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Original Article

Prevalence and severity of micronutrient deficiency: a cross-sectional study among adolescents in Sri Lanka

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In order to determine the prevalence of micronutrient deficiencies (iron, zinc and folate) in Sri Lankan adolescent school children and the extent to which multiple micronutrient deficiencies exist in this population, a cross-sectional survey (2003) in the Galle district of the micronutrient and anthropometric status of 945 school children of ages 12 – 16 years was performed. The prevalence of anemia (Hb <120.0 g/L) was 49.5% in males and 58.1% in females (overall 54.8%, gender difference, P=0.004). In anemic children 30.2% of males and 47.8% of females were iron deficient (serum ferritin <30.0 µg/L). Folate deficiency (<6.80 nmol/L) was found in 54.6% and 52.5% of boys and girls respectively whereas zinc deficiency (<9.95 µmol/L) occurred in 51.5% and 58.3%. Anemic boys had a 1.5 (95% confidence interval (CI) 0.9-2.6) and 1.6-fold (CI; 1.1-2.6) greater risk of being stunted and underweight, whereas the risk among anemic girls was 1.7 (CI; 1.1-2.7) and 1.0 (CI; 0.7-1.5) for being stunted and underweight. The relative risks of having at least two deficiencies in iron, zinc and folate among anemic children were 1.6 (CI; 0.6- 4.2) among boys and 0.8 (CI; 0.5- 1.5) among girls. Iron deficient subjects had a significantly increased risk of 1.8 (CI, 1.1-3.0) of being deficient in folate and 1.7 (CI, 1.2-2.6) of being deficient in zinc. Zinc deficient subjects had a risk of 1.3 (CI, 1.0-1.8) -being iron deficient and 1.2 (CI, 0.9-1.7) of being folate deficient. Multiple micronutrient deficiencies are prevalent in Sri Lankan adolescents.

Key Words: adolescents, micronutrient deficiency, iron, zinc, folic acid, Galle, Sri Lanka

Introduction

Micronutrient malnutrition is a serious threat to the health and productivity of more than 2 billion people worldwide.[1] The sequelae of micronutrient deficiencies, such as iron, zinc, vitamin A, folate, and iodine, are profound and include premature death, poor general health, blindness, growth stunting, mental retardation, learning disabilities, and low work capacity. The prevalence of some micronutrient deficiencies remains largely unknown because of lack of data, but also because of the absence of easily measurable, sensitive and specific indicators of micronutrient status.[2] Adolescents are considered to be a nutritionally vulnerable segment of the population. A rapid growth rate combined with a marginal nutrient intake[3] increases the risk of nutritional deficiencies in this population.

The prevention and correction of micronutrient deficiencies among children and adolescents have become critical goals because of their negative consequences, which include decreased immunity, increased morbidity and impaired cognitive performance.[4,5] It is important to ensure that a satisfactory nutritional status is maintained in adolescent girls in order to meet the nutritional and physiological stresses of pregnancy and lactation. Iron, zinc, and folate are essential trace elements involved in the high growth rates of adolescents.[6]

We hypothesized that Sri Lankan adolescents are often deficient in several micronutrients simultaneously. Thus, the present study was conducted among adolescent school children to investigate the severity and the prevalence of multiple micronutrient deficiencies in iron, zinc and folate. A database on micronutrient status in this population will be critical to the formation of national strategies to correct micronutrient deficiencies in Sri Lanka.

Materials and methods

The study was conducted in Galle District, of the Southern province of Sri Lanka in the year 2003. The study population comprised of 16,191 schoolchildren aged 12 to16 years attending schools in the Galle District. A multistage, stratified random sampling technique based on the location

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and type of school (girls only or coeducational) was used. Three schools (one girls' school and two coeducational schools) were randomly selected. Principals of the selected schools and the class teachers were briefed about the research project. The subjects and their parents were given a letter which described in detail the procedures involved in the study. A cohort of 1150 students, who were officially registered in the selected 43 classes were eligible for enrolment. Nine hundred forty-five (945) children (82.2%) who presented with written consent from their parents were enrolled in the study. The other 205 children elected not to participate in the study. The sample was sufficient to detect a prevalence of 50% of any micronutrient deficiency with a confidence interval of ±5%, an alpha error of 5% and a design effect of two. The study was approved by the Ethics Committee of the Faculty of Medicine, University of Ruhuna, Sri Lanka.

The body weight and height of each subject were measured using a calibrated scale and stadiometer. All the study subjects received a comprehensive physical examination. The chronological age was expressed to the nearest month. A venous blood sample (5 ml) was obtained from the median-cubital vein under aseptic conditions using disposable syringes. Two hundred µl of whole blood was pipetted onto filter paper for hemoglobin measurement, and the rest of the blood was collected in an acid washed centrifuge tube, kept in an ice box, and transferred to the laboratory within 6h. Serum was separated by centrifugation and kept frozen at -20^0C until analysis of folate, ferritin, and zinc levels was completed.

Hemoglobin concentration was measured using the photometric cyanmethaemoglobin method at the Nutrition Research Laboratory, Faculty of Medicine, Galle. Serum ferritin (SF) and folate were measured by the Immunoradiometric assay (IRMA) and the Radioimmuno assay (RIA) technique respectively at the Radioimmunoassay (RIA) laboratory of the Nuclear Medicine Unit, Faculty of Medicine, Galle using reagents supplied by NETRIA Limited, England[7] and Diagnostic Products Cooperation, Los Angeles, USA.[8] Serum zinc (Zn) was analyzed by flame macro sampling[9] at the Industrial Technology Institute (ITI), Colombo by flame atomic absorption spectrophotometry (f-AAS).

Statistical analysis

Results are expressed as mean (± SD) or as proportions. Weight-for-age, height-for-age and BMI-for-age Z scores were derived from EpiInfo version 3.3.0 (CDC, Atlanta, GA, USA) -for windows using the 2000 CDC reference curves. A one-sample Kolmogorov-Smirnov test was used to investigate whether the concentrations of hemoglobin, serum zinc, folate and ferritin and the anthropometric indicators were normally distributed. The distributions of hemoglobin, serum folate and SF values concentrations were skewed thus they were log transformed in all calculations. For presentation, these variables were transformed back to the original scale and presented as mean (± SD) except SF which was presented as the geometric mean and geometric variances.

Student t-tests were used to compare the prevalence of deficiencies and their differences between groups. Pearson correlation coefficients were used to investigate the relationship between micronutrients status and anthropometry. Age adjusted odds ratios and their confidence intervals (CI) were calculated. SPSS (version 10.0; SPSS Inc, Chicago) software package was used for statistical analysis. *P* values less than 0.05 were considered significant.

Anemia was defined as a hemoglobin concentration <120 g/L, depleted iron stores as ferritin <12 µg/l, and iron deficiency anemia (IDA) as anemia with ferritin ≤30 µg/L.[10] Subjects with serum ferritin levels greater than 250 µg/L were further investigated for sub-clinical infections and were excluded from the analysis. Folate deficiency was defined as a serum folate concentration less than 6.80nmol/L (<3.0ng/L), and zinc deficiency as serum zinc concentration less than 9.95 µmol/L (<650 µg/L).[11]

Results

Of the 945 school children in the study sample 35.3% (*N*= 361) were males and 64.7% (*N*= 584) were females. Anthropometric indices of the subjects are presented in Table 1. Children were between 12 to 16 years of and there was no significant age difference between males and females (*P*=0.838). Males (42.1%) were significantly more underweight (weight-for age z-score less than -2.0) than females (33.4%) (*P* <0.001). In the study population 19.9% of males and 17.5% of females were stunted (height-for-age z scores -2.0) and 43.2% of males and 23.8% of females had a BMI-for-age z scores less than -2.0.

The hemoglobin concentrations by age and the prevalences of anemia and IDA are summarized in Table 2. There was a significant difference in the age adjusted mean hemoglobin concentrations between males [119.6 (14.8) g/L] and females [114.6 (13.8) g/L] (*P*=0.001). The average hemoglobin concentration of 113.8 g/L in boys at age 12 y increased to 120.5 g/L by age 16 y, but the trend

Table 1. Anthropometric indices of the study sample[1]

Variable	Mean (SD) among			t-test[2]	*P* value
	Males (*N* = 361)	Females (*N* = 584)	All (*N* = 883)		
Age (month)	162.68 (17.06)	162.75 (18.22)	162.72 (17.78)	-0.064	0.949
Weight (Kg)	36.66 (9.03)	37.88 (8.08)	37.42 (8.47)	-1.986	0.047
Height (cm)	150.91 (10.81)	149.25 (7.79)	149.89 (9.09)	2.335	0.020
BMI (Kg/m^2)	15.91 (2.27)	16.85 (2.60)	16.50 (2.53)	-5.711	<0.001
WAZ	-1.84 (1.24)	-1.53 (1.23)	-1.65 (1.24)	-3.695	<0.001
HAZ	-1.15 (1.04)	-1.14 (0.97)	-1.14 (1.00)	-0.170	0.865
BMIZ	-1.80 (1.41)	-1.18 (1.16)	-1.42 (1.30)	-7.049	<0.001

[1]weight-for-age and height-for-age and BMI-for-age (WA, HA and BMI) Z scores derived from EpiInfo version 3.3.0 of the 2000 CDC growth reference curves; [2]2-sample t-test comparing males and females

was not seen among girls, the concentrations ranging between 113.8 and 114.6 g/L. Hence, the hemoglobin concentrations of males were significantly higher than that of females of the same age as they matured. Although the prevalence of anemia was reduced from 71.4% to 44.1% as males grew older, more than 50.0% of female school children were anemic in each age group.

Iron stores were assessed by SF status in 882 study subjects (Table 3). Sixty-three children (34 males and 29 females) were excluded from the analysis as the sample of serum was insufficient in 50 subjects and 13 had SF levels greater than 250 µg/L. The geometric mean ferritin (SF) levels among males improved with age whereas in girls a rapid decline was noted with the onset of menstruation. Furthermore, a wide variation in iron stores was observed as reflected by a relatively high geometric variation. Although the children in our study were apparently clinically healthy, we did not have any information regarding concurrent subclinical infections. Using a more in-clusive cutoff of SF <30 µg/L instead of <12 µg/L, 24.5% (M-54; F-162) of the sample were classified as iron deficient. Among females with a normal Hb level

Table 2. Hemoglobin status and the prevalence of anemia[1]

Age, Gender	*N*	Mean (SD) g/L	*P* value	% Prevalence of Anemia[2]	*P* value	IDA[3]	*P* value
12 years							
male	53	113.78 (10.8)	0.492	71.7	0.018	34.2	0.310
female	97	113.83 (11.5)		53.6		36.5	
13 years							
male	75	116.00 (11.0)	0.482	68.0	0.224	23.5	<0.001
female	115	116.08 (11.0)		62.6		43.1	
14 years							
male	83	121.80 (10.9)	0.001	41.0	0.018	26.5	0.056
female	129	116.20 (11.3)		55.8		36.1	
15 years							
male	66	125.96 (10.9)	<0.001	28.8	<0.001	36.8	0.036
female	85	113.70 (11.9)		58.8		54.0	
16 years							
male	84	120.55 (11.3)	<0.001	44.1	0.011	35.1	<0.001
female	156	113.37 (11.5)		59.6		63.4	
Over all							
male	361	119.82 (11.1)	<0.001	49.6	0.004	26.6	<0.001
female	584	114.59 (11.5)		58.0		43.0	
Age adjusted							
male	361	119.62 (14.8)	<0.001				
female	584	114.64 (13.8)					

[1]Means and SD were derived from log-transformed data, *P* values were from 2-sample t-test comparing males and females.[2] Anemia was defined as hemoglobin < 120.0 g/L. [3] Iron Deficiency Anemia was defined as hemoglobin < 120.0 g/L with serum ferritin < 30.0 µg/L

Table 3. Serum Ferritin status and percentage of iron store depletion

Age, Gender	*N*	Geometric mean (variance) µg/L	*P* value[1]	Iron storage (%) <12.0 µg/L	12.1-30.0 µg/L	>30.1 µg/L	*P* value[2]
12 years							
male	50	32.92 (1.54)	0.477	8.0	32.0	60.0	0.378
female	93	32.13 (1.63)		7.5	29.1	63.4	
13 years							
male	71	41.72 (1.44)	0.006	1.4	19.7	78.9	0.005
female	112	32.46 (1.53)		8.0	35.7	56.3	
14 years							
male	70	38.53 (1.72)	0.006	5.7	12.9	81.4	0.086
female	114	28.41 (1.79)		14.0	24.6	61.4	
15 years							
male	55	32.11 (1.83)	0.082	10.9	20.0	69.1	0.325
female	82	27.64 (1.55)		8.5	37.9	53.6	
16 years							
male	81	30.77 (1.77)	0.001	9.9	21.0	69.1	0.002
female	154	19.62 (2.23)		14.9	40.3	44.8	
Over all							
male	327	35.03 (1.66)	<0.001	7.0	22.4	70.6	<0.001
female	555	26.62 (1.80)		11.2	33.8	55.0	
Age adjusted							
male	327	35.21 (4.69)	<0.001				
female	555	28.65 (5.18)					

[1]Geometric means and variance were derived from log-transformed data, *P* values were from 2-sample t-test comparing males and females
[2]*P* values were from Chi-square test (3 x 2) comparing males and females

(Hb>120 g/L), 3.4% were iron depleted (SF <12µg/L) and 12.8% had low iron stores (SF 12-30 µg/L). Among boys, the percentages were 3.1% and 10.1% respectively. Among 12-year old anemic children over one third had low iron stores (males 34.2% and females 36.5%). Among 16-year old females nearly two-thirds (63.4%) were iron deficient. This database was the first evaluation of serum zinc and folate levels in this age group in Sri Lanka. Assessment of serum zinc was assessed in 928 subjects. An additional 17 samples were discarded due an error in sample processing. Males had a significantly higher age-adjusted mean serum zinc concentration than females (*P* <0.001) (Table 4).

Table 4. Serum zinc status and deficiency by age and sex[1]

Age, Gender	*N*	Serum zinc (µmol/L)		Deficiency	
		Mean (SD)	*P* value	%[2]	*P* value
12 years					
male	53	9.14 (3.01)	0.316	62.3	0.302
female	95	8.83 (2.78)		57.9	
13 years					
male	75	8.68 (3.29)	0.103	64.0	0.264
female	114	7.98 (3.10)		68.4	
14 years					
male	83	9.99 (3.55)	0.054	49.4	0.422
female	126	9.36 (3.38)		50.8	
15 years					
male	66	10.00 (2.97)	0.001	36.4	<0.001
female	81	8.41 (3.24)		67.9	
16 years					
male	82	9.87 (3.59)	0.309	47.6	0.245
female	153	9.64 (3.69)		52.3	
Over all					
male	359	9.55 (3.36)	0.002	51.5	0.021
female	569	8.93 (3.35)		58.3	
Age-adjusted					
male		9.64 (0.72)	<0.001		
female		8.93 (0.70)			

[1]Means and SD were derived from log-transformed data, *P* values were from 2-sample t-test comparing males and females.
[2]Defined as serum zinc <9.95 µmol/L

Using a cutoff of 9.95 µmol/L, zinc deficiency was seen in 51.5% (*N* = 176) of males and 58.3% (*N* = 325) of females (*P* = 0.02). Assessment of serum folate was conducted in 611 subjects. The sample of serum was insufficient for serum folate assay in the remainder of subjects (Table 5). There was no significant difference in serum folate concentrations between males and females in each age group or after adjusted for age (*P* = 0.49). Folate deficiency was found in 54.6% of males (*N* = 136) and 52.5% (*N* = 214) of females.

Age correlated negatively with serum folate and serum ferritin concentrations (r = –0.1; *P*<0.001 for both) and positively with serum zinc and hemoglobin concentrations (r=0.1; *P*<0.001 for both). Serum zinc concentration was positively correlated with weight and height (r =0.7, r=0.1 respectively; *P*<0.001 for both) and a negative correlation with SF although the latter did not reach statistical significance (r = -0.01; *P* = 0.41).

Table 5. Serum folate status and deficiency by age

Age, Gender	*N*	nmol/L		Deficiency	
		Mean (SD)	*P* value	%[2]	*P* value
12 years					
male	39	6.03 (2.21)	0.117	46.2	0.492
female	74	7.23 (2.03)		45.9	
13 years					
male	51	6.81 (2.08)	0.291	49.0	0.485
female	79	6.32 (2.17)		49.4	
14 years					
male	65	6.10 (2.13)	0.058	63.1	0.097
female	93	5.44 (2.20)		52.7	
15 years					
male	48	5.25 (1.12)	0.485	54.1	0.323
female	58	5.22 (2.28)		58.6	
16 years					
male	46	5.39 (2.19)	0.451	56.5	0.466
female	104	5.29 (2.49)		55.8	
Over all					
male	249	5.91 (2.15)	0.402	54.6	0.295
female	408	5.82 (2.26)		52.5	
Age-adjusted	249	5.91 (0.63)	0.49		
male	408	5.90 (0.87)			
female					

[1]Means and SD were derived from log-transformed data, *P*-values were from 2-sample t-test comparing males and females; [2]Defined as serum folate <6.80 nmol/L

Anemic boys had a 1.5 (95% confidence interval (CI) 0.9-2.6) and 1.6-fold (CI; 1.1-2.6) greater risk of being stunted and underweight respectively, whereas the risk among anemic girls being stunted and underweight was 1.7 (CI; 1.1-2.7) and 1.0 (CI; 0.7-1.5) respectively (Table 6). The risk of being folate deficient was 0.6 (CI; 0.3-1.1) among anemic boys and 1.0 (CI 0.7-1.5) among anemic girls. The risk of having iron, zinc and folate deficiencies among anemic children were 1.6 (CI; 0.6- 4.2) among boys and 0.8 (CI; 0.5-1.5) among girls. 20.5% and 24.0% of zinc deficient individuals were also deficient in iron and folate respectively. Deficiency in both SF and folate was found in 16.0% of the study subjects.

Discussion and Conclusions

This report is a part of a comprehensive study on improving the nutritional status of adolescents in Sri Lanka. The survey was primarily conducted to answer concerns regarding anemia and folate deficiency and their consequences on the reproductive health of adolescent girls. However, as there are no reported data on the nutritional status among adolescent Sri Lankan boys[12,13] we included a representative sample of boys as well in this study.

The prevalence of iron deficiency anemia (IDA) was 24.6 % in males and 40.0 % in females (overall 33.9% for the age group); this is similar to the 36% reported in a National Survey.[14] However, the national survey included a broader age group (10.0-18.9 years) and measured only the hemoglobin concentrations. In this study marginal

Table 6. Risk of anemic school children of having deficiencies of growth and micronutrients[1]

Deficiency Indicator	Boys (*N* = 179)	*P* value	Girls (*N* = 339)	*P* value
Stunting[2]	1.49 (0.86, 2.55)	0.155	1.67 (1.05, 2.65)	0.029
Underweight[3]	1.64 (1.05, 2.55)	0.030	1.03 (0.72, 1.47)	0.866
Iron deficiency[4]	1.45 (0.87, 2.41)	0.150	1.58 (1.11, 2.23)	0.010
Zinc deficiency[5]	0.83 (0.53, 1.30)	0.415	1.07 (0.76, 1.51)	0.700
Folate deficiency[6]	0.58 (0.34, 1.06)	0.045	1.03 (0.69, 1.52)	0.895
Both iron and zinc deficiency	0.62 (0.31, 1.23)	0.169	0.64 (0.43, 0.96)	0.029
Both iron and folate deficiency	1.46 (0.68, 3.13)	0.352	0.91 (0.57, 1.46)	0.691
Both zinc and folate deficiency	1.71 (0.95, 3.01)	0.076	0.93 (0.62, 1.42)	0.747
With iron, zinc and folate deficiency	1.59 (0.60, 4.24)	0.354	0.83, (0.46, 1.49)	0.531

[1] Age adjusted Odds ratios; 95% CIs in parenthesis and anemia defined as hemoglobin < 120 g/L. [2] Defined as HAZ > -2.0 [3] Defined as WAZ > -2.0 [4] Defined as serum ferritin < 30.0 μg/L [5] Defined as serum zinc <9.95 μmol/L [6] Defined as serum folate <6.80 nmol/L

Table 7. Studies on anemia prevalence in South Asia

Year	Population	Country	Prevalence of anaemia
1992[22]	Adolescent girls	Multicenter, India	higher social class – 46.6%
			lower social class – 56.0%
1992[23]	School girls	Islamabad, Pakistan	39%
1997[24]	Adolescent girls	Gujarat, India	overall 60%
1998[25]	Adolescents	Multicenter, Bangladesh	69.0% males, 61.0% females
1999[26]	Adolescent girls	Delhi, India	48%
2000[27]	Adolescent girls	Thamilnadu, India	Premenarcheal – 40.7%, others – 45.2%
2000[28]	Adolescent girls	Bangladesh	27%
2004[29]	School girls	Ahamedabad, India	81.8%
2004 (this study)	Adolescents	Galle, Sri Lanka	males – 49.5%; females – 58.1%

marginal iron stores were noted (SF below 30 μg/l) in 42.2% and depleted iron stores in 14.7 % (SF below 12 μg/L) of subjects. In a previous study on iron status among adolescent females in urban and rural schools in Sri Lanka,[12] 59% had depleted iron stores. A similar finding (54%) was reported in a community and school-based cross sectional survey of adolescents in an urban area of Sri Lanka.[13] In this study, 54.8% of children (M=179; F=339) were found to be anemic (Hb <120g/L), and 1.6% had severe anemia (Hb <80g/L). The better iron status in our study population may be attributed to a better diet and nutritional awareness created by the current education policy of the Country.

Based on the combined cutoff points for Hb and SF concentrations, as recommended by the International Nutritional Anaemia Consultative Group (INACG) in 1985,[15] in this study iron deficiency is attributable to 39.2% of all anemic children. More recently, a study using relative operating characteristics (ROC) curve investigated the sensitivity and specificity of SF as an indicator of iron deficiency, and showed that a cutoff value of 41 μg/L for SF provides optimal diagnostic efficiency among anemic subjects.[16] When this level is adopted for SF in our sample, 46.4% (*N*=179) of anemic boys and 61.7% (*N* =209) of anemic girls were classified as having iron deficiency. It is noteworthy that nearly one-half -of the anemic population does not have iron deficiency, a fact that merits further investigation to determine the causes of anemia in this age group. Although SF is considered to be the most sensitive indicator of iron status, serum ferritin concentrations can be in the normal range even with iron deficiency in conditions of inflammation, concurrent infection, or liver disease.[17,18] The high prevalence of parasitic infections such as lymphatic filariasis in the region[19] might account for concurrent infections in the study population.

DeMaeyer and Tegman[20] estimated the prevalence of anemia among adolescents in developing countries to be 27% with no gender differences. However, in a multinational study[21] on the nutritional status of adolescents conducted by the International Center for Research on Women, anemia was found to be the most widespread nutritional problem, the prevalence of which ranged from 32-55%. This is more consistent with the results from studies of anemia in South Asian countries that are summarized in Table 7.

Although plasma zinc concentration is not considered a reliable indicator of body zinc stores,[30] especially in mild deficiency conditions,[31] at a population level it is the most practical indicator of significant zinc deficiency.[32] There is consistent evidence of this including a recent meta-analysis on the relationship between zinc deficiency and post-natal growth retardation.[33] Countries or communities with a prevalence of stunting over 20% are at a higher risk for associated micronutrient deficiencies, including zinc.[34] The global prevalence of folic acid deficiency is unknown. We were unable to trace any published data on adolescent folate status.

Zinc and folate deficiencies are more difficult to assess than anemia. However, based on the cutoffs used for zinc and folate deficiency in this study, both had a similar prevalence as anemia (55.7% zinc deficient, 53.3% folate deficient, and 54.0% anemic). A recent study in India[35] reported similar results with prevalences of 41.5% (zinc deficiency), 63.8% (folate deficiency), and 27.7% (anemia) among young adult females.

The importance of concurrent micronutrient deficiencies in developing countries is now recognized; their existence is often appreciated after disappointing responses to single micronutrient supplementation programs.[36] Furthermore, focusing on several micronutrients instead of just one is important not only for treating micronutrient deficiencies but also for screening and identifying high risk groups. Iron deficient subjects had a 1.8 times higher risk (CI, 1.1-3.0) of being folate deficient and a 1.7 times higher risk (CI, 1.2-2.6) of being zinc deficient. Zinc deficient subjects had a 1.3 fold risk (CI, 1.0-1.8) of being iron deficient and a 1.2 fold increased risk (CI, 0.9-1.7) of being folate deficient. As we were unable to analyze serum folate concentrations in all study subjects, there is a possibility of confounding. However, as the omissions were purely random as the prevalence of anemia was similar in the analyzed and non-analyzed samples, it is unlikely to significantly influence the results of this study.

This is the first comprehensive nutritional survey conducted among school children in the Galle district of Sri Lanka. This study has identified important nutritional deficiencies and established baseline data for future studies. Most importantly, the results presented here should raise a note of caution for public and private organizations serving underprivileged populations. Malnutrition is not only a stigma for school children; it impairs the overall development of a country.

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Original Article

Prevalence and severity of micronutrient deficiency: a cross-sectional study among adolescents in Sri Lanka

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微量营养素缺乏的普遍性和严重性：一项关于斯里兰卡青少年的代表性研究

在一项代表性的研究（2003）中，为了确定斯里兰卡青少年微量营养素（铁、锌、叶酸）缺乏的流行情况和这些微量营养素缺乏的并发程度，征集了加勒地区 945 名年龄在 12 至 16 岁的学龄儿童，研究了微量营养素和人体测量的状况。49.5％的男性和 58.1％的女性患有贫血（血红蛋白<120.0 g/L）（总的患病率为 54.8％，性别差异，*P*=0.004)。在贫血的孩子中，30.2%的男性和 47.8%的女性缺铁(血清铁蛋白 <30.0 μg/L)，54.6%的男性和 52.5%的女性缺乏叶酸(<6.80 nmol/L) ，51.5%的男性和 58.3%的女性缺锌(<9.95 μmol/L)。贫血男孩身材矮小和体重过轻的危险性分别高出 1.5 倍（95％的置信区间(CI)； 0.9-2.6）和 1.6 倍（CI； 1.1-2.6），而贫血女孩的危险性分别高出 1.7 倍 (CI； 1.1-2.7) 和 1.0 倍 (CI； 0.7-1.5)。对于贫血孩子，至少缺乏铁、锌、叶酸中两种营养素的相对危险度：男孩 1.6 (CI； 0.6-4.2)、女孩 0.8 (CI； 0.5-1.5)。缺铁的孩子会显著提高缺乏叶酸的危险性 1.8 (CI； 1.1-3.0)和缺锌的危险性 1.7(CI； 1.2-2.6)。缺锌的孩子缺铁的危险性为 1.3 (CI； 1.0-1.8)，缺乏叶酸的危险性为 1.2 (CI； 0.9-1.7)。斯里兰卡的青少年缺乏多种微量营养素是一种普遍现象。

关键词：青少年、微量营养素缺乏、铁、锌、叶酸、加勒、斯里兰卡。