compared with the other twenty-seven provinces in Iran (Ministry of Health and Medical Education, 1998). More recently, an empirical study indicated a lack of adequate food for young Qashqa'i children, in part because the children are not fed energy- and protein-rich foods (Salehi *et al.* 2004).

To address the lack of data on the nutritional status of Qashqa'i school children and how their status compares with other subgroups of children, in the present project we examined the nutritional status of children in a newly settled Qashqa'i sub-tribe and a Persian village about 5 miles apart. Additional objectives were to compare the nutrition-related health status of school children from this sub-tribe and a typical Iranian village. Given that health outcomes are associated with people's lifestyle, collecting baseline data on the Qashqa'i school children at this transitional stage and comparing such data with that from school children of a typical sedentary Iranian village will help us to examine how lifestyle change influences population health over time.

## Materials and methods

### *Design*

The University of Wyoming Institutional Review Board for Protection of Human Subjects approved the study. Data were collected in three phases in the native languages (Turkish and Persian). A medical team from Shiraz University of Medical Sciences (including Z. S., a nurse and public health graduate students) supervised/facilitated the medical aspects of the project in the field.

### *Study population*

The Qashqa'i village consisted of seventy households who formed a village. Prior to settling in the village, they migrated in groups of ten to fifteen households with specific summer and winter quarters scattered over several hundred miles. Each group had a school teacher who accompanied them to both winter and summer quarters. Now several school teachers are assigned to teach in the new village. Modern conveniences for this village including telephone, electricity and running water are under construction. About half of the households have moved into the modern village allowing access not only to telephone services but also to television, etc.

In the past, the diet of the Qashqa'i varied substantially with the seasonal availability of food. During the spring and summer most sheep and goats delivered offspring, making dairy products plentiful. Seasonal fruits such as oranges and apples as well as meat and cheaper grains were also available. During the winter, fruit, meat and dairy consumption was minimal with grains and beans forming dietary staples. Some households in this newly settled village will continue to raise domestic animals, and others will farm. Staples for this newly settled village now include bread, potatoes, aubergine, tomato, rice and occasional meat. These practices, along with paving of the road to the village, should decrease seasonal food variation and influence nutrient intake.

The Persian village population has been settled for over a century. Their diet in the past consisted of products locally available. However, improved roads and better transportation systems are now allowing bread, rice, meat and wheat to be staples. Fruit consumption was uncommon among both populations. With the improved infrastructure in the region, fruit is now available; however, the availability for the Qashqa'i is less. All children in these villages attend elementary schools in their village. One junior high serves both villages. Fewer females attend junior high than males.

### *Measurements*

Initially, all 137 students attending the elementary schools in the two villages participated in the study. About one-third of children were found to be anaemic. They were given Fe pills for a period of 6 months. Blood Fe level of twenty-five children was measured in December 2002; however, due to a technical error on the measuring device, readings from only eleven subjects were complete and could be included with the results of the forty-one subjects obtained in Phase III. Thus, the number of subjects in Phase III (fifty-two) was calculated. The field project was conducted in three phases.

*Phase I.* Phase I was conducted in January 2002 before construction of the modern village was completed for the Qashqa'i. Study participants were all 137 children, who attended the elementary schools in the two villages and the middle school serving both villages, on the day of data collection. Heights and weights were obtained using a portable digital scale and portable stadiometer following standard techniques. Blood samples were obtained by venepuncture by medical professionals. Blood samples were analysed in a laboratory at the Shiraz University of Medical Sciences for the following: transferrin saturation, serum Fe, total Fe-binding capacity, serum ferritin, Hb, haematocrit, mean corpuscular volume, mean corpuscular Hb, mean corpuscular Hb concentration and hepatitis antigen. D. G. conducted parental interviews with the assistance of an Iranian health educator on a sub-sample of forty children. Children who met the cut-offs for anaemia of the Centers for Disease Control and Prevention (1998) were prescribed supplemental Fe by the collaborating physician.

*Phase II.* Hb was rechecked in December 2002 using a Hemocue (Auratech Inc., Greensboro, NC, USA) on a sub-sample of twenty-five of the originally anaemic children. A team of researchers travelled to the elementary school sites without previous notification and obtained blood samples from the students present at the time of arrival. At this time, the children were questioned regarding use of Fe supplements.

*Phase III.* Heights and weights were re-measured and Hb was rechecked on a sub-sample of forty-one elementary school children in May 2003. The same protocol as used in Phase II was followed to select students. Students were asked about use of Fe supplements. Thus, two height and weight measurements were available on forty-one children and two Hb values on fifty-two children. Fourteen children had Hb checked in both Phase II and Phase III. The value for Phase III was used in analysis to ascertain whether Hb improved with Fe supplementation.

### *Analysis*

Height-for-age Z-score and BMI for age Z-score were calculated using the EPI-Info 2000 Nutristat program (Centers for Disease Control and Prevention, Atlanta, GA, USA) using the CDC 2000 standards. Low height-for-age and low BMI-for-age was defined as Z-score of $< -2$. Since there were only fifteen females aged 12–15 years, the participants were divided into two age categories for analysis: $<12$ years and $\geq 12$ years of age.

The serum ferritin cut-off of $<12\,\mu$g/l (5th percentile) for individuals 6 years of age and older of the Third National Health and Nutrition Examination Survey (NHANES III) was used to identify individuals with low Fe stores (Centers for Disease Control and Prevention, 1998). The Shiraz University of Medical Sciences normal laboratory range for total Fe-binding capacity of 100–400 $\mu$g/dl, mean corpuscular Hb concentration of 20–40 g/dl, mean corpuscular Hb of 25·0–32·0 pg/cell and serum Fe of 35–100 $\mu$g/dl were used to identify children with abnormal values for these indicators of Fe status. For children aged 6–11 years, $<80$, $<82$ fl for children aged 12–15 years and $<85$ fl for children over the age of 15 years was used to identify those with abnormal mean corpuscular volume (Centers for Disease Control and Prevention, 1998). The NHANES III cut-offs (5th percentile) of 11·8 g/dl for children aged 6–11 years, 11·9 g/dl for female adolescents aged 12–15 years, 12·6 g/dl for male adolescents aged 12–15 years and 13·6 g/dl for male adolescents aged 16–19 years identified individuals with low Hb values (Centers for Disease Control and Prevention, 1998). Differences in anthropometric and Fe status indices by age, gender and village were examined using the $\chi^2$ statistic.

## Results

### *Phase I*

Forty-two per cent of the participants were from the Qashqa'i village and 58 % were from the Persian village. Participants' ages ranged from 7·4 to 19·4 years, with half aged $<12$ years and half aged $\geq 12$ years. Two-thirds of participants were male and one-third female, reflecting the fact that fewer females over 12 years old attend school than males.

The mean BMI-for-age Z-score was $-1{\cdot}3$, with no participant meeting the criterion for overweight (BMI-for-age Z-score $>2$). Twenty-nine children (21 %) met the criterion for wasting (BMI-for-age Z-score $<-2$). Twenty per cent of males and 23 % of females, 18 % of Quashqua'i and 24 % of Persian children, and 12 % of children aged $<12$ years and 31 % of children $\geq 12$ years were wasted (Table 1). Ten children (7·3 %; three females and seven males) had BMI-for-age Z-score $<-3$. The percentage of children with low BMI Z-score did not differ significantly by village or gender ($P>0{\cdot}05$) but did differ by age ($P=0{\cdot}02$). Seventy-eight or 57 % of children had a height-for-age Z-score meeting the criterion for stunting. Fifty-six per cent of males and 62 % of females, 54 % of Quashqua'i and 59 % of Persian children, and 54 % of children aged $<12$ years and 59 % of children $\geq 12$ years of age were wasted (Table 2). The percentage of low height-for-age Z-scores did not differ by age, gender or village ($P>0{\cdot}05$). Thirty-four children (25 %; ten females and twenty-four males) had a height-for-age Z-score $<-3$.

Results of laboratory tests for Fe status are shown in Table 3 and were available for ninety-nine or 111 (72 % or 81 %) children depending on the test. Although only 4 % of those with laboratory results had low ferritin, 71 % had low mean corpuscular volume, 23 % low mean corpuscular Hb and 19 % low serum Fe. No child had a low total Fe-binding capacity. Hb values were available on 111 or 81 % of participants; 22 % (twenty-four) had low Hb. No significant differences in the prevalence of anaemia by age, gender or village were noted. Of the ninety-five children with a normal serum ferritin, fifty had mean corpuscular volume $<80$ fl. Thirty-two per cent were females and 68 % males; 44 % were $<12$ years old and 66 % were aged $\geq 12$ years older. No child was positive for hepatitis.

In the parental interviews, 100 % of parents reported that their child ate lunch, dinner and a snack, and 91 % reported their child ate breakfast. When asked to classify their child's health status as good, fair or poor, 68 % responded 'good', 25 % 'fair' and 7 % responded 'poor'. When asked to rate their child's food intake with the same categories, 55 % of parents said 'good,' 40 % 'fair' and 4 % said 'poor'. Twenty-three per cent of parents said their child had seen a doctor in the last 12 months.

### *Phases II and III*

After eliminating implausible values from children who got smaller, two BMI-for-age Z-scores were available for thirty-six children and two height-for-age Z-scores were available for thirty-seven children. Among this sub-sample the initial mean BMI-for-age Z-score was $-1{\cdot}29$ and the median was $-1{\cdot}41$. Sixteen months later, the mean BMI-for-age Z-score decreased to $-1{\cdot}48$ and the median remained unchanged at $-1{\cdot}42$. The mean difference in BMI-for-age Z-scores was $-0{\cdot}17$, with two scores remaining the same ($\pm 0{\cdot}05$), ten increasing and twenty-four decreasing. The initial height-for-age Z-score of the sub-sample was $-2{\cdot}43$ and the median was $-2{\cdot}52$. For the second measurement, the mean height-for-age Z-score was $-2{\cdot}20$ and the median was $-2{\cdot}32$. The average difference was 0·23, with five scores remaining the same ($\pm 0{\cdot}05$), twenty-one increasing and eleven decreasing.

Self-reported compliance for consuming Fe tablets was still high. Fifty-two children had their Hb level checked twice. In this sub-sample eleven children (21 %) were anaemic in Phase I. Of these eleven children, in nine Hb rose to normal level, in one Hb improved but was still low, and in one Hb dropped when rechecked. Additionally, four children whose Hb was originally normal dropped into the anaemic range when rechecked.

## Discussion

In this study, 22 % of children and adolescents were anaemic. According to a 1993 national study, 11 % of Iranian children between 2 and 14 years of age had Fe-deficiency anaemia (Zohouri & Rugg-Gunn, 2002). A national survey in 1999 of 15 740 children aged 2–14 years found that 14·2 % of females and 15·9 % of males were anaemic (Haghshenass *et al*. 1972). The prevalence of anaemia in the present population is much greater than in previous studies of Iranian children. Although most of a very small sample of anaemic children responded to Fe therapy, the high prevalence of normal ferritin and low mean corpuscular volume is indicative of anaemia of chronic disease.

Although information on the Fe intake of our population is not available, studies show dietary intake of Fe among children in urban and rural areas of Fars to be adequate. Zohouri & Rugg-Gunn (2002) found significant differences in daily Fe intake between city and provincial districts in the south western province of Fars (7·73 and 10·33 mg/d, respectively) but not between gender and season in a study of 4-year-old children. A study of 12-year-old boys in rural Fars province and Shiraz (the major city in Fars province) found that the average Fe intake was 44 mg/d (Zohouri & Rugg-Gunn, 2002). Another study in 1995 of 19–21-year-olds reported average intakes of Fe of 16 mg/d for females and 20 mg/d for males (Zohouri & Rugg-Gunn, 2002).

However, differences in Fe absorption from different foods make total Fe intake a poor indicator of dietary adequacy. A 1972 survey

**Table 1.** Prevalence of wasting in 137 school children in rural Fars province in Iran by gender, village and age
(Number of children in each category)

| | Total | Female | Male | Persian | Quashqua'i | $<12$ years | $\geq 12$ years |
|---|---|---|---|---|---|---|---|
| Wasted* | 29 | 11 | 18 | 19 | 10 | 8 | 21 |
| Normal† | 108 | 36 | 72 | 61 | 47 | 58 | 56 |
| Total | 137 | 47 | 90 | 80 | 57 | 66 | 67 |

* BMI-for-age Z-score $<-2$.
† BMI-for-age Z-score $>-2$ and $<2$.

**Table 2.** Prevalence of stunting in 137 school children in rural Fars province in Iran by gender, village and age
(Number of children in each category)

| | Total | Female | Male | Persian | Quashqa'i | <12 years | ≥12 years |
|---|---|---|---|---|---|---|---|
| Stunted* | 78 | 29 | 49 | 47 | 31 | 36 | 42 |
| Normal† | 59 | 18 | 41 | 33 | 26 | 30 | 29 |
| Total | 137 | 47 | 88 | 80 | 57 | 66 | 71 |

* Height-for-age Z-score < −2.
† Height-for-age Z-score > −2 and < 2.

in rural areas of southern Iran noted that 30 % of children were anaemic despite an intake of Fe greater than recommended (Haghshenass *et al.* 1972). A study of dietary sources of Fe of 103 children aged 4 years in Shiraz and a provincial town in Fars province reported that 71 % of Fe intake came from plant sources while 23 % came from animal sources, with almost half the total Fe intake coming from bread. The contribution of plant sources to total Fe intake was significantly greater for the provincial district than in the city (75 % *v*. 60 %). Meat is recognized as an excellent source of bioavailable Fe. However, only 7 % of dietary Fe intake in the provincial children and 16 % in the city children came from meat. This compares with 29 % in Swedish children and 17 % in British children (Zohouri & Rugg-Gunn, 2002).

Phytates in cereals and legumes, and polyphenols in tea and coffee, inhibit Fe absorption while vitamin C in fruits and vegetables enhances absorption of Fe (World Health Organization Regional Office for the Eastern Mediterranean, 2001; Dickey, 2002). In the previously mentioned study, phytate-rich bread was an important source of Fe supplying 27 % Fe in the city and 51 % in the provincial district (Zohouri & Rugg-Gunn, 2002). Tea is a popular drink in Iran even among children, especially in rural areas. The 4-year-old children in Shiraz drank the equivalent of one ordinary Iranian tea cup while the provincial children consumed about two to four cups daily. It is recommended that tea be given 1–2 h after meals to prevent inhibition of Fe absorption.

Factors in addition to dietary habits possibly contributing to the anaemia noted in these children include parasitic and infectious disease, and gastrointestinal bleeding (Zohouri & Rugg-Gunn, 2002). Fifty children had normal serum ferritin and low mean corpuscular volume values indicative of anaemia of chronic disease. In pre-school children in Tanzania, a low-dose Fe supplement improved Fe status and appetite but did not improve anaemia. Quarterly anthelmintic treatment improved not only appetite and Fe status but also growth (Stoltzfus *et al.* 2003).

One possible source of infection is the bacterium *Helicobacter pylori*. *H. pylori* infection is present in 80 % of the population in developing countries; the prevalence of infection among individuals aged 6–20 years was reported as 47·5 % in one province and 30·6 % in another province in Iran (Mikaeli *et al.* 2003). Infection with *H. pylori* has been associated with several micronutrient deficiencies including Fe (Annibale *et al.* 2002; Dickey, 2002; Yakoob *et al.* 2003). *H. pylori* has been associated with Fe-deficiency anaemia in 6–12-year-old Korean children (Seo *et al.* 2002), Korean female adolescents but not males (Choe *et al.* 2003), Alaskan natives (Petersen *et al.* 1996; Yip *et al.* 1997; Parkinson *et al.* 2000), Indian adults (Pavithran *et al.* 2003) and French adults (Nahon *et al.* 2003). It has been speculated (Choe *et al.* 2003) that a relationship between *H. pylori* and Fe-deficiency anaemia is found in females but not males due to their marginal Fe status. *H. pylori* infection should be considered a cause of Fe deficiency refractory to Fe supplementation (Choe *et al.* 2003; Pavithran *et al.* 2003).

The prevalence of stunting was very high and increased throughout the 1·5 years of the study. Stunting was higher initially among children aged ≥12 years, indicating possible delayed puberty. Zn deficiency may be contributing to the high prevalence of stunting. Zn deficiency was identified as a cause of stunting and delayed development in the Middle East in the 1970s (Sandstead, 1991). According to a review of community-based, randomized, placebo-controlled micronutrient supplementation trials even mild or moderate Zn deficiency may affect growth (Rivera *et al.* 2003). Zn deficiency occurs in populations whose diets are low in rich sources of Zn such as red meat and high in whole-grain cereals rich in fibre and phytate, which decrease Zn absorption. Additionally tannins in tea can decrease Zn absorption (Sandstead, 1998; PDRHealth, 2004).

Zn deficiency has been reported in children and adolescents from Egypt, Iran, Turkey, China, Yugoslavia and the USA (Sandstead, 1991). A 1997 study of 881 adolescents in Tehran reported that almost one-third showed biochemical signs of Zn deficiency and 50 % consumed less than 50 % of their Zn requirement according to 24 h diet recalls (Mahmoodi & Kimiagar, 2001). The addition of animal foods with micronutrient supplements or other supplemental foods or the addition of skimmed

**Table 3.** Results of tests of iron status in 137 Iranian school children
(Number of children in each category and percentage in parentheses)

| Test | Low | Normal | High | Missing |
|---|---|---|---|---|
| Serum ferritin | 4 (2·9) | 95 (69·3) | 0 | 38 (27·7) |
| Total Fe-binding capacity | 0 | 74 (54·0) | 25 (18·2) | 38 (27·7) |
| Mean corpuscular volume | 79 (57·7) | 32 (23·3) | 0 | 26 (19·0) |
| Mean corpuscular Hb concentration | 0 | 111 (81·0) | 0 | 26 (19·0) |
| Mean corpuscular Hb | 25 (18·2) | 86 (62·8) | 0 | 26 (19·0) |
| Serum Fe | 19 (13·9) | 67 (48·9) | 13 (9·5) | 38 (27·7) |
| Hb | 24 (17·5) | 84 (61·3) | 3 (2·2) | 26 (19·0) |

milk powder alone enhances growth (Rivera *et al.* 2003). According to the Nutrition Collaborative Research Support Programme, diets of primarily vegetarian children in rural Egypt, Kenya and Mexico were low in vitamin A, vitamin $B_{12}$, riboflavin, Ca, Fe and Zn leading to anaemia, poor growth, impaired cognitive performance and poor growth (Murphy & Allen, 2003).

Other nutrient inadequacies may be present, as there are no good data on the nutrient intake of children in the present study. Meal and snack consumption was regular among this sample. Breakfast was the meal most often skipped, although only 9 % of mothers reported their child did not eat breakfast. This compares with 15 % of school children in a large study in Saudia Arabia (Abalkhail & Shawky, 2002).

It is known that the study children and their families lead a subsistence lifestyle and there is seasonal variety in their food intake. The extent to which energy inadequacy, other micronutrient deficiencies in addition to Fe and Zn, or the presence of parasites could be contributing to poor growth has not yet been investigated. In Kenyan school children, multiple nutrient deficiencies (Ca, Zn, Fe, riboflavin, vitamin A and vitamin $B_{12}$) attributed to a diet low in animal products and high in fibre and phytates have been linked to stunting, poor development and rickets (Bwibo & Neumann, 2003; Neumann *et al.* 2003). Dietary supplementation with meat or milk enhanced gain in weight and lean body mass in these children and improved cognitive performance (Grillenberger *et al.* 2003; Whaley *et al.* 2003). In 30–90-month-old rural Malawian children, supplementation of their maize-based diet with more animal foods and decreasing phytic acid increased energy, protein, Ca, available Zn, haem Fe and vitamin $B_{12}$. The supplementation also increased mid-arm circumference and arm muscle area and decreased anaemia and common infections (Gibson *et al.* 2003).

## Conclusion

Increasing access to animal foods and fruits and vegetables is one suggestion for improving the nutritional status of the present study population. Animal foods are high in Fe and Zn, and the vitamin C in fruits and vegetables enhances Fe absorption. In fact, this is one of the four parts of the WHO's Comprehensive Regional Strategy for the Eastern Mediterranean for combating Fe deficiency and anaemia. The other parts are: supplementation with Fe tablets; public health activities, such as the control of parasitic infestations and family planning; the fortification of staple food with Fe (World Health Organization Regional Office for the Eastern Mediterranean, 2001). Further investigation into the cause of stunting, wasting and anaemia is recommended in this unique population to improve its health and nutritional status. This should include a comprehensive assessment of dietary intake and tests for *H. pylori* and other infectious agents. The in-progress phases of the present project are investigating these unknowns.

## References


Abalkhail B & Shawky S (2002) Prevalence daily breakfast intake, iron deficiency anemia and awareness of being anaemic among Saudi school students. *Int J Food Sci Nutr* **53**, 519–528.

American Academy of Pediatrics Committee on Nutrition (1998) Cholesterol in childhood. *Pediatrics* **101**, 141–147.

Annibale B, Capurso G & Delle Fave G (2002) Consequences of *Helicobacter pylori* infection on the absorption of micronutrients. *Dig Liver Dis* **34**, Suppl. 2, S72–S77.

Azizi F, Allahverdian S, Mirmiran P, Rahmani M & Homammadi F (2001*a*) Dietary factors and body mass index in a group of Iranian adolescents: Tehran lipid and glucose study-2. *Int J Vitam Nutr Res* **71**, 123–127.

Azizi F, Rahmani M, Madjid M, Allahverdian S, Ghanbili J, Ghanbarian A & Hajipour R (2001*b*) Serum lipid levels in an Iranian population of children and adolescents: Tehran lipid and glucose study. *Eur J Epidemiol* **17**, 281–288.

Bwibo NO & Neumann CG (2003) The need for animal source foods by Kenyan children. *J Nutr* **133**, Suppl., 3936S–3940S.

Centers for Disease Control and Prevention (1998) Recommendations to prevent and control iron deficiency in the United States. *MMWR* **47**, 1–28.

Choe YH, Kim SK & Hong YC (2003) The relationship between *Helicobacter pylori* infection and iron deficiency: sero-prevalence study in 937 pubescent children. *Arch Dis Child* **88**, 178.

CIA (2003) Iran. The World Factbook. http://www.cia.gov/cia/publications/factbook/geos/ir.html

Dickey W (2002) Iron deficiency, gastric atrophy and *Helicobactor pylori*. *Dig Liver Dis* **34**, 313–315.

Gibson RS, Yeudali F, Drost N, Mtitimuni BM & Cullinan TR (2003) Experience of a community based dietary intervention to enhance micronutrient adequacy of diets in animal source foods and high in phytates: a case study in rural Malawian children. *J Nutr* **133**, Suppl., 3992S–3999S.

Grillenberger M, Neumann CG, Murphy SP, Bwibo NO, van't Veer P, Hautvast JG & West CE (2003) Food supplements have a positive impact weight gain and the addition of animal source foods increases lean body mass of Kenyan schoolchildren. *J Nutr* **133**, Suppl., 3957S–3964S.

Haghshenass M, Mahloudji M, Reinhold JG & Mohammad N (1972) Iron-deficiency anaemia in an Iranian population associated with high intakes of iron. *Am J Clin Nutr* **25**, 1143–1146.

Kadivar MR, Yarmohammadi H, Mirahmadizadeh AR, Vakili M & Karimi M (2003) Prevalence of iron deficiency anemia in 6 months to 5 years old children in Fars, Southern Iran. *Med Sci Monit* **9**, CR100–CR104.

Karimi M, Kadivar R & Yarmohammadi H (2002) Assessment of the prevalence of iron deficiency anemia by serum ferritin in pregnant women in southern Iran. *Med Sci Monit* **8**, CR488–CR492.

Keshavarz H & Sarraf Z (1997) Qashqa'i tribeswomen and their health. *Rev Epidemiol Sante Publique* **45**, 279–285.

Mahmoodi MR & Kimiagar SM (2001) Prevalence of zinc deficiency in junior high school students of Tehran City. *Biol Trace Elem Res* **81**, 93–103.

Mikaeli J, Malekzadeh R, Ziad Alizadeh B, Nasseri S, Mogaddam, Valizadeh M, Khoncheh R & Massarrat S (2003) Prevalence of *Helicobacter pylori* in two Iranian provinces with high and low incidence of gastric carcinoma. Tehran, Iran: Digestive Diseases Research Center, Tehran University of Medical Sciences

Ministry of Health and Medical Education (1998) *The Nutritional Status of Children October–November*. Tehran: Ministry of Health and Medical Education.

Murphy SP & Allen LH (2003) Nutritional importance of animal source foods. *J Nutr* **133**, Suppl., 3932S–3935S.

Nahon S, Lahmek P, Massard J, Lesgourgues B, Mariaud de Serre N, Traissac L, Bodiguel V, Adotti F & Delas N (2003) *Helicobacter pylori*-associated chronic gastritis and unexplained iron deficiency anemia: a reliable association? *Helicobacter* **8**, 573–577.

Neumann CG, Bwibo NO, Murphy SP, Sigman M, Whaley S, Allen LH, Guthrie D, Weiss RE & Demment MW (2003) Animal source foods improve dietary quality, micronutrient status, growth and cognitive function in Kenyan school children: background, study design and baseline findings. *J Nutr* **133**, Suppl., 3941S–3949S.

Parkinson AJ, Gold BD, Bulkow L, Wainwright RB, Swaminathan B, Khanna B, Petersen KM & Fitzgerald MA (2000) High prevalence of

*Helicobacter pylori* in the Alaska native population and association with low serum ferritin levels in young adults. *Clin Diagn Lab Immunol* **7**, 885–888.

Pavithran K, Arjun R, Aruna R & Thomas M (2003) Refractory iron deficiency anemia – is *Helicobacter pylori* the culprit? *MedGenMed* **5**, 32.

PDRhealth (2004) Zinc. http://pdrhealth.com/drug_info/nmdrugprofiles/nutsupdrugs/zin_0281.shtml.

Petersen KM, Parkinson AJ, Nobmann ED, Bulkow L, Yip R & Mokdad A (1996) Iron deficiency anemia among Alaska natives may be due to fecal loss rather than inadequate intake. *J Nutr* **126**, 2774–2783.

Rivera JA, Hotz C, Gonzalez-Cossio T, Neufeld L & Garcia-Guerra A (2003) The effect of micronutrient deficiencies on child growth: a review of results from community-based supplementation trials. *J Nutr* **133**, Suppl., 4010S–4020S.

Salehi M, Kimiagar SM, Shahbazi M, Mehrabi Y & Kolahi AA (2004) Assessing the impact of nutrition education on growth indices of Iranian nomadic children: an application of a modified beliefs, attitudes, subjective-norms and enabling-factors model. *Br J Nutr* **91**, 779–787.

Sandstead HH (1991) Zinc deficiency. A public health problem? *Am J Dis Child* **145**, 853–859.

Sandstead HH (1998) Zinc deficiency and development. http://www.iza.c/omzhe_org/Articles/Art-02.htm

Seo JK, Ko JS & Choi KD (2002) Serum ferritin and *Helicobacter pylori* infection in children: a sero-epidemiologic study in Korea. *J Gastroenterol Hepatol* **17**, 754–757.

Stoltzfus RJ, Chway HM, Montresor A, Tielsch JM, Jape JK, Albonico M & Savioli L (2003) Low dose daily iron supplementation improves iron status and appetite but not anemia, whereas quarterly anthelminthic treatment improves growth, appetite and anemia in Zanzibari preschool children. *J Nutr* **134**, 348–356.

Whaley SE, Sigman M, Neumann C, Bwibo N, Guthrie D, Weiss RE, Alber S & Murphy SP (2003) The impact of dietary intervention on the cognitive development of Kenyan school children. *J Nutr* **133**, Suppl., 3965S–3971S.

World Health Organization Regional Office for the Eastern Mediterranean (2001) Half of children and women in eastern Mediterranean region are anaemic. http://www.emro.who.int/NFS/FlourFortificationPressRelease1306.htm

Yakoob J, Jafri W & Abid S (2003) *Helicobacter pylori* infection and micronutrient deficiencies. *World J Gastroenterol* **9**, 2137–2139.

Yip R, Limburg PJ, Ahlquist DA, *et al.* (1997) Pervasive occult gastrointestinal bleeding in an Alaska native population with prevalent iron deficiency. Role of *Helicobacter pylori* gastritis. *JAMA* **277**, 1135–1139.

Zohouri FV & Rugg-Gunn AJ (2002) Sources of dietary iron in urban and provincial 4-year-old children in Iran. *Asia Pac J Clin Nutr* **11**, 128–132.