Iron-deficiency anaemia and physical performance in adolescent girls from different ethnic backgrounds

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Iron-deficiency anaemia and physical performance in adolescent girls from different ethnic backgrounds

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One hundred and fourteen 11–14-year-old schoolgirls from Wembley, Middlesex, were assessed for Fe status (haemoglobin (Hb), packed cell volume and mean corpuscular Hb concentration, height, weight, eating habits, and ethnic origin, and undertook a step test to assess physical performance. Overall, 20% of girls had Hb less than 120 g/l, ranging from 11% in White girls to 22–25% in girls of Asian origin. Prevalence of low Hb was 20% in vegetarians, higher in White vegetarians compared with non-vegetarians (23 *v*. 4%), but lower in the Indian vegetarians compared with non-vegetarians (17 *v*. 32%). Low Hb was present in 25% of girls who had tried to lose weight in the previous year, and was more common in girls from manual social class backgrounds than non-manual (24 *v*. 10%). At the start of the step test the twenty-three girls with low Hb had heart rates similar to those with normal Hb, but heart rates in the low Hb group were significantly elevated immediately after the step test, and still significantly elevated 1 min later. The present results confirm the findings of a previous study in White girls, and suggest that physical performance may be compromised at mild levels of anaemia.

Iron: Anaemia: Adolescence: Ethnic origin: Physical activity

Recent studies in the UK (Department of Health, 1989; Nelson *et al.* 1990; Adamson *et al.* 1992) suggest that Fe intakes in adolescent girls are commonly well below the Reference Nutrient Intake (Department of Health, 1991). The consequence is likely to be Fe-deficiency anaemia, and Nelson and co-workers (1993) have recently shown that in a group of apparently healthy White schoolgirls aged 12–14 years, 10·5% were anaemic.

The implications of this finding relate to health and academic and physical performance in schoolchildren. Fe deficiency and Fe-deficiency anaemia are established causes of reduced immune response (Brock & Mainou-Fowler, 1986; Dallman, 1987). Fe deficiency and Fe-deficiency anaemia are known to be associated with less than optimal behaviour and poorer performance in intelligence tests (Pollitt *et al.* 1989; Pollitt, 1990), and with poorer school performance (Webb & Oski, 1973) and disruptive behaviour (Webb & Oski, 1974). Recent well-designed studies in Indonesia (Soemantri *et al.* 1985; Soemantri, 1989), Thailand (Pollitt *et al.* 1989) and India (Seshadri & Gopaldas, 1989) all indicate that anaemia in adolescence is associated with poor performance in academic tests, and that Fe supplementation of anaemic children over a period of 3 months (or longer) results in significant improvements in performance. Differences in the brain function of anaemic and non-anaemic children have been noted (Tucker *et al.* 1989). Anaemic children in India perform significantly worse at both submaximal and maximal workloads on step-tests (Bhatia & Seshadri, 1987), and in running 1600 m (Satyanarayana *et al.* 1990). While the levels of Fe deficiency and anaemia in British schoolchildren are generally less severe than in Third World countries, one cannot rule out the possibility that health and academic and physical performance may be compromised in British children because of poor Fe status.

There may also be long-term consequences of anaemia in adolescent girls. Godfrey *et al.* (1991) have shown that low haemoglobin (Hb) in pregnancy is associated with a raised placenta:birth weight ratio. This, in turn, may be a predictor of high blood pressure in adult life (Barker *et al.* 1990). If anaemia in adolescent girls persists into their reproductive years, this has important implications for the long-term health of their offspring.

Variations in diet between different ethnic groups in the UK suggest that Fe deficiency may be more common amongst Asians, due in part to the higher prevalence of vegetarianism within some Asian communities. Most of the information available relates to pregnancy (Wharton *et al.* 1984; Abraham *et al.* 1987) or young children (Ehrhardt, 1986) or infants, and there is no information currently available on prevalence of anaemia in adolescent Asian girls.

The present project follows on from previous work carried out in Southwest London (Nelson *et al.* 1993), and was undertaken as a preliminary assessment of the prevalence of Fe-deficiency anaemia in a cross-section of 11–14-year-old British schoolgirls from a variety of ethnic backgrounds. Its additional purpose was to assess the relationship between Fe status and physical performance.

METHODS

A comprehensive school in North London attended by children from a wide variety of socio-economic and ethnic backgrounds was selected for the study. A letter was sent to the parents of all girls in years 7–10 (age 11–14 years) asking if they would be willing for their daughters to take part in the study. Of 305 girls, written permission to take part was received for 140 (46 %), and of those, 114 (37 %) completed the study. The letter to parents included a short questionnaire on ethnic origin, parents' occupation, household composition, and history of infection in their daughter over the previous 6 months.

Girls were called for appointments at 20 min intervals to the school medical room. They were asked to complete a questionnaire on eating habits, menstruation, and habitual levels of activity. Height was measured in stockinged feet, and weight in light indoor clothing. Each child completed a 2 min step test (0·2 m height, 100 steps/min), heart rate being measured by a wrist pulse with the subject seated immediately before, immediately after, and 1 min after completion. Capillary blood samples were collected from the thumb into two 20 μl capillary tubes for Hb determination (cyanmethaemoglobin method, Van Kampen & Zijlstra, 1961), and two 10 μl samples for packed cell volume. Low to borderline Fe status was deemed to be present if Hb concentration was less than 120 g/l (Dallman & Siimes, 1979).

RESULTS

Table 1 shows the number of girls in the study by ethnic origin, with their mean age, height and weight. The lower mean age of the White girls is accounted for by the higher proportion of children from year 7 in this group, while the higher mean age in the 'Other' ethnic group is because they were all in year 10. The Afro-Caribbean girls were significantly taller ($P = 0{\cdot}004$) than the girls of Indian and Pakistani origin, and heavier than both White and Asian girls ($P = 0{\cdot}001$; one-way analysis of variance).

Table 2 shows the haematological characteristics of the sample by ethnic origin. Mean Hb, packed cell volume and mean corpuscular Hb concentration (MCHC) were in the normal range, and there were no statistically significant differences between ethnic groups. The percentage of girls with low Hb (< 120 g/l) was highest in the Afro-Carribbean group (50 %) and the Pakistani group (25 %), but the number of subjects was small (*n* 8 in each group). Amongst Indian girls, 22 % had Hb < 120 g/l. The White girls had a prevalance

Table 1. *Height and weight of 114 schoolgirls aged 11–14 years living in Wembley, Middlesex, by ethnic origin*

Mother's ethnic origin	n	Age (years)	Height (m) Mean	Height (m) SD	Weight (kg) Mean	Weight (kg) SD
White	37	12·8	1·59	0·10	50·3[c]	11·2
Afro-Caribbean	8	13·6	1·64[a]	0·06	65·4[d]	12·7
Indian	58	13·8	1·55[b]	0·07	48·4[c]	10·1
Pakistani	8	13·9	1·52[b]	0·06	48·4[c]	11·1
Other	3	14·7	1·58	0·08	59·3	14·1
All origins	114	13·5	1·57	0·08	50·5	11·6

[a,b,c,d] Mean values within a column with unlike superscripts were significantly different (one-way analysis of variance): [a,b] $P = 0{\cdot}004$; [c,d] $P = 0{\cdot}001$.

Table 2. *Haematological characteristics of 114 schoolgirls aged 11–14 years living in Wembley, Middlesex, by ethnic origin**

Mother's ethnic origin	n	Hb (g/l) Mean	Hb (g/l) SD	PCV Mean	PCV SD	MCHC (g/l) Mean	MCHC (g/l) SD	Hb < 120 g/l No.	Hb < 120 g/l %
White	37	132	12	0·397	0·086	341	48	4	11
Afro-Caribbean	8	125	10	0·374	0·023	335	24	4	50
Indian	58	129	11	0·388	0·030	332	22	13	22
Pakistani	8	128	9	0·385	0·017	331	20	2	25
Other	3	131	14	0·403	0·015	325	21	0	0
All origins	114	130	11	0·390	0·055	335	33	23	20

Hb, Haemoglobin; PCV, packed cell volume; MCHC, mean corpuscular Hb concentration.
* For details of subjects and procedures, see p. 428.

of low Hb of 11%. The 'Other' group (Chinese and Moroccan) had no children with Hb < 120 g/l. The chi-squared test (combining Other with White, and Indian with Pakistani, to allow for the small numbers in some cells) showed that there were statistically significantly higher proportions of girls with low Hb in the Black and Asian girls compared with White and Other (χ^2 7·257, $P < 0{\cdot}05$). Examination of blood slides revealed no sickle-cell trait or abnormal cells indicative of haemoglobinopathies.

The distribution of Hb values by ethnic origin is shown in Fig. 1. The vertical line indicates the World Health Organization cut-off for anaemia in adolescent girls (120 g/l). The majority of the twenty-three girls who had low Hb had values just below 120 g/l.

There were statistically significant differences between girls with Hb above or below 120 g/l for age, Hb, packed cell volume, and MCHC (Table 3). There were no statistically significant differences between the two groups regarding height (1·58 *v.* 1·57 m), weight (51·7 *v.* 50·2 kg), age at menarche (11·9 *v.* 12·0 years), number of incidents or days of infection, or in the average levels of reported activity over and above participation in school physical education classes. The girls with low Hb had, on average, been menstruating for longer (2·1 years) than those who had Hb values above 120 g/l (1·4 years).

Fifty-four girls (47%) were classified as vegetarian (Table 4): twenty-six lacto-ovo-vegetarians (some of whom ate meat, meat products or fish occasionally but always less

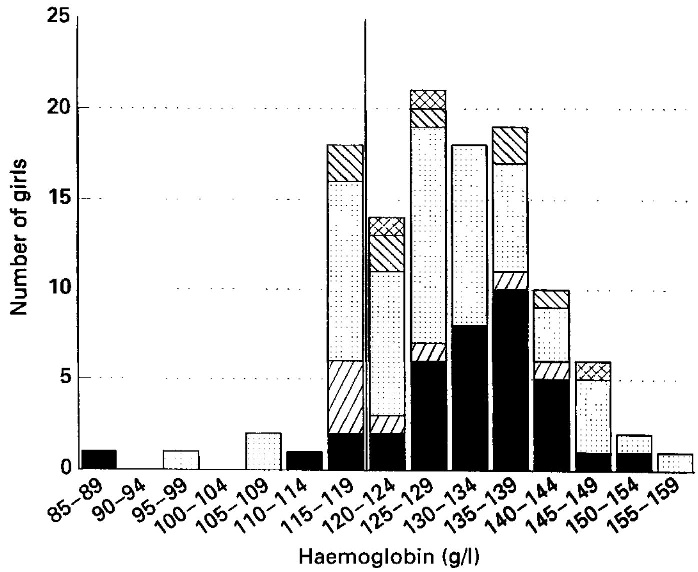

Fig. 1. Haemoglobin levels in 114 schoolgirls aged 11–14 years living in Wembley, Middlesex, according to ethnic origin. (■), White; (▨), Black; (▦), Indian, (▧), Pakistani; (⊠), other. The vertical line indicates the World Health Organization cut-off point for anaemia in adolescent girls (120 g/l).

Table 3. *Age, haemoglobin (Hb), packed cell volume, and mean corpuscular Hb concentration (MCHC) in 114 schoolgirls aged 11–14 years living in Wembley, Middlesex, according to Hb level**

	Hb < 120 g/l (*n* 23)		Hb ⩾ 120 g/l (*n* 91)		
	Mean	SE	Mean	SE	*P*
Age (years)	14·0	0·23	13·4	0·21	0·04
Haemoglobin (g/l)	115	1·6	133	0·9	< 0·001
Packed cell volume	0·37	0·005	0·39	0·003	0·002
MCHC (g/l)	312	0·58	343	0·33	< 0·001
Menarchial duration (years)	2·1	0·33	1·4	0·14	0·026

* For details of subjects and procedures, see p. 428.

than once per week), twenty-six lacto-vegetarians, and two vegans. The proportion of vegetarians was highest amongst Indian girls (62%) compared with the other groups. Overall, there was no difference in the proportion of girls with low Hb between vegetarians (11/54) and non-vegetarians (12/60). Amongst the White girls, however, three (23%) of the thirteen vegetarians had low Hb compared with only one (4%) of the twenty-four non-vegetarians. In contrast, amongst the Indian girls, six (17%) of the thirty-six vegetarians had low Hb, compared with seven (32%) of the twenty-two non-vegetarians. The proportion of non-vegetarians with low Hb was statistically significantly greater amongst the Indian (7/22) compared with the White girls (1/24; Fisher's exact test, $P = 0{\cdot}018$).

Twenty-four girls said they had dieted in order to lose weight in the previous year, of whom six (25%) had Hb < 120 g/l, compared with seventeen (19%) of the ninety who had

Table 4. *Number and percentage of vegetarians, and number and percentage of vegetarians and non-vegetarians with haemoglobin (Hb) < 120 g/l in 114 schoolgirls aged 11–14 years living in Wembley, Middlesex, by ethnic origin**

Mother's ethnic origin	n	Total vegetarian		With Hb < 120 g/l: Vegetarian		With Hb < 120 g/l: Non-vegetarian	
		No.	%	No.	%	No.	%
White	37	13	35	3	23	1	4
Afro-Caribbean	8	1	12	1	100	3	43
Indian	58	36	62	6	17	7	32
Pakistani	8	3	38	1	33	1	20
Other	3	1	33	0	0	0	0
All origins	114	54	47	11	20	12	20

* For details of subjects and procedures, see p. 428.

Table 5. *Heart rate (beats/min) before, immediately after, and 1 min after a 2 min step test, in 114 schoolgirls aged 11–14 years living in Wembley, Middlesex, according to haemoglobin (Hb) level**

	Hb < 120 g/l (n 23)		Hb ⩾ 120 g/l (n 91)		
	Mean	SE	Mean	SE	P
Before step test	88·0	3·1	84·5	1·5	0·31
Immediately after step test	134·8	3·3	125·6	2·2	0·025
1 min after step test	100·9	2·8	93·7	1·8	0·04

* For details of subjects and procedures, see Table 1 and p. 428.

not tried to lose weight. There were eighty children from social classes III, IV and V of whom twenty (24%) had low Hb, compared with three (10%) of the twenty-nine from social classes I and II. Neither of these differences was statistically significant.

Table 5 shows the heart rate measures before and after the step test according to Hb level. The low Hb group had significantly higher heart rates immediately after and 1 min after the step test ($P < 0·05$). Immediately after the step test the difference in heart rate between the girls with low and normal Hb levels was greatest in the Indian girls (140 *v.* 126 beats/min, $P < 0·01$).

DISCUSSION

The initial response rate was disappointingly low (46%). This may have resulted from inclusion of the questionnaire with the letter to parents asking for permission for their daughter to take part in the study. The questionnaire included items on ethnic group, occupation, and household composition, which may have discouraged some parents from responding. Of the 140 whose parents gave permission, 114 (81%) completed the study.

The number of White and Indian girls was sufficient to make reasonable estimates of the prevalence of low Hb in this age group. The number of girls with Afro-Caribbean, Pakistani and other ethnic backgrounds was small, and estimates of prevalence in these groups are probably less reliable. Nevertheless, the χ^2 test suggests that the higher observed prevalence of low Hb in the Indian and Pakistani girls compared with the White girls was unlikely to have arisen just by chance (Table 2). The value in White girls (11 %) confirms the value observed in a previous study (Nelson *et al.* 1993).

The mean packed cell volume and MCHC were both significantly lower in the low Hb group, suggesting that there were true differences in Fe status between the two groups (Table 3). While a single low Hb value is not necessarily indicative of Fe-deficiency anaemia, in the absence of histological evidence of haemoglobinopathies it is likely to be an indicator of low to borderline Fe status. The majority of girls with low Hb levels had values just below 120 g/l, and could therefore be regarded as having a mild Fe deficiency. Even at these levels, however, there appear to be consequences in terms of physical performance.

An important reason for choosing a school with a high proportion of girls of Indian origin was the likelihood that many of the girls would be vegetarian. Surprisingly, when all ethnic origins were pooled, the proportion of girls having low Hb was the same amongst vegetarians as amongst the non-vegetarians, whereas a previous study (Nelson *et al.* 1993) reported that the proportion was higher in vegetarians (25 %) than non-vegetarians (9 %). When analysed by ethnic origin, however, the present study supports the previous finding that amongst White girls, being a vegetarian confers an increased likelihood of having a low Hb level. This may be because most of the White vegetarians had only recently adopted the practice, and a proportion may not have found suitable dietary alternatives which provide the Fe previously supplied by meat and meat products. In contrast, amongst the Indian girls, being vegetarian did not confer an increased risk of having low Hb, suggesting that vegetarians of long-standing (typical of most of the Indian girls) will not necessarily have prevalence of low Hb that was higher than their omnivorous classmates. More dietary details would be required from a larger sample to be able to clarify these issues.

The results of the step test (Table 5) suggest that for a given body size the O_2-carrying capacity of the blood was lower in the low Hb group, necessitating a higher heart rate. It cannot be said what effect this difference might have on activity generally. There is anecdotal evidence to suggest that patients with low Hb levels reduce their activity levels in order to avoid precipitating clinical symptoms of anaemia (e.g. tiredness, lassitude, palpitations) and thus appear to function normally albeit at reduced levels of activity. If this were so, then it is possible that the low Hb group would have lower activity levels, which may have consequences for long-term bone health over and above other risk factors for reduced bone mass. Failure in the present study to demonstrate differences in the level of leisure activity outside school may have had to do with the insensitivity of the measuring instrument, and further evidence of the effect of low Hb on activity generally is needed for girls in this age group.

The results from this study show that low Hb is likely to be more common in the Indian population than the White population. The present results confirm and extend those of a previous study (Nelson *et al.* 1993) which suggested that low Hb levels are common amongst apparently healthy adolescent girls. The effect of low Hb on short-term physical performance is evident, and further measures of physical performance need to be undertaken in relation to Fe status.

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