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Anaemia and vitamin A status among adolescent schoolboys in Dhaka City, Bangladesh

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Abstract

Objectives: To investigate the prevalence of anaemia and subclinical vitamin A deficiency among adolescent schoolboys in Dhaka City, Bangladesh, and to identify factors related to anaemia and vitamin A status.

Design: A cross-sectional study.

Setting: Government high schools in Dhaka City, Bangladesh.

Subjects and methods: A total of 381 boys, aged 11–16 years, from 10 schools in Dhaka City participated in the study. Socio-economic, anthropometric and dietary data were collected. Haemoglobin and serum retinol (vitamin A) concentrations were determined.

Results: Seven per cent of the boys were anaemic and 22% had serum vitamin A levels below the adequate level of 1.05 μmol l^{-1}, with only 1.5% having subclinical vitamin A deficiency ($<$0.70 μmol l^{-1}). Food frequency data revealed poor dietary habits. Multiple regression analysis showed that age, body mass index (BMI), parents' occupation, serum vitamin A level and frequency of intakes of meat and fruit were significantly independently related to haemoglobin level. The overall *F*-ratio (13.1) was highly significant ($P < 0.000$) and the adjusted R^2 was 0.192. For serum vitamin A, BMI, father's education, per capita expenditure on food, haemoglobin concentration and frequency of intake of vitamin A-rich fruit were found to be significantly independently related. The overall *F*-ratio (14.5) was highly significant ($P < 0.000$) and the adjusted R^2 was 0.186.

Conclusion: The data show that adolescent schoolboys in Dhaka City have anaemia and inadequate vitamin A status, although the extent of the problems is lower than in other population groups in the country. Sociodemographic and dietary factors appear to have important relationships with anaemia and vitamin A status of these boys.

Keywords
Adolescent boys
Anaemia
Vitamin A deficiency
Body mass index
Bangladesh

Iron-deficiency anaemia and vitamin A deficiency are probably the most common micronutrient deficiencies in developing countries worldwide[1]. Iron is an essential nutrient for skeletal growth, and thus iron deficiency may limit growth during adolescence[2]. Iron-deficiency anaemia is known to affect neurological development and school achievement among adolescent children[3–5]. Vitamin A has also been indicated to be important for growth, development and maturation[2]. Individuals with subclinical vitamin A deficiency are at increased risk of impaired immunity, anaemia and increased morbidity and mortality from a range of infectious diseases[6–8].

In Bangladesh, anaemia and vitamin A deficiency have long been identified as two of the major public health problems[9,10]. A significant number studies have been conducted in the past but mainly focused on the most vulnerable groups, such as infants, pre-school children and pregnant women, and were largely carried out in rural populations. Almost one-quarter of the total population in Bangladesh are adolescents[11]. Adolescence is a critical stage of life when growth is accelerated and major physical and sexual development takes place[12]. It is the time when more than 20% of the total growth in stature and up to 45% of adult bone mass are achieved, and weight gained during this period contributes about 50% to adult weight[13]. There is evidence that the tempo of growth during adolescence is slower in undernourished populations[14]. Nevertheless, adolescent nutrition has not received adequate attention in the country, although a few studies have been carried out recently on adolescent girls[15–18]. As a consequence, data on adolescent boys in Bangladesh are very limited[19].

The present study was undertaken to investigate the prevalence of anaemia and subclinical vitamin A deficiency among adolescent schoolboys in Dhaka City, Bangladesh. Furthermore, we examined the relationships of various

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sociodemographic and dietary factors with haemoglobin and serum vitamin A concentrations among these boys.

Subjects and methods

Subject identification and selection

The study group comprised 381 boys, aged 11–16 years, who were students of grades VI–X at 10 different government high schools in Dhaka City. The participants were selected using a multistage sampling technique, which included 10 randomly selected thanas (administrative unit) in the Dhaka Metropolitan area. One school from each thana was purposively selected. For each school, 40 students, eight from each grade, were also selected by simple random sampling.

A minimum sample size of 384 boys was estimated on the basis of 95% confidence interval, at 0.05 level of desired accuracy with a conservative prevalence of 50% of anaemia or subclinical vitamin A deficiency. Only boys who obtained written parental consent were included in the study. A total of 19 boys or their parents refused to give blood samples. The study was approved by the Institute of Nutrition and Food Science, University of Dhaka and was conducted from September to October 2000.

Questionnaire and sample collection

A questionnaire was developed to collect socio-economic and demographic information of the participants, and parents were asked to complete this form. The data on socio-economic information were not available for 24 participants. The dietary pattern was assessed by interviewing the subjects using a 7-day food-frequency questionnaire (FFQ) on selected food items. Anthropometric measurements and blood samples were collected following the interview. Two millilitres of venous blood were drawn from each subject. An aliquot of the blood was placed immediately in a tube containing Drabkin's solution for haemoglobin estimation. The remaining blood specimen was placed in a glass centrifuge tube and immediately wrapped in foil to protect against degradation of vitamin A by light. After centrifugation, serum samples were separated and kept frozen at −20°C until further analysis. Serum vitamin A analysis was done within 3 months of blood collection.

Anthropometric and biochemical measurements

Height and body weight of the subjects were taken using a combined height–weight scale (Detecto-Medic; Detecto Scales Inc., Missouri, USA) by standard methods, which have been validated[18]. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m). Using the 2000 growth chart tables from the Centers for Disease Control and Prevention and the least mean squares method, *Z*-scores were calculated for height-for-age and BMI-for-age[20]. According to the recommendation made by the World Health Organization (WHO) Expert Committee, a cut-off of less than minus two standard deviations (−2SD) for height-for-age was used to define stunting[21]. The prevalence of thinness was estimated as BMI-for-age less than −2SD[20]. Haemoglobin concentration was determined by the cyanomethaemoglobin method, using a commercial kit (Boehringer Mannheim, Germany). Serum retinol (vitamin A) was determined by high-performance liquid chromatography according to Bieri *et al.*[22] with modifications, as described elsewhere[17].

Statistical analyses

Statistical analysis was done using SPSS version 12.0 (SPSS Inc., Chicago, IL, USA). Univariate analysis comprised simple frequency distribution of selected variables. For each of the variables, a normality test for distribution of the data was performed using the Kolmogorov–Smirnov goodness-of-fit test. Where necessary, data were normalised using appropriate transformations. Data are presented as mean ± SD when normally distributed and median (25–75 percentile) when not normally distributed. Prevalence of anaemia was determined according to WHO criteria, i.e. haemoglobin $<115\,\mathrm{g\,l^{-1}}$ for 11-year-olds, $<120\,\mathrm{g\,l^{-1}}$ for 12–14-year-olds and $<130\,\mathrm{g\,l^{-1}}$ for 15–16-year-olds[23]. Serum retinol concentration $<0.70\,\mu\mathrm{mol\,l^{-1}}$ was classified as subclinical vitamin A deficiency, and $>1.05\,\mu\mathrm{mol\,l^{-1}}$ was accepted as adequate vitamin A status[7].

To assess the relationship of sociodemographic factors with haemoglobin and serum vitamin A, selected variables were divided into groups, either on the basis of prior logical categories (father's and mother's education and occupation) or to produce approximately equal numbers of subjects in each group (per capita income or per capita expenditure on food). Parents' occupation was categorised reflecting the family's socio-economic status. Mean haemoglobin and serum vitamin A were calculated for each group, and the statistical significance of differences between groups assessed by one-way analysis of variance followed by Duncan's multiple range test (where appropriate) using log-transformed values for serum vitamin A only. Pearson's correlation test was performed to examine the associations of haemoglobin and serum vitamin A with various social, demographic and food frequency data. Finally, backwards stepwise logistic regression analysis was performed to examine the independent relationship of various social, demographic and dietary variables with haemoglobin and serum vitamin A concentrations.

Results

The majority of the boys came from families in which the parents had achieved a high education level (Table 1). Over 50% of the fathers and 18% of the mothers were at least graduates (>14 years of schooling). Occupations of the fathers were varied. Nearly 55% of the subjects' fathers were professionals, managers or big businessmen, and 21% had either a clerical or office worker's position.

Table 1 Characteristics of the study participants*

Variable	Frequency distribution (%)
Education of father	
Below matriculate (< 10 years of schooling)	12.6
Matriculate to below graduate (10–12 years of schooling)	36.0
Graduate and above (> 14 years of schooling)	51.4
Occupation of father	
Big businessman	13.1
Professional and managerial	41.4
Clerical/office worker	20.9
Small trader	24.6
Education of mother	
Below matriculate (< 10 years of schooling)	32.4
Matriculate to below graduate (10–12 years of schooling)	49.4
Graduate and above (> 14 years of schooling)	18.2
Occupation of mother	
Professional and managerial	8.1
Clerical/office worker	4.5
Housewife	87.4
Family size	
Small, < 4 members	31.5
Medium, 5–6 members	51.8
Large, > 7 members	16.7

*$n = 381$, data on socio-economic information were not available for 24 samples.

Most of the mothers (87%) were housewives. A large majority of the boys came from small to medium-sized families, and only about 6% of the boys came from relatively low-income families (data not shown). Anthropometric data are presented in Table 2. The prevalence of stunting was 8.1%, while 15.7% were found to be wasted.

The mean haemoglobin level was $142.6 \pm 13.2\,\mathrm{g\,l^{-1}}$ (Table 2), with a range from 83.0 to $184.7\,\mathrm{g\,l^{-1}}$ and was normally distributed. Using the age-specific cut-off points for haemoglobin, 7% of the boys were anaemic. Serum vitamin A level ranged from 0.37 to $2.99\,\mu\mathrm{mol\,l^{-1}}$ and the distribution was skewed towards higher values. Nearly 22% of the boys had inadequate vitamin A status (serum retinol $< 1.05\,\mu\mathrm{mol\,l^{-1}}$), with only 1.5% having subclinical vitamin A deficiency (serum retinol $< 0.70\,\mu\mathrm{mol\,l^{-1}}$).

The mean frequency of consumption of eggs, milk, meat, liver, large fish, small fish, dark green leafy vegetables (DGLV) and fruits were 3.6, 3.1, 3.8, 0.4, 2.8, 2.2, 2.9 and 12.0 servings per week, respectively. A significant proportion of the boys did not consume milk (33%), liver (78%), small fish (38%), large fish (21%) and DGLV (23%) at all during the week preceding the interview (Table 3). On the other hand, 43% of the boys consumed eggs, 38% consumed milk, 45% consumed meat and 90% consumed fruits at least four times a week.

The relationships of selected sociodemographic factors with haemoglobin and serum vitamin A levels are shown in Table 4. The mean haemoglobin level for younger boys was significantly lower than for older boys. Parents' education, per capita family income and per capita expenditure on food had no significant relationship with haemoglobin level. Boys of less educated parents had significantly lower serum vitamin A levels than the boys of higher educated parents. Compared with the boys of middle- and higher-income families, serum vitamin A levels were significantly lower in boys of lower-income families. Boys of families with lower per capita expenditure on food (up to Taka 884 per month) had significantly lower serum vitamin A levels

Table 2 Anthropometric and biochemical measures of the participants

Variable	Mean ± SD	Median (25–75 percentile)
Anthropometry		
Height (cm)		159.6 (151.8–164.3)
Weight (kg)	45.5 ± 10.7	
BMI ($\mathrm{kg\,m^{-2}}$)		17.5 (16.1–19.6)
BMI-for-age *Z*-score	− 0.70 ± 1.27	
Height-for-age *Z*-score	− 0.49 ± 1.07	
Biochemistry		
Haemoglobin ($\mathrm{g\,l^{-1}}$)	142.6 ± 13.2	
Serum retinol ($\mu\mathrm{mol\,l^{-1}}$)		1.30 (1.10–1.56)

SD – standard deviation; BMI – body mass index.

Table 3 Distribution of the participants (%) by frequency of intake of selected vitamin A- and/or iron-rich foods

	Frequency/week			
Food item	0	1–3	4–6	≥7
Eggs	15.7	41.4	14.9	28.0
Milk	33.2	29.1	8.4	29.3
Liver	78.0	19.4	1.8	0.8
Meat	6.2	49.0	32.5	12.3
Large fish	20.9	49.0	18.6	11.5
Small fish	38.0	36.9	15.7	9.4
DGLV	22.8	46.9	19.6	10.7
Fruit	1.3	8.9	15.7	74.1

DGLV – dark green leafy vegetables.

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Table 4 Relationship of selected sociodemographic factors with haemoglobin and serum vitamin A levels

		Haemoglobin ($g\,l^{-1}$)		Serum vitamin A ($\mu mol\,l^{-1}$)	
Variable	*n*	Mean ± SD	*P*-value	Mean ± SD	*P*-value*
Age (years)					
11–13	200	140.4 ± 13.8	0.001	1.32 ± 0.35	0.098
14–16	181	145.2 ± 11.9		1.39 ± 0.40	
Father's education					
< 10 years of schooling	45	145.6 ± 14.2	0.074	1.16 ± 0.34	0.001
> 10 years schooling†	312	141.8 ± 13.0		1.38 ± 0.37	
Mother's education					
< 10 years of schooling	116	144.0 ± 13.4	0.090	1.26 ± 0.37	0.001
> 10 years of schooling†	241	141.4 ± 13.0		1.40 ± 0.37	
Per capita income (Taka‡/month)					
Low third (up to 1667)	122	143.5 ± 13.6	0.362	1.22 ± 0.36[a]	0.000
Middle third (1668–3333)	120	142.2 ± 13.0		1.42 ± 0.38[b]	
High third (>3334)	115	141.0 ± 13.0		1.44 ± 0.35[b]	
Per capita expenditure on food (Taka‡/month)					
Low third (up to 844)	119	143.1 ± 13.5	0.382	1.26 ± 0.41[a]	0.000
Middle third (485–1333)	121	142.6 ± 13.7		1.37 ± 0.36[b]	
High third (>1334)	117	140.9 ± 12.4		1.44 ± 0.34[b]	

SD – standard deviation.
* Based on one-way analysis of variance of log-transformed value of serum vitamin A. Values with different subscripts differ significantly by Duncan's multiple range *post hoc* test.
† Matriculate or above.
‡ $US 1 = Taka 58.

than boys from families with middle and higher per capita expenditure on food.

There were significant positive correlations between haemoglobin and age ($r = 0.27$; $P < 0.000$), BMI ($r = 0.23$; $P < 0.000$), father's occupation ($r = 0.18$; $P < 0.001$), mother's occupation ($r = 0.11$; $P < 0.04$), meat intake ($r = 0.12$; $P < 0.02$), fruit intake ($r = 0.10$; $P < 0.04$) and serum vitamin A levels ($r = 0.21$; $P < 0.000$). Statistically significant positive correlations were also observed between serum vitamin A levels and age ($r = 0.15$; $P < 0.003$), BMI ($r = 0.33$; $P < 0.000$) and intake of vitamin A-rich fruit ($r = 0.13$; $P < 0.009$).

Table 5 Multiple regression analysis for haemoglobin and serum vitamin A

Variable	*B*	SE(*B*)	β	*P*-value
Haemoglobin ($g\,l^{-1}$)				
Age (years)	2.03	0.47	0.22	0.001
BMI ($kg\,m^{-2}$)	0.82	0.22	0.19	0.001
Father's occupation	2.61	0.64	0.20	0.001
Mother's occupation	4.93	1.94	0.12	0.010
Serum vitamin A	3.91	1.79	0.11	0.030
Total fruit	0.18	0.08	0.12	0.020
Meat	0.43	0.22	0.10	0.052
Serum vitamin A ($\mu mol\,l^{-1}$)				
Age (years)	0.023	0.014	0.09	0.089
BMI ($kg\,m^{-2}$)	0.032	0.006	0.26	0.001
Father's education	0.215	0.056	0.19	0.001
Per capita expenditure on food	0.0001	0.000	0.12	0.015
Haemoglobin	0.004	0.001	0.14	0.010
Vitamin A-rich fruit	0.027	0.013	0.10	0.042

SE – standard error; BMI – body mass index.
Haemoglobin: $R = 0.456$; $R^2 = 0.208$; adjusted $R^2 = 0.192$; $F = 13.1$; $P = 0.000$.
Serum vitamin A: $R = 0.447$; $R^2 = 0.20$; adjusted $R^2 = 0.186$; $F = 14.5$; $P = 0.000$.

Table 5 shows the findings of multiple regression analysis for haemoglobin. Age, BMI, parents' occupation, serum vitamin A level and frequency of intakes of meat and fruit were included in the analysis and exclusion criteria were set at $P = 0.10$. All the above variables remained in the equation, and were found to be independently related to haemoglobin level. The overall *F*-ratio was 13.1 (df = 7) and was highly significant ($P < 0.000$). The adjusted R^2 was 0.192, explaining 19.2% of the variation in haemoglobin level. A similar analysis was also done for serum vitamin A (Table 5). When age, BMI, father's education, mother's education, per capita income, per capita expenditure on food, haemoglobin level, frequency of intake of vitamin A-rich fruit were included in the analysis and using $P = 0.10$ for exclusion, mother's education and per capita income dropped out of the model. Among the variables remaining in the equation, BMI, father's education, per capita expenditure on food, haemoglobin level and frequency of intake of vitamin A-rich fruit were found to be significantly independently related to serum vitamin A level. The overall *F*-ratio was 14.5 (df = 6) and was highly significant ($P < 0.000$). The adjusted R^2 was 0.186, explaining 18.6% of the variation in serum vitamin A level.

Discussion

This study did not include boys who were not attending schools and therefore did not take account of boys from the urban poor. The boys in the present study came from backgrounds which represent better education and relatively better economic conditions, and therefore the subjects were not representative of the wider population. Rather they represent the most favourable picture and it is likely that for most adolescent boys the situation would be no better than that reported here.

Overall, 7% of the boys were anaemic, which is much lower than the rate reported for urban adolescent schoolgirls (20%) in Dhaka City[15]. In contrast, Shahabuddin *et al.*[19] reported a very high prevalence (94%) of anaemia among adolescent boys in a rural community in Bangladesh. In the latter study 75% of the boys were wasted and nearly half were stunted, while our data show only about 16% wasting and 8% stunting. These variations could be explained by the level of urbanisation and socio-economic conditions of the two population groups. Furthermore, we found that the prevalence of anaemia was nearly three times higher in older boys (11%) than in younger boys (3.5%). One possible explanation for the higher rates of anaemia among older boys could be inadequate iron reserves to meet the increased demand during the growth spurt as well as haematopoiesis. Although other non-nutritional factors such as hookworm infestation may cause anaemia, it is less likely in this group because they have good access to health-care facilities and live in more hygienic conditions than children of the urban poor.

The data on dietary patterns indicate that a large proportion of boys did not consume liver at all, a rich source of haem iron in the diet. Further, nearly half of the boys ate meat and large fish only one to three times per week. Both fish and meat contain haem iron and their intakes are known to promote absorption of non-haem iron[24]. Thus it is likely that a significant proportion of boys was also suffering from mild to moderate iron deficiency without anaemia; this may pose important health implications as iron-deficiency anaemia is reported to be associated with impaired cognition in adolescents[3] and lower school achievement[4,5].

Although only a small proportion (1.5%) of the boys had subclinical vitamin A deficiency as such, about 22% had inadequate vitamin A status ($<1.05\,\mu mol\,l^{-1}$), which is higher than reported for urban adolescent schoolgirls (11%) in Dhaka City[15]. It is important to note that reduction of serum vitamin A level has been described during the acute phase of a wide range of infections[25]. Although we do not have any information on subclinical infection in the present study, at the time of blood collection all participants were apparently healthy. Furthermore, as mentioned earlier, subclinical infection is less likely to be a major concern in this group. Dietary data indicate that a large proportion of the boys did not consume liver, milk and small fish at all, and a substantial proportion consumed these foods only occasionally. Liver, milk, eggs and fish are common dietary sources of preformed vitamin A[26]. DGLV are a predominant source of provitamin A; about 70% of the boys either did not consume DGLV at all or ate them occasionally. During the time of the study vitamin A-rich fruits such as mango and jackfruit were not available, and these boys consumed mainly ripe papaya and orange. While we do not have any quantitative information, the food frequency data suggest that a large proportion of the boys might have had inadequate vitamin A intake. Even if the severity of vitamin A deficiency is less evident, sub-optimal vitamin A status may pose a significant health risk in these boys who are still growing because vitamin A has been indicated to be important for growth, development and maturation in adolescence[2].

This study also explored the relationship of selected socio-economic, personal and dietary factors with haemoglobin and serum vitamin A levels. Bivariate analyses revealed that the boys' haemoglobin level was significantly related only to parents' occupation (data not shown), and not related to any other indicators of socio-economic status. However, in a previous study we found that the haemoglobin level of school-age children in Dhaka City was related to their family income[27]. This could be attributable to the difference in the population groups studied. Adolescents usually make their own food choices that may be unrelated to socio-economic status. When serum vitamin A levels were considered, parents' education level, family income and expenditure on foods were significantly related. Earlier studies in Bangladesh also showed that the levels of serum vitamin A were lower in individuals from poorer socio-economic backgrounds than in people from better circumstances[27,28].

We also carried out multiple regression analysis to identify factors that are independently related to haemoglobin level. The result indicates that the haemoglobin levels of these boys were significantly influenced by a number of independent factors such as age, BMI, parents' occupation, vitamin A status and intakes of meat and fruit. Previously we found an independent relationship between age and haemoglobin levels in urban school-age children[29]. As mentioned above, meat provides highly bioavailable haem iron. Fruits, especially citrus fruits, are also known to influence non-haem iron absorption[24]. An association between haemoglobin and serum retinol concentrations has also been observed in adolescent schoolgirls in Bangladesh[15,16]. There has been a suggestion that vitamin A exerts an influence on the metabolic availability of iron and hence on haemoglobin formation[30].

Multiple regression analysis also revealed that age, BMI, father's education, per capita expenditure on food, haemoglobin level and intake of vitamin A-rich fruits were significantly independently related to serum vitamin A levels in these boys. Further, the data indicate that for every unit change in haemoglobin level there was a 0.004 unit change in serum vitamin A while controlling for all other factors. Previously we found a similar relationship in urban school-age children[29] and adolescent females[17] in Bangladesh. Studies have shown an improvement in plasma vitamin A and transport protein of vitamin A following iron supplementation in pre-school children, indicating that iron may play a role in vitamin A metabolism[31].

In conclusion, in the present study we have shown that, even in a relatively affluent group of Bangladeshi society,

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adolescent schoolboys suffer from anaemia and inadequate vitamin A status. Although the extent of the problem is less than in other population groups in the country, various sociodemographic and dietary factors have been found to influence anaemia and vitamin A status of these boys. Considering the possible implications of anaemia and vitamin A deficiency on adolescent growth and development, the nutritional status of this group should not be overlooked. Suitable approaches designed to improve adolescent nutrition should be considered.

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