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Research Article

Iron deficiency and iron deficiency anaemia in children of school canteens in Abidjan, Côte d'Ivoire

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Abstract: In Côte d'Ivoire very few studies have been devoted to the exploration of iron status among school-age children. This study aims to evaluate iron status in children aged 5 to 11 years in good health in three canteens of three municipalities in of Abidjan (Côte d'Ivoire). A total of 103 students, including 42 girls and 61 boys were selected for this study. Blood samples were taken in each of these children in order to investigate some parameters of blood count and determine some biochemical parameters of iron status. The mean values of various biological parameters of iron status were normal in accordance to physiological reference values from the literature with the exception of hemoglobin in boys which is below normal rate. All parameters did not indicate significant differences between girls and boys ($p > 0.05$). Our study indicated that in children about two out of three have abnormal iron status. Abnormal iron status is composed respectively by 3.9% of iron deficiency, 8.7% iron deficiency anaemia, 22.3% of simple inflammatory anemia and 23.3% of inflammatory anaemia associated to deficiency martial. Iron deficiency anemia was the only type of nutritional anaemia noted in this work. In addition, we observed two types of anaemia of inflammatory origin.
Keywords: Children, School canteens, Iron deficiency, Iron deficiency anaemia, Inflammatory anaemia, Abidjan (Côte-d'Ivoire).

INTRODUCTION

Iron is an important mineral for the body which uses it for the production of hemoglobin, a key pigment of red blood cells. Iron is also a component of many essential enzymes in the development of cells, growth of the appropriate cells of the brain, muscle, and immune system [1]. In the healthy subject, there is equilibrium between intake and output of iron. The upsetting of this balance resulting by in an inadequate intake of iron to maintain normal functions marks iron deficiency [2]. This iron deficiency affects all parts of the world, especially the developing countries where it constitutes the most common nutritional disorder [3].

The infants present a particular risk due to their rapid growth and limited dietary sources of iron [4]. Several studies have linked iron deficiency to several consequences on the development of these ones, particularly the motor and cognitive development [5-7], their Growth [8], the immune function with an increased risk of infection [9,1].

Iron deficiency is a common nutrient deficiency that approximately affects two billion people worldwide, causes more than 500 million cases of anemia [10]. In developed countries, iron deficiency is usually the main cause of anemia. Indeed, data from the United States show that for every case of anaemia, there are 2.5 cases of iron deficiency [11]. However, no data shows that this ratio applies to other parts of the world, such as sub-Saharan Africa, where iron deficiency is not always the only or main cause of anaemia. However, a study in Côte d'Ivoire [12] shows that iron deficiency anaemia accounted for about 50% of the observed anaemia. In that study, the proportion of anaemic people with iron deficiency, varied according to age and sex. Approximately 80% of anaemic children, preschoolers, were suffering from iron deficiency anaemia, whereas this proportion was 50% in the age children to attend school and in women and 20% of men suggesting a link between anaemia and iron deficiency.

The aim of this study is to determine, iron status in a schoolboy population supposed to be healthy in the Abidjan (Côte d'Ivoire) and reveal the types associated anemia.

MATERIALS AND METHODS

Design and study population

A total of 120 pupils were selected to reach a final enrollment of 103 pupils, including 42 girls and 61 boys. The sex ratio was 1.5. The mean age of the study population was 9 ± 0.2 and ranged from 5 to 11 years (Table 1).

Table-1: General characteristics of study population

General characteristics	Total population N=103	Girls N=42	Boys N=61
Age (year)	9 ± 0.2	9.2 ± 0.2	8.8 ± 0.2
5 – 6	10.7% (11)	7.1% (03)	13.1% (08)
7 - 11	89.3% (92)	92.9% (39)	86.9% (53)
Height (cm)	131 ± 1.0	133 ± 1.7	129.6 ± 1.2
Weight (kg)	27 ± 0.6	28.8 ± 1.2	25.9 ± 0.7
Wasting (W/A)			
(Z-score rated, mean)	-0.9 ± 0.1	-0,4 ± 0,2	-0,6 ± 0,1
< -2Z	10.7 % (11)	9.5 % (4)	11.5 % (7)
-2Z – 2Z	87.4 % (90)	88.1 % (37)	86.9 % (53)
> 2Z	1.4 % (02)	2.4% (01)	1.6 % (01)
Stunting (H/A)			
(Z-score rated, mean)	-0.5 ± 0.1	0.0 ± 0.2	-0.1 ± 0.1
< -2Z	2.9 % (03)	4.8 % (2)	1.6 % (01)
-2Z – 2Z	90.3 % (93)	88.1 % (37)	91.8 % (56)
> 2Z	6.8 % (7)	7.1 % (3)	6.6 % (4)
BMI			
(Z-score rated, mean)	-0.4 ± 0,1	-0.3 ± 0,1	-0.4 ± 0,1
< -2Z	3.9 % (04)	1 % (01)	2.9 % (03)
-2Z–2Z	96.1 % (99)	39.8 % (41)	56.3 % (58)
> 2Z	-	-	-

(): Observed numbers in each group of subjects are in brackets; N: Size of subject groups

Our work was, a cross-sectional study, descriptive analytic in school children located of three municipalities in Abidjan. They are school groups named "Libanaise" Ananeraie Yopougon, "Rosier 5" of Cocody belle côte and "Agbékoi" of Abobo. Our works were carried out during the period from January 2013 to March 2013.

The collection of anthropometric data from this study was done using a questionnaire to pupils with free and informed consent of the parents, following an explanation of the interest of the study.

For the selection of subjects, a set of criteria including clinical and biological signs allowed to exclude and include subjects for the need of our investigations. This is in the case of non-inclusion, especially haematologic complications, digestive and inflammation in the three months preceding the study and girls menstruation. All these observations were made by a medical team from the National Institute of Public Health (INSP) Abidjan-Adjamé, Côte d'Ivoire. All other children present on the day of the study and attending school canteen were included in the study.

Sampling and assay of blood samples

Samples of venous blood from each child were taken fasting in tubes containing an anticoagulant, the Ethylene Diamine Tetra Acetic Acid (EDTA) and dry tubes, the morning between 7:00 and 8:00 in these schools. These blood samples are shipped the same day of collection at the Biological Laboratory of the National Institute of Public Health for the realization of the full blood count.

The samples obtained with dry tubes were used for biochemical analysis. Before they were were centrifuged at 3,000 rpm for 5 minutes and the serum was aliquoted into micro bowls.

The determination of biochemical parameters of iron status (serum iron, serum transferrin and serum ferritin) was performed on COBAS INTEGRAS 400. The COBAS INTEGRA Iron cassettes, COBAS INTEGRA Ferritin Gen 2 (FERR2), COBAS INTEGRA transferrin Ver.2 (TRSF2) contain diagnostic reagents for *in vitro* quantitative determination of iron, immuno-enzyme of the transferrin and human ferritin in serum and plasma.

The other biochemical indicators such as the total iron binding capacity (TIBC) of transferrin, saturation coefficient of transferrin (SCT) and the iron reserves were determined by calculation using the following formulas: TIBC (mmol/l) = Transferrin (g/l)×25 SCT (%) = 100×[serum iron (mmol/l)/TIBC] and iron stores (mg) = 8×[ferritine (ug/l)].

The determination of haematological parameters of blood count was performed immediately after homogenization on Coulter of the samples contained in EDTA tubes by an automatic analyzer, the Sysmex KX 21N.

The criteria defined by the World Health Organization (WHO) were used to estimate the various prevalences, of major haematological and biochemical parameters.

Statistical analysis

For statistical analysis, the data were entered and analyzed by the STATISTICA software (Windows version 7.1). The mean values of various parameters investigated in the children were compared using the non-parametric U test of Mann-Whitney. The comparisons of different proportions of key parameters obtained from the blood count and biochemical parameters of iron status were performed by the test Loglikelihood ratio (Test "G") with the "R" Windows 2.0.1 statistical software. A value of $p<0.05$ was considered as indicative of significance.

RESULTS

Changes in biological parameters of iron status

The mean values of various biological parameters of iron status associated with the standard error of the mean (SEM) are indicated in Table 2. These values were normal according to reference values, excepting of hemoglobin rates in boys which was below normal rate. All parameters did not indicate significant differences between girls and boys ($p > 0.05$).

Table-2: Mean values of biological parameters related to iron status

Biochemical parameters of iron status	Total population N= 103	Girls N=42	Boys N=61	P value
Globular numeration				
Red blood cells (10^6/µl)	4.7 ± 0.0	4.8±0.1	4.7±0.1	0.4(NS)
Hemoglobin (g/dl)	11.5 ± 0.1	11.6±0.2	11.4±0.1	0.5(NS)
Hématocrite (%)	36 ± 0.3	36.4±0.5	35.6±0.4	0.2(NS)
Erythrocytes Indices				
MCV (fl)	76 ± 0.5	76.7±0.9	75.5±0.7	0.1(NS)
MCH (pg)	24.3 ± 0.2	24.5±0.3	24.2±0.2	0.3(NS)
MCHC (g/dl)	32 ± 0.1	32±0.2	32.1±0.1	0.5(NS)
Plasma compartment				
Serum iron (µmol/l)	13.5 ± 0.5	13.3±0.8	13.7±0.7	0.8(NS)
Serum transferrin (g/l)	3.1 ± 0.0	3.2±0.1	3.0±0.1	0.2(NS)
Total iron binding capacity (µmol/l)	77.6 ± 1.4	79.9±2.1	76±1.9	0.3(NS)
Saturation coefficient of Transferrin (%)	17.5 ± 0.6	16.7±0.9	18±0.8	0.4(NS)
Compartment of reserves				
Serum ferritin (µg/l)	31.9 ± 2	35.2 ± 3.3	29.7 ± 5.1	0.1(NS)
Iron reserve (mg)	255.4±16.3	281.5±26.5	237.4±20.4	0.1(NS)

N: Total number of each subject groups; MCV: Mean Corpuscular Volume; MCH: Mean corpuscular hemoglobin; MCHC: Mean corpuscular hemoglobin concentration; S: Statistically different for p value < 0.05; NS: Not statistically significant for p value < 0.05.

Prevalences of anaemia and proportions of main parameters of iron status

The proportions of the biological parameters of iron status are presented in Table 3. Our results were indicated a very high level of anaemia rates (54.4%), hypochromia (38.8%) over the entire population. The macrocytosis and microcytosis were observed respectively in 3.9% and 11.7% of subjects with no significant difference ($p > 0.05$) between sexes. The proportion of subjects whose hematocrit was less than 36% was very high (54.4%). This rate did not vary significantly ($p > 0.05$) by sex.

Anaemia was observed in 57.4% of boys and 50% of girls with no statistically significant difference ($p > 0.05$).

The distribution of anaemia according to the typology and sex is summarized in Table 3. The macrocytic anaemia among boys (2.9%) were significantly ($p = 0.04$) higher compared to girls (0%). Also, the normocytic hypochromic anaemias were encountered more in boys (42.9%) than in girls (33.3%) with no significant difference ($p > 0.05$). However, the normochromic normocytic anaemia and hypochromic microcytic anaemia were higher among girls (47.7% respectively 19%) than boys (37.1% respectively 17.1%) with no significant difference ($p > 0.05$).

Table-3: Proportion of haematological parameters types of anaemia

Haematological parameters	Total Population N=103		Girls N=42		Boys N=61		P-Value
	n	%	n	%	n	%	
Erythrocytes indice							
Hemoglobin (g/dl)							
8.8 – 11.5	56	54.4	21	50	35	57.4	0.5(NS)
11.5 – 14.8	47	45.6	21	50	26	42.6	0.5(NS)
Hematocrit (%)							
27.3 – 36	56	54.4	20	47.6	36	59	0.3(NS)
36 – 43.4	47	45.6	22	52.3	25	41	0.3(NS)
MCV (fl)							
61 – 70	12	11.7	4	9.5	8	13.1	0.5(NS)
70 – 86	87	84.5	37	88.1	50	82	0.7(NS)
86 – 89.7	4	3.9	1	2.4	3	4.9	0.5(NS)
MCH (pg)							
18.9 - 24	40	38.8	14	33.3	26	42.6	0.3(NS)
24-31	63	61.2	28	66.7	35	57.4	0.4(NS)
Types of anaemia							
MHA	10	17.9	4	19	6	17.1	0.8(NS)
NHA	22	39.3	7	33.3	15	42.9	0.3(NS)
NNA	23	41.1	10	47.7	13	37.1	0.2(NS)
mNA	1	1.8	0	0	1	2.9	0.04(S)

N: Total number of each subject groups; n: subjects number observed in each group;
MCV: Mean Corpuscular Volume; MCH: Mean corpuscular hemoglobin; MHA: Microcytic Hypochromic Anaemia; NHA: Normocytic Hypochromic Anaemia; NNA: Normocytic Normochromic Anaemia; mNA: macrocytic Hypochromic Anaemia, S: Statistically different for p value < 0.05; NS: Not statistically significant for p value < 0.05

The exploration of biochemical parameters proportions of iron status was presented in Table 4. The results were revealed that the proportions of serum iron and coefficient saturation decreased are respectively higher among boys (39.3% and 64%) than girls (7.1% and 42.9%). This difference was highly significant proportions ($p < 0.01$) for serum iron and significant ($p = 0.04$) in terms of coefficient saturation. The amounts of transferrin and total iron binding capacity reduced were higher in boys than in girls with no significant difference.

The frequency of children, with low ferritin concentration is 12.6%. This concentration was lower in boys than in girls with no significant difference. It was the same observation for iron stores.

Prevalences of iron status

The iron status of children presented in Figure 1 was shown that 58.3% of subjects had abnormal iron status against 41.7% of children with the normal iron status. Abnormal iron status is composed by 3.9% of iron deficiency, 8.7% iron deficiency anaemia, 22.3% of simple inflammatory anaemia and 23.3% of inflammatory anaemia associated to iron deficiency. Iron deficiency anaemia was the only type of nutritional anaemia noted in this work. In addition, we observed two types of anaemia of inflammatory origin.

The iron status by sex presented in Figure 2 was indicated that 42.6% of boys had abnormal iron status against 40.5% girls. Abnormal iron status is composed of 7.1% and 9.8% of iron deficiency anaemia, 16.7% and 26.2% of inflammatory anaemia and 28.6% and 19.7 inflammatory anaemia associated to iron deficiency, respectively, in girls and boys. The differences in proportions for the above mentioned parameters was not statistically significant. In contrast, iron deficiency was significantly ($P < 0.05$) higher in females (7.1%) than boys (1.6%).

Table-4: Proportion of biochemical parameters combined with iron status

Biochemical parameters of iron status	Total Population N=103		Girls N=42		Boys N=61		P Value
Plasma compartment	n	%	n	%	n	%	
Serum iron (µmol/l)							
<6.6 / <11	27	26.2	3	7.1	24	39.3	0.001(S)
6.6 – 26 and 11- 28	76	73.8	39	92.9	37	60.7	0.01(S)
>26 and >28	-	-	-	-	-	-	
Serum transferrin (g/l)							
< 2	4	3.9	1	2.4	3	5	0.3(NS)
2 – 3.6	87	84.5	35	83.3	52	85.2	0.9(NS)
> 3.6	12	11.6	6	14.3	6	9.8	0.4(NS)
Total iron binding capacity (µmol/l)							
< 50	4	3.9	1	2.4	3	5	0.3(NS)
50 – 90	87	84.5	35	83.3	53	85.2	0.9(NS)
> 90	12	11.6	6	14.3	6	9.8	0.4(NS)
Saturation coefficient of Transferrin (%)							
< 15 / <20	57	55.3	18	42.9	39	64	0.04(S)
15-35 / 20-40	46	44.7	24	57.1	22	36	0.03(S)
Compartment of reserves							
Serum ferritin (µg/l)							
< 15	13	12.6	5	11.9	8	13.1	0.8(NS)
15-80	86	83.5	34	81	52	85.2	0.7(NS)
> 80	4	3.9	3	7.1	1	1.6	0.005(S)
Iron Reserves (mg)							
< 120	13	12.6	5	11.9	8	13.1	0,8(NS)
120-640	86	83.5	34	81	52	85.2	0,7(NS)
>640	4	3.9	3	7.1	1	1.6	0,005(S)

N: Total number of each subject groups; n: Subjects number observed in each group;
MCV: Mean Corpuscular Volume; MCH: Mean corpuscular hemoglobin; S: Statistically different for p value < 0.05; NS: Not statistically significant for p value < 0.05

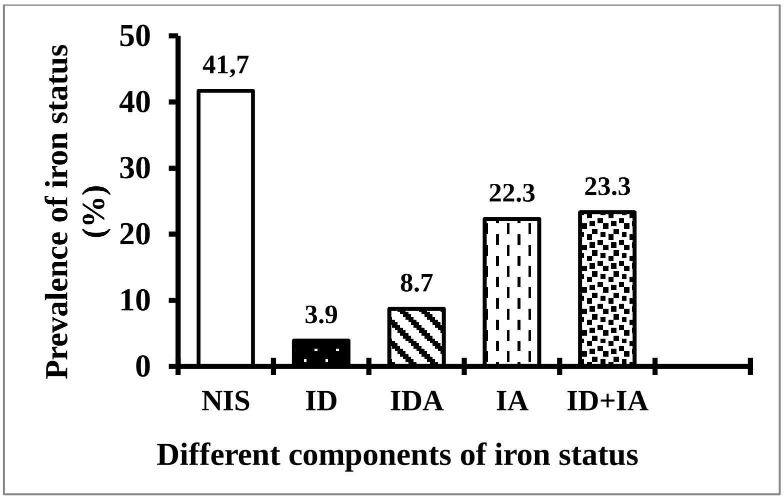

Fig-1: Prevalence of iron status in children

SIN: Normal Iron Status; ID: Iron Deficiency; IDA: Iron Deficiency Aneamia;
IA: Inflammatory Aneamia; ID+IA: Inflammatory Aneamia associated with Iron Deficiency

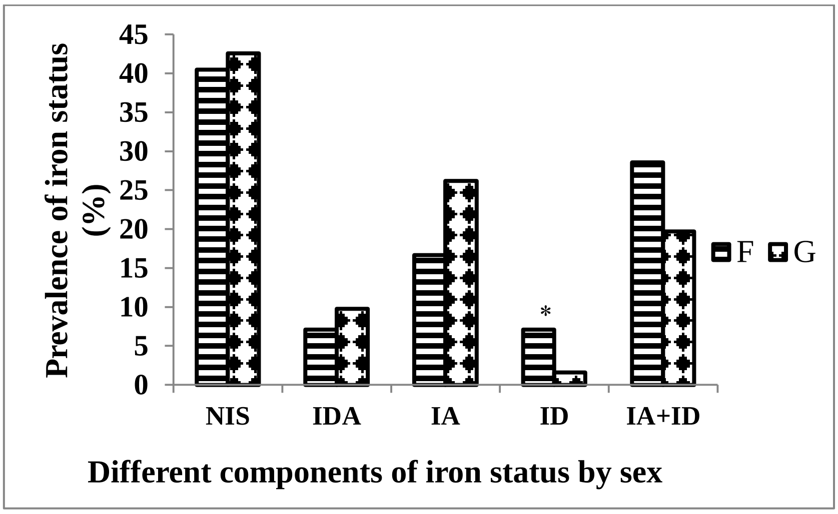

Fig-2: Prevalence of iron status in children by sex

NIS: Normal Iron Status; ID: Iron Deficiency; IDA: Iron Deficiency Aneamia; IA: Inflammatory Aneamia; IA+ID: Inflammatory Aneamia associated with Iron Deficiency

DISCUSSION

Iron deficiency, results from an imbalance in the balance of iron in the body; in children, it is most often an insufficient of contributions to the needs more important deal with especially in infancy than in adults. According to our results, the prevalence of abnormal iron status (58.3%) is higher among children in our study. Among children with iron deficiency, 69.2% are anemic. These rates are higher than those obtained by [12] in a population of the same age in Côte d'Ivoire. The anaemia by Iron deficiency in our study sample of about 9% is lower than in the Kenyan students [13] a developing country likes Côte d'Ivoire. Furthermore this high prevalence result from a lack of iron stocks in mothers during pregnancy. In effect, Bleyere *et al* [14] showed a deterioration of iron stores in the first three months of pregnancy Ivorian adolescents.

According to Herceberg *et al*. [15], three stage of iron deficiency, allow describing the deficit of iron in the body. First, the simple depletion of tissue iron stores without deficit of erythropoiesis that is characterized by an isolated decrease of serum ferritin below of 15 mg/l (in children). Then, the depletion of reserves, with deficiency of erythropoiesis is accompanied by a decrease in the coefficient saturation of transferrin, increased transferrin and total iron binding capacity, a decrease in serum iron and disruption of conventional erythrocyte parameters. The last stage is iron deficiency anaemia, where the fall in hemoglobin below the threshold limit, allows recognizing anaemia [16].

MCV and MCH are lowered, respectively, of 11.7 and 38.8% in children. These results show the falling of red blood cell parameters. In additional, the ferritin and the saturation coefficient of transferrin, are lowered respectively of 12.6% and 55.3% in school children. Regarding the transferrin, total iron binding capacity and ferritin, they are increased about 12% in our study subjects. More than half of our study populations (54%) are anaemic. Among these, about 18% are hypochromic. The same results were observed in adolescents during pregnancy in Côte d'Ivoire [17]. It is the same among adult women in pregnancy [18]. This suggests an early iron supplementation during pregnancy in our country.

These results describe perfectly that iron deficiency leads to anaemia. Moreover, other studies in Africa have shown that numerous Africans have a diet that contains little or no animal protein. The diet of most Africans is based on plants [18-19]. The iron in plant is non-heme, so no easily absorbable [20]. That could justify low level of iron stores in relation to the present work. However, we get only 9% of iron deficiency anaemia. That suggesting that the anaemia causes is other than those nutritional in this study.

Abnormal iron status is composed of iron deficiency, different types of anaemia related to either iron deficiency or inflammation. Iron deficiency without anaemia in our study is below that obtained by El Hioui *et al*. [21] who realized their study in a rural province of Moroccan on school children aged of 6 to 16 years. Besides iron deficiency, inflammatory anaemia and inflammatory anaemia associated to iron deficiency coexist among schoolchildren. The latter type of anaemia is usually caused by infectious syndromes [20]. In this sense, the prevalence of abnormal iron status could be explained by the existence of a number of factors such as infectious and inflammatory syndromes responsible for deviation and sequestration of iron circulating in the body [22-23].

CONCLUSION

At the end of the study, the prevalence of abnormal iron status observed among school children in Abidjan was 58.3%. This abnormal status comprises

3.9% of iron deficiency, 8.7% of iron deficiency anaemia, 22.3% of simple inflammatory anaemia and 23.3% of inflammatory anaemia associated to iron deficiency. Anaemia according to the results is mostly due to an inflammatory cause. Iron deficiency anaemia is very little pronounced in this study.

The saturation coefficient of transferrin (SCT) is the most lowered biological parameter (55.5%) in these children. The lowered percentage of ferritin in the whole of population is 12.6%. The anaemia in this study has others causes than those nutritional linked to iron deficiency.

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