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IRON STATUS AND HAEMATOLOGICAL PARAMETERS IN NIGERIAN ADOLESCENTS FROM A SUB-URBAN REGION OF LAGOS STATE, NIGERIA

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ABSTRACT: Haemoglobin (Hb), haematocrit (Hct), plasma iron (PI) and total iron binding capacity (TIBC) were measured in 100 adolescents (68 boys and 32 girls) aged 14 - 17 years in three secondary schools on Ojo Local Government Area of Lagos State. Of the subjects, 33, 26 and 31 per cent had Hb, Hct and PI levels below accepted normal values respectively. 26 per cent of them had values below normal in all the three parameters. Further analysis of Hb levels in the population studied showed that 44.74 per cent of the females and 25.8 per cent of the males had Hb levels below normal (11 g/dl) indicating a higher occurence of anaemia in the females. Direct measurements of 7-day food intake revealed that intakes of iron, protein and energy were below recommended allowance for both sexes. A significant relationship was also observed between dietary iron intake and serum iron levels.

INTRODUCTION

Adolescents are considered to be a nutritionally vulnerable group within a population, and a high prevalence of iron deficiency anaemia has been found among them (1). About 30 to 60 per cent of African adolescents have been reported to be deficient in iron (2). This is as a result of the rapid growth rate as well as the unexpected increase in total body haemoglobin associated with puberty (3,4). The quality of food intake and food habits in the adolescent (5,6), occurence of menorrhogia and parasitic infestation, especially in the tropics (7,8) further puts this group at risk of iron deficiency anaemia. This has been found to be associated with immunocompetence, cognition, physical work capacity and other functions affecting productivity or economic output and scholastic performance of adolescents (9,10). The incidence of iron-deficiency anaemia in adolescents is, therefore, one of the most serious public health problems.

The present investigation was undertaken to evaluate Hb, Hct, PI and TIBC (as indicators of iron deficiency anaemia) in adolescents from a sub-urban area of Lagos, Nigeria. The effects of dietary iron and sex differences on these parameters were studied.

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MATERIALS AND METHODS

One hundred students from Kuje Secondary School, Amuwo Grammar School and Awori Ajeromi School, all located at Agboju in Ojo Local Government Area (a newly developed, semi-urban, area of Lagos State) about 8 kilometers from the Lagos State University were recruited for the study. Consent for the study was obtained from the School Management Committee, Ojo, Lagos State, as well as from the Principals of the respective schools.

The students were made up of 38 females and 62 males. Their ages ranged between 14 and 17 years. They all came from average income families, with over 50% of fathers as Civil Servants and about 28.6% as petty traders. Their weights and heights were recorded by standard methods (11).

Approximately 10 ml of blood (non-fasting) was collected intravenously. Whole blood haemoglobin and haematocrit levels were determined by the cyanmethaemoglobin method (12) and by micro haematocrit centrifugation (13) respectively. Plasma was obtained from heparinized tubes and frozen for later analysis. Plasma iron and total iron binding capacity were determined by the method of Caraway (14) which uses the chromogenic agent bathophenanthroline.

A seven-day diary of daily intake of food was recorded for each student. Each of them was given a specially designed diary in which to record a description of all foods and drinks taken, the time of consumption and an estimate of the amount consumed in household measures. They were then individually interviewed on the last day in order to verify and add to the information provided.

The students' description was used with a selection of calibrated visual aids to arrive at a quantitative estimate of intake. Food tables modified as necessary was then used to calculate intake of iron.

The Student t-test was used to compare haematological values within and between sexes. Linear regression equation was used to test the association within haematological parameters, and between plasma iron. The association plasma and dietary iron was also tested.

RESULTS

A total of 62 boys and 38 girls took part in the study. They were physically healthy adolescents. Table 1 shows the characteristics of the subjects studied. All of them had a mean age of 15 years with a range between 14 and 17 years. The height of the boys were significantly higher than that of the girls ($P < 0.05$), but the girls were slightly heavier than the boys. This is reflected in the body mass index (BMI), which is an indication of the state of leaness or obesity.

Iron Nutritional Status. The iron status parameters for the boys and girls subpopulations are presented in Table 2. The values of Hb, Hct and TIBC for males are slightly but significantly higher than the values for girls ($P < 0.05$). However, the slight difference observed with plasma iron (PI) was not significant ($P > 0.05$). Based on the levels recommended by the WHO (15) for classifying individuals into low categories (i.e. Hb < 11 g/dl; Hct < 33% and PI < 50 ug/dl), the percentage of subjects exhibiting low or deficient values ranged from 26% for Hb to 31% for PI. A significantly greater proportion of the girls exhibited low Hb ($P < 0.05$), Hct ($P < 0.05$) and PI ($P < 0.05$). However, 26% of the total population could be classified as anaemic using the three criteria.

Further classification of the iron parameters associated with adequate and low Hb is presented in Table 3. The Student t-test was used to determine whether Hb, Hct, PI and TIBC values differed within and between sexes.

Table 1: Vital statistics of the subjects.

Parameters	Males (n = 62)	Females (n = 38)
Age (yrs)	15.29 ± 1.05 (14 - 17)	15.21 ± 0.93[b] (14 - 17)
Height (m)	1.58 ± 0.1 (1.2 - 1.8)	1.56 ± 0.08[b] (1.2 - 1.7)
Weight (kg)	46.16 ± 8.27 (27 - 65)	48.97 ± 5.68[c] (40 - 61)
BMI (kg/m)	29.16 ± 3.82 (22.5 - 38.24)	31.28 ± 3.36[c] (25.32 - 37.17)

[a] Values represent the means ± SD. [b] Values not significantly different from male ($P > 0.05$)

[c] Values significantly different from male ($P < 0.05$) [d] BMI: Body Mass Index, weight/height (kg/m)

Table 2: Iron status of subjects in comparison with WHO criteria.

Parameters	Males (n=62)	WHO*	Females (n=38)	WHO*	All (n=100)	WHO*
Hb (g/dl)	12.9 ± 3.6 (3.3-21.1)	25.8	12.2±3.4[b] (7.0-21.8)	44.7	12.7 ± 3.5 (3.3 - 21.8)	33.0
Hct (%)	40.8±10.3 (9.5-64)	19.4	37.4±10.9[b] (22-65)	36.8[c]	39.6±9.9 (9.5-65)	26.0
PI (ug/dl)	65.5±25.5 (15.0-120.6)	24.2	63.6±32.4[d] (36.4-125.0)	42.1[c]	63.1±24.2 (15-125.0)	31.0
TIBC (ug/dl)	258.0±59.6 (180.9-411.4)	-	239.25± 43.4[b] (191.0-414.7)	-	251.11± 54.2 (180.9-414.7)	-

*Figures show percentage falling below WHO criteria.
[a] Values represent the means ± SD with ranges in parentheses.
[b] Significantly different from the male ($P < 0.05$)
[c] Significantly different among the sexes ($P < 0.05$)
[d] Not significantly different from the male ($P > 0.05$).

Table 3: Classification of iron status in adolescents.

Group	n	Hb (g/dl)	Hct (5)	PI (ug/dl)	TIBC (ug/dl)
Males I	16	8.62±1.67	31.09±8.05	46.20± 11.62	211.86± 34.94
II	7	11.43±0.8b	37.14± 1.53b	54.04± 22.74b	232.72± 15.32b
III	39	14.95± 2.57b	45.43± 8.97b	76.32± 26.27b	276.51± 63.83b
Females I	17	9.37±0.96d	30.68± 4.87d	45.93± 7.08d	206.62± 22.79d
II	1	11.4c	40.0c	59.67c	264.49c
III	20	14.72± 2.57bd	42.85± 9.14bd	69.42± 24.52bd	252.3± 49.88bd

[a]Values represent the mean ± SD.
[b]Values are significantly different from group 1 within sexes ($P < 0.05$).
[c]Values are significantly different between sexes ($P < 0.05$).
[d]Values are not significantly different between sexes ($P > 0.05$).

Linear regression analyses were carried out for all possible pairs of the iron status parameters in both male and female groups. Table 4 shows the regression coefficients relating haemoglobin to iron status parameters by sex. Significant positive correlations ($P < 0.05$) were observed between Hb and Hct levels in both males and females. PI and TIBC levels were also positively and significantly correlated with Hb.

Table 4. Regression coefficient relating haemoglobin to iron status parameters by sex.

Variable	Haemoglobin	
	Male	Female
Hct	0.80[a]	0.73[a]
PI	0.89[a]	0.54[a]
TIBC	0.46[a]	0.39[a]

[a]Significantly correlated with Hb ($P < 0.05$).

The relationship and association between haematological parameters and age were also checked. For the females, the data showed an inverse but significant relationship between age and Hb:

(Hb = 22.37 - 0.67x; r = -0.37, $P < 0.05$)

(Hct = 59.44 - 1.49x; r = -0.28, $P < 0.05$) and

(PI = 88.19 - 1.93x; r = -0.18, $P < 0.05$).

However with males, the trend was different. A positive but not significant relationship was observed between age and Hct:

(Hct =21.37 + 1.28x; r = 0.06, $P > 0.05$)

(PI = 50.12 + 1.10x; r = 0.045, $P > 0.5$).

Hb tends to reduce with age, but the correlation factor was not significant (r = -0.036, $P > 0.05$).

The results of dietary iron intake and their relationship to iron status parameters for both males and females are presented in Table 5. Dietary iron intake for females are slightly but significantly higher than for males, though both fall short of their recommended dietary allowances. Subjects met only 75 and 67 per cent of their daily allowances for males and females respectively. There were no significant correlations between iron intake and Hb, Hct and PI levels in the females but the relationships in males were significant. Analysis of variance indicated that the significant male-female differences observed in mean Hb, Hct and PI levels were affected by dietary iron intake.

Table 5: Dietary iron intake and correlation coefficients between iron status parameters[a].

	Males (n = 62)	Females (n = 38)
Dietary iron intake (mg/day)	13.52 ± 3.6	16.05 ± 3.5[b]
Recommended Dietary Allowance (%)	75	66
Correlation Coefficients (r):		
Hb	0.43[c]	0.16
Hct	0.46[c]	0.23
PI	0.55[c]	0.12

[a]Values represent the means ± SD.
[b]Significant difference between sexes ($P < 0.05$).
[c]Significant difference in correlation ($P < 0.05$).

DISCUSSION

The subjects studied were random samples and they all belong to the same socio-economic group, thereby eliminating bias in data collection. Their BMI indicated that none of them was obese. None of them also had physical deformity and all the girls have attained menarche.

The data presented show that all the mean haematological values for the males were slightly higher than those for the females. However, the values for both sexes were much lower than those observed for similar groups in studies carried out in the United States (6,16). From the present results, it was observed that low Hb levels were associated with significantly lower Hct, PI and TIBC values. The positive regression observed in both sexes for Hb against PI and TIBC could be a reflection of the homeostatic adjustment by the body to provide additional iron for Hb synthesis. Adolescents typically exhibit a high growth rate and thus the need for an increased iron requirement to support the high rate of Hb synthesis characteristic of this period. A progressive decline was also observed in the iron status of females with age. Similar results were demonstrated by Seltzer et al. (17) and Bailey et al. (18). They indicated a higher risk of iron deficiency with age, especially with adolescent females. This may be associated with inadequate dietary iron intake to compensate for the monthly losses of iron through menstruation. Our studies further revealed a positive trend in association between dietary iron intake and iron status parameters. Thus, the lower Hb, Hct and PI observed in the females further confirms a higher prevalence of iron deficiency among this sex. The occurence of anaemia was also found to be higher in the female based on their Hb, Hct and PI values which were 44.7, 37.0 and 42.0 per cent respectively, compared to the males with corresponding values of 25.8, 19.4 and 24.2. Diagnosis based on all three criteria revealed that 37% of females and 19.4% of males were anaemic.

The data presented here show that Hb, Hct and PI estimates at commonly assumed normal values (Hb, 11g/dl; Hct 33% and PI 50ug/dl) detected only 33, 26 and 31 per cent of anaemia cases respectively. The proportion of subjects having 33% Hct but who had Hb values of 11g/dl was 7%. This suggests an occurence of 6.4% and 7.9% among the males and females respectively. Thus using only Hct values to detect possible iron deficiency resulted in failure to detect 7% of the population who might prove to be anaemic using the Hb criteria, whereas in using the PI criteria, there was failure to detect only 2% of the population. However, using all three criteria, 26% of the total population were anaemic.

The present study demonstrates that a good proportion of the adolescent population have iron deficiency anaemia. Numerous factors could be responsible for this, among which are, inadequate iron intake, parasitic infestation which is becoming very common among urban dwellers, malabsorbtion syndromes and, especially, the onset of menstruation in adolescent females.

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REFERENCES

1. Greenwood, C. T. and Richardson, P. (1971) Nutrition during adolescence. World Review of Dietetics. pp. 31 - 34.
2. Behar, M. (1976) Appraisal of the nutritional status of population groups. In: Nutrition in Preventive Medicine (Beaton, G. H. and Bengoa, J. M., eds.). WHO Monogram Series, Geneva. pp. 26, 48, 449 - 456.
3. Burma, D. (1979) Adolescent Nutrition. Practitioner B37, 615 - 623.
4. Brusal, J. (1977) Factors that affect the nutritional requirement in adolescents. Curr. Concepts in Nutr. 5, 63 - 65.
5. United States Department of Agriculture (1972) Household Food Consumption Survey: 1965 - 66. Food and nutrient intake of individuals in the United States. Washington DC Government Printing Office Report II.
6. Hodges, R. E. and Krehl, W. A. (1965) Nutritional status of teenagers in IOWA. Am. J. Clin. Nutr. 17, 200 - 207.
7. Layrisse, M. and Roche, M. (1964) The relationship between anaemia and hookworm infestation. Am. J. Hyg. 79, 279 - 301.
8. Roche, M. and Layrisse, M. (1966) The nature and causes of hookworm anaemia. Am. J. Trop. Med. Hyg. 15, 1031 - 1100.
9. Devhuiti, V. and Chandra, R. K. (1984) Functional implication of iron deficiency. In: Iron Nutrition in Infancy and Childhood. (Stekel, A. ed.). Nestle Nutrition. pp. 21 - 25.
10. Don, M. T.; Harold, H. S.; James, G. P.; Steven, L. D. and David, B. M. (1984) Iron status and brain

function. Serum ferritin levels associated with assymetrics of cortical electrophysiology and cognitive performance. Am. J. Clin. Nutr. 39, 105 - 113.

11. Jeliffe, D. B. (1966) The assessment of the nutritional status of the community. World Health Organization Monograph Series, No. 53, Geneva.
12. Davies, R. L. F. and Park, C. (1970) A method for the determination of haemoglobin as cyanmethaemoglobin for use in conjunction with coulter-counter. J. Med. Lab. Tech. 27, 58 - 60.
13. McGovern, J. J.; Jones, A. R. and Steinberg, A. G. (1955) The haematocrit of capillary blood. New Engl. J. Med. 253, 308 - 312.
14. Caraway, W. T. (1963) Macro and micro method for the determination of plasma iron. Clin. Chem. 9, 188 - 199.
15. World Health Organization (1968) Nutritional Anaemias. WHO Technical Report Series, No. 405, Geneva.
16. Lee, C. J. (1978) Nutritional status of selected teenagers in Kentucky. Am. J. Clin. Nutr. 31, 1453 - 1464.
17. Seltzer, C. C.; Wenzel, B. J. and Mayer, J. (1963) Serum iron and iron binding capacity in adolescents. Am. J. Clin. Nutr. 13, 343 - 353.
18. Bailey, L. B.; Wagner, P. A.; Christakis, G. J.; Davis, C. G.; Appledord, H.; Araujo, P. E.; Dorsey, E. and Dinning, J. S. (1982) Folacin and iron status and haematological findings in black and Spanish American adolescents from urban low income households. Am. J. Clin. Nutr. 35, 1023 - 1028.