Iron status and associated factors among adolescents in the Kandy district

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Abstract

Introduction

Adolescents are a group prone to iron deficiency. Lack of data on prevalence and the determinants of iron deficiency among adolescents in Sri Lanka led to this study.

Methodology

A school based cross sectional study was carried out among 13–15 year old students attending urban big, urban small, rural and estate schools in the Kandy district. The iron status was determined by haemoglobin and serum ferritin levels.

Results

The final analysis included data of 960 students. 30.4% of girls and 19.3% of boys suffered from iron deficiency (ID). Iron deficiency anaemia was found among 14.7% of girls and 5.7% of boys. Among boys, the prevalence of both ID and IDA were highest in estate schools (29.8% and 12.5% respectively). Among girls, the prevalence of ID ranged from 36.8% in urban small schools to 25.7% in rural schools. Of those with anaemia, only 39.2% had IDA.

Father's occupation, father's level of education, mother's level of education and consumption of fruits with major meals showed significant associations with ID among boys. Among girls, none of the factors studied showed a significant relationship with ID.

Conclusions

There is a need to improve the iron status of girls in all types of schools and in boys particularly from estate and urban small schools. The common practice of approximating the prevalence of anaemia to the prevalence of ID and supplementing all those with anaemia with iron is questionable. Fruit consumption with major meals should be promoted as it would be an easy and an acceptable method of improving the iron status.

Key words

adolescents; iron deficiency; anaemia; determinants of iron deficiency.

Introduction

Iron deficiency is the most prevalent nutritional disorder in the world (1). Iron is a trace element having several vital functions in the body. Iron deficiency anaemia (IDA) occurs at a late stage of iron deficiency once the iron stores are depleted. The prevalence of iron deficiency (ID) which is usually detected by low serum ferritin concentrations is estimated to be 2 to 2.5 times the prevalence of IDA (2). Most research and surveys carried out in the past have focused on IDA. Recently, attention is paid also on the prevalence and consequences of ID without anaemia.

Adolescents are a group prone to ID. In Sri Lanka, the few studies that have been carried out on the iron status of adolescents have targeted only girls (3, 4, 5). These subjects were mainly girls attending less privileged Sinhalese schools in the district of Colombo. Lack of data on the iron status in a representative sample of adolescent school children in Sri Lanka led to the present study.

Since the most prevalent cause of anaemia is ID, it has been the tradition to approximate the prevalence of anaemia in a population to the prevalence of IDA. However, other conditions such as inherited disorders like thalassaemias, folate deficiency, vitamin B_{12} deficiency, vitamin A deficiency, malaria, liver diseases and other chronic diseases are also causes of anaemia (6, 7). A low serum ferritin (SF) is highly specific for iron deficiency (8). Use of SF level and haemoglobin value (Hb) in combination is considered as the best method to diagnose ID and its severity in an otherwise healthy group like adolescents (8, 9).

Over several decades, the background knowledge on iron requirement, metabolism, enhancers and inhibitors, iron loss and the populations at risk of ID have received our attention. However, not many studies have assessed the determinants of iron deficiency in free living human populations. Besides, the variables that were considered as important determinants of ID three or four decades ago may not be so anymore today. Therefore, the present study made an attempt to determine the correlates of ID among adolescents.

Methodology

The district of Kandy is well represented by all ethnic and socio-economic groups in Sri Lanka. A school based cross sectional study was carried out among 13–15 year old adolescents in the district of Kandy. The sampling frame consisted of all the state managed schools having classes for the eligible age group (grades 8, 9 and 10) in Kandy (n = 451). Upon certain criteria, these schools were divided into four strata namely urban big (UB), urban small (US), rural and estate. The

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schools under the urban/municipal councils were defines as urban schools. The schools having a total of 400 or more students in grades 8, 9 and 10 were considered as UB schools. If the total number was less than 400, they were named as US schools. The rural schools were the schools under Pradeshiya Sabha (other than estate schools). Those categorized as estate schools by the Ministry of Education were considered as estate schools. A total of 19 schools was selected randomly (4 UB, 5 US, 5 rural and 5 estate schools). The targeted sample size was 1000.

The required sample was drawn by simple random sampling from the name list of eligible subjects in each randomly selected class. Since SF is an acute phase reactant, it could be elevated in some disease conditions irrespective of iron deficiency (10). Hence, the students having chronic infections, liver diseases, malignancy or those who were suffering from an acute illness on the day of data collection were excluded from the study. Data collection was carried out by the principal investigator and four other trained medical doctors. To assess the iron status, 3.5 ml of blood was drawn from each participant. The Hb level was assessed by the Indirect Cyanmethhaemoglobin method which is considered as the gold standard. The SF level was determined by the Enzyme Linked Immuno Assay (ELISA) technique. Hb and SF levels were repeated in 5% of the sample to ensure reliability of data.

The relevant data were collected from students using an interviewer administered questionnaire. Information on parental education and their occupation was obtained from the parents using a request form. Occupations were categorized depending on the income and the level of education required for each occupation. Groups 1 to V comprised better to worse occupational groups. The subjects were asked about the usual current frequency of intake of common iron rich food items in Sri Lanka. A scoring system was developed to assess the haem iron consumption based on the amount of iron in an edible portion of each food item and the frequency of intake. Finally the scores were added up to compute a single score which described haem iron consumption of each subject as low, moderate or high. Egg consumption was considered separately as the bioavailability of iron from eggs is reduced by egg proteins.

The subjects were considered as anaemic if the Hb value was $\leq$ 12g/dl. Irrespective of the Hb value, those who had a SF level $\leq$ 12µg/l were defined as iron deficient. If both Hb and SF levels were below the cutoff points, they were considered to have IDA.

Ethical approval for this study was granted by the Committee on Research and Higher Degrees, Faculty of Medicine, Peradeniya. Approval was obtained by the Ministry of Education and the relevant principals of schools. Informed written consent was obtained from the parents/ guardian of students.

Results

Twelve subjects had to be excluded from the study based on exclusion criteria. A further ten subjects were removed from the analysis due to non-availability of one of the indicators of iron status. The final analysis included data of 960 subjects. The response rate was 98.2%.

The prevalence of ID and IDA among 13–15 year old adolescents in Kandy district was 20.5% and 9.9% respectively (calculated giving a weightage to the proportion of students from each stratum of school). 30.4% of girls suffered from iron deficiency. Among boys, 19.3% had ID. IDA was found among 14.7% of girls and 5.7% of boys.

The iron status according to sex and the stratum of school is shown in Table 1. Boys from the estate and urban small schools showed a higher prevalence of ID. The prevalence of IDA among boys from the estate schools was almost ten times higher than that of the boys from urban big

Table 1 – The iron status of the boys from four strata of schools

Stratum of School	ID		Total		IDA		Total	
	n	%	n	%	n	%	n	%
Urban big	19	(15.0)	127	(100)	2	(1.6)	127	(100)
Urban small	29	(22.7)	128	(100)	7	(5.5)	128	(100)
Rural	13	(11.1)	117	(100)	5	(4.3)	117	(100)
Estate	31	(29.8)	104	(100)	13	(12.5)	104	(100)
Total	**92**	**(19.3)**	**476**	**(100)**	**27**	**(5.7)**	**476**	**(100)**
Significance	$\chi^2 = 14.4$	df = 3	p = 0.002		$\chi^2 = 13.4$	df = 3	p = 0.004	

Table 2 – The iron status of the girls from four strata of schools

Stratum of School	ID		Total		IDA		Total	
	n	%	n	%	n	%	n	%
Urban big	39	(31.2)	125	(100)	17	(1.6)	125	(100)
Urban small	35	(36.8)	95	(100)	16	(5.5)	95	(100)
Rural	37	(25.7)	144	(100)	22	(4.3)	144	(100)
Estate	36	(30.0)	120	(100)	16	(12.5)	120	(100)
Total	**147**	**(30.4)**	**484**	**(100)**	**71**	**(5.7)**	**484**	**(100)**
Significance	$\chi^2 = 3.6$	df = 3	p = 0.31		$\chi^2 = 2.9$	df = 3	p = 0.4	

schools (Table 1). The girls from urban small schools showed the highest prevalence of ID and IDA (Table 2). Surprisingly, the iron status did not differ significantly among girls in the four strata of schools.

A low Hb level (anaemia) was found among 29.8% of girls and 22.3% of boys. Only 3.4% of the sample suffered from moderate to severe anaemia (Hb level less than 10g/dl). Of those with anaemia, only 39.2% had iron deficiency. Even when a higher cut-off point (SF< 25μg/l) was used to define iron deficiency as suggested following a Receiver Operator Curve analysis by another researcher (11), only 43.2% of the anaemics were deficient in iron.

The reliability of the Hb measurement (r=0.74; p<0.001) and SF measurement (r=0.91; p< 0.001) was high.

To prevent a dilution of strength of associations, the group (n = 152) with anaemia without ID (students with a low Hb and a normal SF level) was removed from the analysis when determining the factors associated with ID.

Father's occupation, father's level of education, mother's level of education and consumption of fruits with major meals showed highly significant associations with the iron deficiency among boys (Table 3a). Among girls, none of the factors studied showed a significant relationship with ID (Table 3b). However, IDA of girls showed a significant positive association (p=0.009) with the father's occupation (results not shown). Haem iron consumption was associated only with IDA among boys (p=0.02) (results not shown). Though the prevalence of ID was higher among girls who have attained menarche when compared to who have not attained menarche, the difference was not statistically significant (Table 3b). The girls who have been menstruating for a longer period were more prone to ID. However, the differences seen did not attain statistical significance (Table 3b). The de-worming status and consumption of dark green leaves failed to show a significant relationship with the iron status of either sex. In this study sample, 61% of mother's were housewives. Also, only 3.9% were currently using a vitamin/mineral supplement. Therefore, the association of these two factors with the iron status could not be analyzed.

Discussion

A high prevalence of ID is reported even among adolescents from the most developed countries. Some authors have attributed this to the low energy life style and the changing dietary pattern among adolescents in the developed countries. Among a group of Swedish adolescents (15–16 years), 40% of girls and 15% of boys were deficient in iron (12). In a Norwegian community, 30% of boys and 25% of girls in the 14–15 year age group were iron deficient (13). According to a national survey in Canada, iron deficiency among 15–16 year old boys and girls was 32% and 40% respectively (12). The above findings highlight the importance of screening adolescents for iron deficiency. In the present study, 19.3% of boys were deficient in iron. Hence, future studies on iron status in Sri Lanka should include not only girls but also boys.

When social class was categorized on father's occupation, only 7.4% of girls from UB schools belonged to lower social classes. Over 50% of the girls from other categories of schools were from lower social classes. Nevertheless, a high prevalence of ID even among girls attending UB schools is noteworthy. A study which determined the iron status among 13–19 year old girls in the Colombo district found ID (SF $\leq$ 12μg/l) among 24% of urban girls and 19.9% of rural girls (4). This study included only the schools in which more than 70% of the girls were from the low socio-economic group. In the present study, 36.8% of the girls from urban small schools and 25.7% of girls from rural schools were deficient in iron. In both studies, girls from rural schools

Table 3a – The association of iron deficiency (ID) with factors studied (In boys)

Factors	Normal		ID		Total		*P value
	n	(%)	n	(%)	n	(%)	
Father's occupation							
Class I,II,III	164	(82.0)	36	(18.0)	200	(100)	0.004
Class IV,V, Unemployed	129	(72.5)	49	(27.5)	178	(100)	
Father's education							
A/L & above	66	(88.0)	9	(12.0)	75	(100)	0.008
Passed O/L	103	(78.0)	29	(22.0)	132	(100)	
Below O/L	124	(72.5)	47	(27.5)	171	(100)	
Mother's education							
A/L & above	79	(88.8)	10	(11.2)	89	(100)	0.001
Passed O/L	107	(77.5)	31	(22.5)	138	(100)	
Below O/L	119	(70.4)	50	(29.6)	169	(100)	
De-worming status							
De-wormed within the past one year	150	(78.9)	40	(21.1)	190	(100)	0.4
Not de-wormed within the past one year	112	(75.2)	37	(24.8)	149	(100)	
Haem iron intake							
High	68	(76.4)	21	(23.6)	89	(100)	0.4
Moderate	148	(79.6)	38	(38.0)	186	(100)	
Low	89	(73.0)	33	(27.0)	122	(100)	
Eggs							
Once a week or more often	213	(76.3)	66	(23.7)	279	(100)	0.42
Less often than once a week	92	(81.1)	20	(22.0)	118	(100)	
Dark green leaves							
2 – 3 times a week or more often	219	(75.3)	72	(7.2)	291	(100)	0.22
Once a week or less often	86	(81.1)	20	(10.4)	106	(100)	
Fruits with major meals							
2 – 3 times a week or more often	134	(83.2)	27	(16.8)	161	(100)	0.008
Once a week or less often	171	(72.5)	65	(27.5)	236	(100)	

* P value calculated using the Chi – squared test

showed a better iron status. No data is available to support the prevalence of ID observed among girls from state managed UB schools and estate schools.

A comparison of the iron status of boys in the present study with that of another study is not possible due to unavailability of data in Sri Lanka. According to the findings from our study, there is a need to improve the iron status of all the girls and especially the iron status of boys from the estate and urban small schools in the district of Kandy.

In the present study, only 39.2% of those with anaemia suffered from iron deficiency. Findings from studies carried out in Bangladesh, Kazakhstan and Venezuela are comparable with our study. Among 11–16 year old girls from Bangladesh, only 32% of those with anaemia had ID (14). Of the anaemic children in Kazakhstan (6–15 year old boys and girls), only 32.4% had IDA (15). In Venezuela, ID was noted only among 43% of the subjects (1–16 year olds) having anaemia (16). The same cut-off points used for the Hb and SF values to define anaemia and ID in the present study has been used in all three studies mentioned above.

Like most developing countries, assessing the prevalence of anaemia as a proxy measure of IDA has been the usual practice in Sri Lanka. Hitherto, the aetiology and the distribution of anaemia in Sri Lanka are not known. Studies carried out in Sri Lanka in the recent past had revealed that the prevalence of folate deficiency ranged from 27.5% to 36% among children aged 5–10 years (11, 17). Among a group of 13–19 year old girls in Sri Lanka, the prevalence of vitamin A deficiency was 21.1% (18). Thalassaemia trait is an important cause of anaemia in Sri Lanka (19, 20). These causes would contribute to the

Table 3b – The association of iron deficiency (ID) with factors studied (In girls)

Factors	Normal		ID		Total		*P value
	n	(%)	n	(%)	n	(%)	
Father's occupation							
Class I,II,III	122	(67.8)	58	(32.2)	180	(100)	0.09
Class IV,V, Unemployed	124	(60.8)	80	(39.2)	204	(100)	
Father's education							
A/L & above	56	(66.7)	28	(33.3)	84	(100)	0.53
Passed O/L	62	(59.6)	42	(40.4)	104	(100)	
Below O/L	128	(65.3)	68	(34.7)	196	(100)	
Mother's education							
A/L & above	55	(64.7)	30	(35.3)	85	(100)	0.44
Passed O/L	67	(59.8)	45	(40.2)	112	(100)	
Below O/L	140	(67.0)	69	(33.0)	209	(100)	
De-worming status							
De-wormed within the past one year	134	(60.1)	89	(39.9)	223	(100)	0.08
Not de-wormed within the past one year	93	(67.9)	44	(32.1)	137	(100)	
Haem iron intake							
High	50	(61.7)	31	(38.3)	81	(100)	0.67
Moderate	126	(63.3)	73	(36.7)	199	(100)	
Low	88	(67.2)	43	(32.8)	131	(100)	
Eggs							
Once a week or more often	176	(63.1)	103	(36.9)	279	(100)	0.28
Less often than once a week	88	(66.7)	44	(33.3)	132	(100)	
Dark green leaves							
2 – 3 times a week or more often	192	(79.7)	49	(20.3)	241	(100)	0.54
Once a week or less often	72	(76.6)	22	(23.4)	94	(100)	
Fruits with major meals							
2 – 3 times a week or more often	110	(79.1)	29	(20.9)	139	(100)	0.86
Once a week or less often	154	(78.6)	42	(21.4)	196	(100)	

* P value calculated using the Chi – squared test

prevalence of anaemia in our country. Therefore, the present study highlights three important points noteworthy for health managers and policy makers in Sri Lanka. Firstly, it is not appropriate to approximate anaemia prevalence to that of iron deficiency as less than 50% of those with anaemia are iron deficient. Secondly, it is irrational to supplement all those with anaemia with iron. Thirdly, it is necessary to find out the aetiology of anaemia and its pattern of distribution in Sri Lanka.

Both the subjects and the interviewers were blind to the iron status of the participants at the time of data collection. This would have prevented an information bias entering into the study. The strong relationship observed with the iron status of both boys and girls confirms the father's occupation as an important determinant of iron deficiency among adolescents.

In agreement with the present study, a research carried out among pregnant mothers in Sri Lanka has failed to find a significant association between haem iron consumption and the iron status (21). May be due to the influence of so many factors in the diet on absorption of non-haem iron from dark green leaves, no association was observed between the iron status and the consumption of dark green leaves. A similar finding has been observed in a study involving Mexican Americans and Non-Hispanic white females (22).

Citric, ascorbic and malic acids are enhancers of non-haem iron absorption from meals (23, 24). Fruits are rich in all the above ingredients. However, studies have not assessed the effects of fruits on the body iron status before. Intake of dark green leaves which is a common source of dietary non-haem iron was high among 73% of our study sample. This reflects the importance of enhancing the non-haem iron absorption from the

diet of adolescents. As fruits are abundant in Sri Lanka, the iron status could be improved by a socially accepted method such as consuming fruits with major meals.

The mean number of months of menstruation among the girls who have attained menarche was 22.1. Probably, a blood loss for such a short period did not contribute to a significant difference in their iron status. Further, this study failed to consider the amount of blood loss during menstruation in each individual. Supporting the findings of the present study, no association has been observed between the iron status and duration of menstruation among girls in the Colombo study (4).

The most amazing finding of the present study is the significant association of several factors with the iron status of boys but not with that of girls. Whether this is due to the biological variation between the two sexes or due to another unforeseen factor is not explainable from the available data in this study. Not a single study in literature has studied the determinants of iron deficiency according to sex in any population. Hence, this is a new finding that needs to be studied further.

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