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Haematological profile of adolescents in Abidjan (Côte d'Ivoire)

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Abstract

In Côte d'Ivoire, haematological status of adolescents has not yet been established. The aim of this study was to evaluate the haematological profile of healthy adolescents in Abidjan (Côte d'Ivoire). Our study was undertaken with 847 healthy volunteers adolescents aged from 12 to 18 years. They were selected in three municipalities of Abidjan. The complete blood cells count was analyzed for each of these adolescents and each blood sample was screened for hemoglobin pathologies by using electrophoresis on cellulose acetate membranes at alkaline pH. The values of all parameters in the complete blood cells count were normal for 9.4 % against 90.6 % with the abnormal haematological status. In the abnormal values, the prevalence of anaemia was 53.1 % with 43.3 % of microcytic hypochromic anaemia, 16.9 % of normocytic normochromic anaemia, 15.6 % of normocytic hypochromic anaemia and 1.1 % of microcytic hypochromic anaemia. The microcytosis (44.4 %), hypochromia (60.3 %), leukopenia (35.1 %), neutropenia (13 %), monocytopenia (4.1 %), thrombocytopenia (6.4 %) and decreased proportion of eosinophils (9.8 %) were also observed in total study population. In addition, a significant difference was indicated between both sexes for mean values of the red cells blood count, hemoglobin, hematocrit, thromcytes, eosinophils, and monocytes. In this context, the boys showed generally the greatest mean values of these parameters compared to girls. Typing of hemoglobin showed that 15.5 % of subjects presented abnormal hemoglobins corresponding to 17 % for boys and 13.9 % for girls. The components of the abnormal hemoglobin status have included the hemoglobin AS, SS, AC, CC and SC. The study showed that the haematological profile of adolescents is more altered in Abidjan (Côte d'Ivoire). In addition, our investigations revealed also that over half (53.1 %) adolescents indicated anaemia. In the same vein, all the white blood count parameters were modified in adolescent's population. Future studies in all municipalities of Abidjan, in all regions of Côte d'Ivoire for a representative sample will lead to real values of the parameters of normal blood count of adolescents in our country.

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Introduction

The complete blood count is one of the most prescribed laboratory tests and the most useful in medical practice. Its changes may address a wide variety of pathologies (Rakoto *et al.*, 2000). The complete blood count has two types of analysis: a quantitative analysis to measure the absolute number of cells per unit of volume of blood and a qualitative analysis that reveals the different forms of blood cells. Its interpretation is therefore essential in guiding diagnosis, prescribing additional analysis or deciding a specialized consultation (Quaranta *et al.*, 1990).

The complete blood count allows affirming the existence of anaemia on hemoglobin levels below 13 g/dl in men, 12 g/dl in women and children, or less than 10.5 g/dl in pregnant women (Williams, 1983; UNCEF/UNU/WHO, 2001; FSH, 2006). In addition, it is used to specify the central or peripheral anaemia and to determine their causes from the erythrocyte indices (Wajcman *et al.*, 1992; Bernard *et al.*, 1996). In many developing countries, anaemia can derive from certain hemoglobinopathies, infections due to malaria (Dillon, 2000; Akhigbe *et al.*, 2010), inflammatory disorders (Yip and Dallman, 1988) and deficits of other nutrients such as folate, vitamin B12 or vitamin A and iron (Suharno *et al.*, 1993; Savage *et al.*, 1994; Khattak and Ali, 2010).

In Côte d'Ivoire, the haematological status in adolescent's population is not carried out. In addition, we do not currently have the usual values of the complete blood count parameters of the population as in certain countries (Rakoto *et al.*, 2000). Moreover, scientific studies so far are partially carried out (Paknahad *et al.*, 2008). Further, the values of the full blood count established from Caucasian individuals are not always appropriate to determine the diagnosis of anaemia at risk populations in developing countries paths (WHO, 2001).

That's why we undertook a survey of a population ensure a healthy adolescence in order to:

- measure the complete blood count parameters in adolescents;
- compare the proportions of the full blood count main parameters between the sexes in adolescents;
- estimate the prevalence of anemia;
- determine the types of anemia in this population;
- propose standards for various parameters of the complete blood count of the Ivorian adolescents;
- eventually establish the typing of hemoglobin.

Materials and methods

Locations and study population

The study subjects were adolescents aged 12 to 18 years for both sexes combined. This study was conducted over a period from October 2008 to September 2009. These adolescents were enrolled in primary, secondary and households of three municipalities in Abidjan: Abobo, Adjamé and Yopougon. This group of volunteers' adolescents was selected from various social groups. The collection of anthropometric data of this study was done using a questionnaire sent to adolescents with the informed consent of 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 topics for the need of our investigations. He acted in any pregnancy (female subject) gynecological, digestive, hematological complications and especially of inflammation in the three months preceding the study. All these observations were made by a medical team from the National Institute of Public Health (INSP) of Côte d'Ivoire.

Amongst the 943 volunteers included, we selected only 847 divided as follows 436 adolescent males (51.5 %) and 411 females (48.5 %) after applying the criteria for inclusion and exclusion of subjects (Fig. 1).

The males predominated with a sex ratio of 1.1. The mean age of the study population was 14.6 ± 0.1 years

and ranged from 12 to 18 years. The mean value of body mass index (BMI) was 18.6 ± 0.1 kg/m² for the total population. Moreover, the majority of subjects attends school 94.9 % against 1.3 % and 3.8 % of school dropouts in (Table 1).

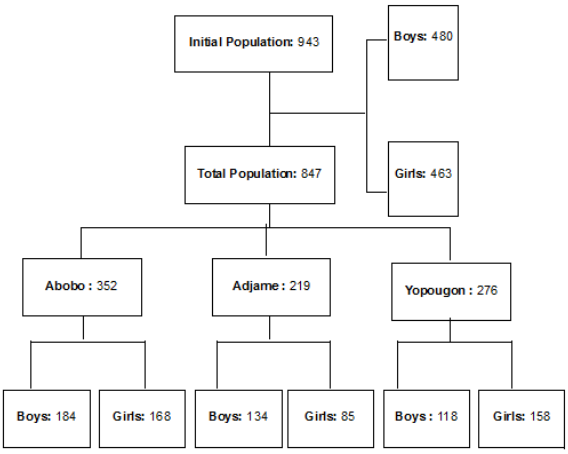

Fig. 1. Trial profile.

Blood samples and biological assays

At each of the adolescents, a blood sample by venipuncture open the elbow was performed fasting in the morning between 7 and 9 hours in a 5 ml tube containing an anticoagulant, ethyl diamine tetra acetic acid (EDTA). The blood sample used to determine both the variables of the complete blood count and hemoglobin electrophoresis. Each dose of the blood sample from the same collection is duplicated to reduce the errors of manipulation. And the mean of two obtained is used for the study. The automated hematology analyzer type "Sysmex KX-21N" was used to measure the variables of full blood count. An electrophoretic profile of each individual is determined from a volume of packed red blood cells. The equipment type Helena was used to assess the types of hemoglobin electrophoresis at alkaline pH on cellulose acetate (Schneider, 1973).

Table 1. Characteristics of studied population.

Parameters	Total population (N = 847)	Boys (N = 436)	Girls (N = 411)
Age (years)	14.6 ± 0.1	14.9 ± 0.1	14.35 ± 0.1
12-17	79.46 % (673)	75.23 % (328)	83.94 % (345)
18	20.54 % (174)	24.77 % (108)	16.06 % (66)
Weight (kg)	46.32 ± 0.47	46.78 ± 0.71	45.82 ± 0.62
Height (m)	1.56 ± 0.004	1.58 ± 0.007	1.54 ± 0.005
Body mass index (kg.m^{-2})	18.58 ± 0.11	18.21 ± 0.15	18.97 ± 0.17
< 18.5	11.45 % (97)	13.76 % (60)	9 % (37)
18.5-26	85.13 % (721)	83.72 % (365)	86.62 % (356)
> 26	3.42 % (29)	2.52 % (11)	4.38 % (18)
Education			
Educated	94.92 % (804)	94.5 % (412)	95.38 % (392)
Non educated	1.3 % (11)	0.92 % (4)	1.7 % (7)
Dropouts	3.78 % (32)	4.58 % (20)	2.92 % (12)

Table 2. Mean values of haematological parameters in relation to references

Haematological parameters	Mean values ± SEM	Reference Values[α]
Blood cell counts		
Red cells blood (10^{12}/l)	4.8 ± 0.02	4.5–6/4-5.4
Hemoglobin (g/dl)	12.5 ± 0.1	13–18/12-16
Hematocrit (%)	38.3 ± 0.2	40–50/35-47
Erythrocytes Indices		
MCV (fl)	80.6 ±0.2	80–100
MCH (pg)	26.2 ± 0.09	27–31
MCHC (g/dl)	32.9 ± 0.1	32–36
Leukocytes Count		
Leukocytes (10^9/l)	5.6 ± 0.1	5-10
Eosinophils (%)	0.1 ± 0.02	1-5
Neutrophils (%)	2.5 ± 0.4	45-70
Basophils (%)	0.001 ± 0.01	0-3
Monocytes (%)	0.3 ± 0.1	2-10
Lymphocytes (%)	2.7 ± 0.2	15-40
Thrombocytes Bloodline		
Thrombocytes (10^9/l)	259.1 ± 2.7	150–400
Haematological status		
Normal (TP)	(80) **9.4 %**	
Abnormal (TP)	(767) **90.6 %**	
Normal (G)	(38) **9.2 %**	
Abnormal (G)	(373) **90.8 %**	
Normal (B)	(42) **9.6 %**	
Abnormal (B)	(394) **90.4 %**	

α: Haemotological reference parameters respectively in boys and girls according to SFH, 2006; SEM: Standard error of mean: TP: Total population; G: Girls; B: Boys

Ethics

Experimental procedures and protocols used in this study were approved by ethical committee of Health Sciences, University of Cocody (Abidjan/Côte d'Ivoire). These guide line were in accordance with the internationally accepted principles for laboratory use and care. Then, this study was approved by the Ministry of Higher Education and Scientific Research and the Ministry of Health and Public Hygiene in the Republic of Côte d'Ivoire.

Statistical exploitation of biological parameters

The study data have been statistically analyzed to express the results by sex in the form of means associated with the standard error of the mean (SEM) with a confidence interval of 95 %. The "t" Student test for independent samples by variables performed with Statistica software windows version 6.0 (StatSoft, data analysis software system) was used to compare the means of biological parameters between the sexes. For the comparison of different proportions obtained, the "G" test is conducted by the statistical program R version 2.1.1 software windows. A probability level $p < 0.05$ was chosen for the statistical significance tests.

Results

Changes in haematological parameters and prevalence of anaemias

The overall data of haematological parameters of the study population are summarized in Table 2. The mean

values of all the haematological parameters were normal compared to international references except the mean corpuscular hemoglobin (UNCEF/UNU/WHO, 2001; FSH, 2006). The values of all parameters in the complete blood cells count were normal for 9.4 % against 90.6 % with the abnormal haematological status (Table 2). To the same effect, the girls (90.8 %) and boys (90.4 %) adolescent reported similar proportions of haematological status (Table 2). The sex distribution for mean values of parameters full blood count is reported in Fig. 2 and 3. The data from the red cells blood indicated a significant difference ($p < 10^{-6}$) by sex for the number of erythrocytes, the values of hemoglobin and hematocrit (Fig. 2). In this context, the boys showed the greatest mean values of these parameters compared to girls (4.9 ± 0.03 10^{12}/l vs 4.6 ± 0.03 10^{12}/l, 12.8 ± 0.07 g/dl vs 12.1 g/dl, 39.5 ± 0.2 % vs 37 ± 0.2 % respectively). However, no significant difference ($p > 0.05$) by sex was observed for the mean corpuscular volume (MCV), the mean corpuscular hemoglobin (MCH) and the mean corpuscular hemoglobin concentration (MCHC).

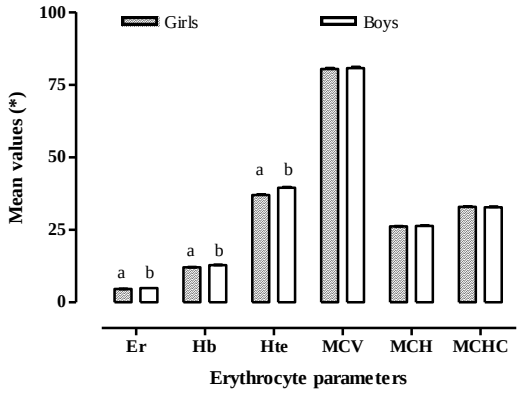

Fig. 2. Changes in erythrocyte parameters in sex group. *: Mean values of Er (10^{12}/l), Hb (g/dl), Hte (%), MCV (fl), MCH (pg) and MCHC (g/dl) for girls and boys; a and b: Groups of subjects statistically different for $P < 0.05$; α: Unit of erythrocyte parameters; Er: Erythrocytes; Hb: Hemoglobin; Hte: Hematocrit; MCV: Mean Corpuscular Volume; MCH: Mean Corpuscular Hemoglobin; MCHC: Mean Corpuscular Hemoglobin Concentration.

The parameters of leukocytes and thrombocytes reported a significant difference between boys and girls for eosinophils ($p = 0.035$), monocytes ($p = 0.0005$) and thombocytes ($p = 0.005$). In this respect, the girls showed mean values of these parameters (1.7 ± 0.04 % vs 1.5 ± 0.04 %, 4.6 ± 0.07 % vs 4.3 ± 0.06 %, 266.9 ± 3.8 10^9/l vs. 251.9 ± 3.9 10^9/l respectively) higher than boys (Fig. 3). In contrast, white blood cells, neutrophils, basophils and lymphocytes showed no significant difference ($p > 0.05$) between the two sexes (Fig. 3). Mean values of all haematological parameters were obtained from adolescents with normal full blood count (Table 3). These values were all normal compared with references established by international organizations. In this Table 3, statistically significant differences were presented for the number of red blood cells ($p = 0.001$), hemoglobin ($p = 0.001$), hematocrit ($p = 0.001$), lymphocytes ($p = 0.03$) and thrombocytes ($p = 0.002$) between boys and girls. In a similar vein, girls in our study reported the lowest mean values compared to boys with the exception of white blood cells (5.3 ± 0.2 10^9/l vs 5.7 ± 0.2 10^9/l) for basophils (0 % vs 0.04 ± 0.02 %), monocytes (3.8 ± 0.2 % vs 4.1 ± 0.2 %), lymphocytes (46.4 ± 1.5 % vs 50.7 ± 1.3 %) and thrombocytes (230.7 ± 6.8 10^9/l vs 261.5 ± 6.8 10^9/l).

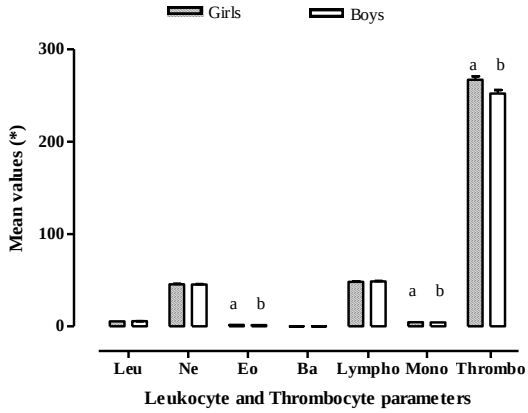

Fig. 3. Leukocyte and thrombocytes evolution in sex group. * : Mean values of Leu (10^9/l), Ne (10^9/l), Eo (10^9/l), Ba (10^9/l), Lympho (10^9/l), Mono (10^9/l) and

Thrombo (10^9/l) for girls and boys; Leu: Leukocytes; Ne: Neutrophils; Eo: Eosinophils; Ba: Basophils; Lympho: Lymphocytes; Mono: Monocytes; Thrombo: Thrombocytes.

Table 3. Mean values of haematological parameters in normal subjects

Haematological parameters	Total Population N = 139	Boys N = 57	Girls N = 82	Reference Values[α]
Blood cell counts				
Red cells blood (10^{12}/l)	4.8 ± 0.03	5.01 ± 0.04***	4.6 ± 0.04	4,5–6/4-5,4
Hemoglobin (g/dl)	13.6 ± 0.1	14.4 ± 0.1***	13.1 ± 0.1	13–18/12-16
Hematocrit (%)	41.1 ± 0.3	43.5 ± 0.3***	39.5 ± 0.3	40–50/35-47
Erythrocytes Indices				
MVC (fl)	86.1 ±0.4	87.1 ± 0.6	85.5 ± 0.4	80–100
MCH (pg)	28.5 ± 0.1	28.7 ± 0.1	28.4 ± 0.1	27–31
MCHC (g/dl)	33.7 ± 0.1	34.4 ± 0.2	33.2 ± 0.1	32–36
Leukocytes Count				
Leukocytes (10^9/l)	5.6 ± 0.1	5.3 ± 0.2	5.7 ± 0.2	5-10
Eosinophils (%)	1.35 ± 0.1	1.5 ± 0.1	1.3 ± 0.1	1-5
Neutrophils (%)	45.5 ± 0.97	47.5 ± 1.6	44.1 ± 1.2	45-70
Basophils (%)	0.02± 0.01	0	0.04 ± 0.02	0-3
Monocytes (%)	4.01± 0.1	3.8 ± 0.2	4.1 ± 0.2	2-10
Lymphocytes (%)	48.9± 0.99	46.4 ± 1.5*	50.7 ± 1.3	15-40
Thrombocytes Bloodline				
Thrombocytes (10^9/l)	248.8 ± 5.1	230.7 ± 6.8*	261.5 ± 6.8	150–400

N: Total number of each subjects group; n: subjects number observed in each group; MCV: Mean Corpuscular Volume; MCH: Mean Corpuscular Hemoglobin; MCHC: Mean Corpuscular Hemoglobin Concentration; *: Statistically significant difference for $p < 0.05$ between boys and girls; ***: Statistically significant difference for $p < 0.001$ between boys and girls; α: Haemotological reference parameters respectively in boys and girls according to SFH, 2006.

Main parameters proportions of the complete blood count

For the red cells blood, the proportions of the main study parameters, summarized in Table 4 showed that 53.1 % of the total population for adolescents indicated anaemia against 45.1 % with the normal rate and 1.8 % for increased rate. Furthermore, no significant differences ($p > 0.05$) were observed between boys (62.2 %) and girls (43.6 %). The boys presented a high prevalence of anaemia compared to girls (Table 4). However, 15 girls reported higher values of hemoglobin in contrast to boys (0 %). The proportions of 42.9 % and 2.7 % of all adolescents reported respectively a decreased and increased values of hematocrit against 54.4 % of subjects with normal values.

Boys reported a prevalence significantly ($p = 0.0005$) higher (58.3 %) of low values of hematocrit compared to girls (26.5 %). Microcytosis and hypochromia were observed respectively in 44.4 % and 60.3 % of adolescents. However, no macrocytosis has been shown in adolescents of our study. The proportion of anaemia is high in the study population (450/847). Typing of anaemia based on erythrocyte indices in 450 anaemic adolescents summarized in Table 4, highlighted 195 cases (43.3 %) of microcytic hypochromic anaemia (MHA), 70 cases (15.6 %)

normocytic hypochromic anaemia (NHA), 76 cases (16.9 %) normocytic normochromic anaemia (NNA) and 05 cases (1.1%) microcytic normochromic anaemia (MNA). The microcytic hypochromic anaemia predominated in the population studied. It was significantly (P = 0.01) higher in girls (57.5 %) compared to boys (33.9 %). Similarly, the prevalences of normocytic normochromic anaemia and normocytic hypochromic anaemia indicated significant differences (P = 0.02 and p = 0.001 respectively) between boys (11.4 % and 10.3 % respectively) and girls (25.1 % and 23.5 % respectively).

Table 4. Distribution of proportions of the major erythrocytes indices

Haematological parameters	Total Population (N = 847)		Boys (N = 436)		Girls (N = 411)		p value
	n	%	n	%	n	%	
Hemoglobin (g/dl)							
Low	450	53.1	271	62.2	179	43.6	0.07 (NS)
Normal	382	45.1	165	37.8	217	52.8	0.1 (NS)
High	15	1.8	0	0	15	3.6	0.03 (S)
Types of anaemia							
NNA	76	16.9	31	11.4	45	25.1	0.02 (S)
MNA	5	1.1	1	0.4	4	2.2	0.2 (NS)
MHA	195	43.3	92	33.9	103	57.5	0.01 (S)
NHA	70	15.6	28	10.3	42	23.5	0.001 (S)
Hematocrit (%)							
Low	363	42.9	254	58.3	109	26.5	0.0005 (S)
Normal	461	54.4	169	38.7	292	71.1	0.002 (S)
High	23	2.7	13	3	10	2.4	0.8 (NS)
MCV (fl)							
Low	376	44.4	193	44.3	183	44.5	0.9 (NS)
Normal	471	55.6	248	55.7	223	55.5	0.9 (NS)
Hight	0	0	0	0	0	0	-
MCH (pg)							
Low	511	60.3	364	83.5	247	60.1	0.05 (NS)
Normal	336	39.7	172	14.5	164	39.9	0.0004 (S)

N: Total number of each subjects group; n: subjects number observed in each group; MCV: Mean Corpuscular Volume; MCH: Mean corpuscular hemoglobin; NNA: Normocytic Normochromic Anaemia; MNA: Microcytic Normochromic Anaemia; NHA: Normocytic Hypochromic Anaemia; MHA: Microcytic Hypochromic Anaemia; S: Significant difference for $p < 0.05$, NS: not significant for $p < 0.05$.

Table 6. Profile hemoglobin of adolescents.

Subject groups	Normal	Abnormal	Abnormal				
			AS	SS	AC	CC	SC
Total Population (N = 847)	84.5 % (716)	15.5 % (131)	6.7 % (57)	0.1 % (1)	7.7 % (65)	0.6 % (5)	0.4 % (3)
Boys (N = 436)	83 % (362)	17 % (74)	7.3 % (32)	0 % 0	8.7 % (38)	0.5 % (2)	0.5 % (2)
Girls (N = 411)	86.1 % (354)	13.9 % (57)	6.1 % (25)	0.2 % (1)	6.6 % (27)	0.7 % (3)	0.2 % (1)
p-value	0.7 (NS)	0.7 (NS)	0.7 (NS)	0.7 (NS)	0.7 (NS)	0.7 (NS)	0.7 (NS)

N: Total population of adolescents; (): Numbers of subjects for each group; S: Statistically significant difference for $p < 0.05$; NS: Not statistically significant for $p < 0.05$; AS, SS, AC, CC, SC: Observed forms of hemoglobinopathies.

Almost all of the adolescents had their leukocytes and thrombocytes within normal limits regardless of sex (Table 5). If we consider account of all leukocytes, there were 73.4 % of adolescents who have all of their white blood cell parameters normal against 26.6 %. For thrombocytes, 92.9 % of adolescents have thrombocytes counts normal against 7.1 %. The results of our investigations have revealed the rates among all adolescents of leukopenia (35.1 %), neutropenia (13 %) of monocytopenia (4.1 %), thrombocytopenia (6.4 %) and decreased proportion of eosinophils (9.8 %). No lymphopenia was observed in the study population (Table 5). In addition, the investigations for boys and girls indicated a leukocytosis (0.7 %), leukocytosis in neutrophils (1.2 %), leukocytosis in basophils (0.2 %), lymphocytosis (3.1 %) and thrombocytosis (0.7 %). Leukocytosis in eosinophils and monocytes have been reported in our study. Overall, high rates of adolescents with normal values of the leukocytes and thrombocytes parameters were identified throughout our investigations (Table 5).

Moreover, no significant differences (all $p > 0.05$) were presented between boys and girls for all the proportions of the main leukocytes and thrombocytes parameters.

Prevalence of the hemoglobin types

Typing of hemoglobin from the electrophoresis technique at alkaline pH showed that 15.5 % of subjects presented abnormal hemoglobins corresponding to 17 % for boys and 13.9 % for girls (Table 6). The components of the abnormal hemoglobin status have included the hemoglobin AS, SS, AC, CC and SC. No significant differences (all $p > 0.05$) were observed between boys and girls for this abnormal hemoglobin status (Table 6).

Discussion

This study among a population of adolescents in three municipalities of Abidjan presents a variability of the complete blood count different parameters. For erythrocyte parameters, anaemia, microcytosis and hypochromia are most observed. The high proportion of anaemia in the subjects studied (53.1 %) shows that anaemia is one of the main problems in our population. This high prevalence of anaemia is similar to that encountered by Angoué *et al.* (2008) on non pregnant women. It would be related to the age of our subjects (12-18 years). This age group corresponds to the adolescence defined by World Health Organization (WHO).

We know that adolescence is characterized by rapid growth accompanied by profound metabolic hormonal and psychological changes which expose them to particularly nutritional deficiencies (Maurage, 1999; Mian *et al.*, 2002). One of these clinical consequences of these nutritional deficiencies is anaemia. In general, this prevalence is more collapsed in adolescent girls than adolescent boy (Khattak and Ali, 2010). Indeed, the adolescent girls from their menstrual cycles are more exposed to anaemia (Blum, 1991; Straetmans, 2002).

In the context of our investigations, no significant differences were shown between girls and boys. However, boys have a higher prevalence of anaemia (62.2 % vs 43.6 %) than girls. This would mean that the boys in Abidjan are affected by anaemia as well as girls. In addition, the results showed the different types of anaemia include: microcytic hypochromic anaemia predominant (43.3 %), normocytic normochromic anaemia (16.9 %), normocytic hypochromic anaemia (15.6 %) and finally, a microcytic normochromic anaemia (1.1 %). The predominance of microcytic hypochromic anaemia in this age group confirms that anaemia may be explained by the frequency of nutritional deficiencies including iron and vitamins (Turconi and Turconi, 1992; Abu-Samak *et al.*, 2008; Kanoa *et al.*, 2011). Therefore, we observed in subjects of our study, the decreases of hemoglobin, mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH). Indeed, hypochromia and microcytosis are reliable criteria for screening for iron deficiency (Archambeau-Breton *et al.*, 1989; Navarro and Macia, 1997). In addition, Atanda *et al.* (1997) in the Congo and Diagne *et al.* (2010) in Senegal reported on a similar population, the rates of microcytic hypochromic anaemia above to that obtained in our study. In addition, the prevalence of anaemia in adolescents, is also associated with chronic inflammatory and infectious concept common in tropical regions (Yip and Dallman, 1988; Massawe *et al.*, 2002). These infectious and inflammatory chronic syndromes would justify as microcytic hypochromic anaemia, the normocytic hypochromic anaemia and the normocytic normochromic anaemia observed as well in boys than in girls (Akhigbe *et al.*, 2010). For the leukocytes, the rates of eosinophils and monocytes those of more important observed among adolescents girls may be explained by specific physiological conditions such as menstrual cycle (Paknahad *et al.*, 2008). In fact, the menstrual cycle increases the number of leukocytes as revealed by Quaranta *et al.*, 1990). The comparison of our results compared to those of other studies can find the common hypoleucocytose of black race, compared to Caucasian populations (Saxena and Wong, 1990; Guilhot, 1992). Monocytes and eosinophils as neutrophils involved in defense of the body against germs and other foreign materials are sensitized. The eosinophil phagocytosis is especially prevalent in complex antigen antibodies. Monocytes, in turn are able to phagocytose and kill bacteria. This would explain the increase in monocytes and eosinophils observed. The comparative studies of monocytes in different populations, conducted in 1990 by Saxena and Wong, 1990 and by Taylor *et al.* 1997 give were showed similar results. For the thrombocytes, the level observed in girls of our study would be justified by involving them in stopping bleeding after menstruation. In fact, thrombocytes contain various substances that promote coagulation, resulting in hemostasis (Bernard *et al.*, 1996). At the level of hemoglobin, typing showed that 15.5 % of subjects presented abnormal hemoglobins. This rate is similar to results obtained by Assobayire *et al.* (2001). This study was also conducted in order to define the normal parameters of complete blood count in a population of healthy Ivorian adolescents, and compared with normal values found among other populations. However, the values we obtained may not be as representative of the Ivorian population living in three municipalities of Abidjan (Côte d'Ivoire). From these normal values proposed, significant differences were observed in boys and girls. This phenomenon, often reported in the literature in populations of

different origin (Shiga *et al.*, 1990), can be explained by physiological losses in micronutrient including iron, most important for the girl one hand (Eslami *et al.*, 2010), and second, by stimulating erythropoietic of origin androgenic more important in boys (Gonzalez-Silva *et al.*, 1994).

Conclusion

Our study showed that the haematological profile of adolescents is more altered in Abidjan (Côte d'Ivoire). In addition, our investigations revealed also that over half (53.1 %) adolescents indicated anaemia. A variation in erythrocyte parameters resulted in an observation of types of anaemia including the microcytic hypochromic anaemia which is predominant. The high prevalence of anaemia was observed both in girls than in boys. Comparison of the main parameters proportions of the complete blood count by sex reported that girls were by far the most affected by the degradation of haematological data compared to boys. In order to best explain the prevalence rate among adolescents, studies on the nutrients metabolism required for quantity and quality of blood should be performed. In the same context, an assessment of nutritional status based on the determination of certain biochemical, immunological and calculations of nutritional index may be conducted. A significant difference was shown among adolescents in the establishment of normal values for the parameters of the complete blood count. This difference was explained by the needs of their state of growth and physiological losses. Future studies in all municipalities of Abidjan, in all regions of Côte d'Ivoire for a representative sample will lead to real values of the parameters of normal blood count of adolescents in our country.

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Authors' contributions

All authors contributed equally in the study. They made substantial contributions to the design of the study, the collection of the data as well as the preparation and analysis of the data. They also drafted the manuscript and gave final approval for its submission to the journal for consideration of publication.

Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

References

Abu-Samak M, Khuzaie R, Abu-Hasheesh M, Jaradeh M, Fawzi M. 2008. Relationship of Vitamin B12 Deficiency with Overweight in Male Jordanian Youth. Journal of Applied Sciences **8**, 3060-3063.

Akhigbe RE, Bamidele JO, Abodunrin OL. 2010. Seroprevalence of HIV Infection in Kwara, Nigeria. International Journal of Virology **6**, 158-163.

Angoue PY, Nahounou MB, Dominique JE, Yao JD, Ehouman EE. 2008. Prevalence of anaemia and iron deficiency in women of childbearing age, pregnant and nonpregnant. Annales de Biologie Clinique Quebec. **45**, 24–28.

Archambeau-Breton M, Dommergues JP, Ducot B, Rossignol C, Yvart J, Techerna G. 1989. Reevaluation of the utility of mean cell heamoglobin (MCH) screening of infants for iron

deficieny. Nouvelle Revue Française d'Hématologie **31**, 307–309.

Assobayire SF, Adou P, Davidsson I, Cook DJ, Hurell F. 2001. Prevalence of iron deficiency with and without concurrent anemia ion population groups with high prevalence of malaria and other infectuions: a studiy in Côte d'Ivoire. American Journal of Clinical Nutrition **74,** 776-782.

Atanda HL, Bon JC, Force-Barge P, Porte J, Rodier J. 1997. Contribution a letude de la prevalence de lanemie chez lenfant en milieu tropical: C.M.S. Elf-Congo-Pointe-Noire = Study of the prevalence of anemia in children in tropical zone. Médecine d'Afrique Noire **44,** 40-44.

Bernard J, Levy JP, Varet B, Clauvel JP, Rain JD, Sultan Y. 1996. Hematology.
8th Edn., Masson, Paris, 68-74.

Blum RW. 1991. Global trends in adolescent health. Journal of American Medicine Association **265,** 2711-2719.

Diagne I, Fall A-L, Diagne-Gueye NR, Déme-Ly I, Lopez-Sall P, Faye C-E, Sarr M, Camara B, Sow H-D. 2010. Hypochromic microcytic anemia in pediatrics: Frequency and response to the iron treatment. A study in outpatients in Albert Royer National Children Hospital of Dakar, Senegal. Journal de Pédiatrie et Puériculture **23,** 119-124.

Dillon JC. 2000. Prevention of iron deficiency and iron deficiency anemia in tropical areas. Médecine Tropicale **60,** 83-91.

Eslami S, Karandish M, Marandi SM, Zand-Moghaddam A. 2010. Effects of Whey Protein Supplementation on Hematological Parameters in Healthy Young Resistance Male Athletes. Journal of Applied Sciences **10,** 991-995.

Gonzalez-Silva M, Bernal MD, Cabezon I. 1994. Hematologic values and iron levels in a rural student population. Sangre **39,** 99-103.

Guilhot F. 1992. Hyperleukocytosis with Neutrophila. In: Haematology of Bernard Dreyfus, Breton-Gorius, J., F. Reyes, H. Rochant, J. Rosa and J.P. Vernant (Eds.). Medecine-Sciences Flammarion, Paris, 567-568.

Kanoa BJ, Zabut BM, Hamed AT. 2011. Nutritional Status Compared with Nutritional History of Preschool Aged Children in Gaza Strip: Cross Sectional Study. Pakistan Journal of Nutrition **10,** 282-290.

Khattak MMAK, Ali S. 2010. Malnutrition and Associated Risk Factors in Pre-School Children (2-5 Years) in District Swabi (NWFP)-Pakistan. Journal of Medical Sciences **10,** 34-39.

Massawe SN, Ronquist G, Nyströn L, Lindmark G. 2002. Iron status and iron deficiency anaemia in adolescents in a Tanzanian suburban area. Gynecologic and Obstetric Investigation **54,** 137-144.

Maurage C. 1999. Iron status in adolescents. Journal de Pédiatrie et Puériculture **12,** 204-207.

Mian RMA, Ali M, Ferroni PA, Underwood P. 2002. The Nutritional Status of School-Aged Children in an Urban Squatter Settlement in Pakistan. Pakistan Journal of Nutrition **1,** 121-123.

Navarro JF, Macia ML. 1997. Hypochomie red cells as an indicator of iron deficiency. Journal of Rheumatology. **24,** 804-805.

Paknahad Z, Mahboob S, Omidvar N, Ebrahimi M, Ostadrahimi A, Afiatmilani SH. 2008. Body Mass Index and its Relationship with Haematological

indices in Iranian Women. Pakistan Journal of Nutrition **7,** 377-380.

Quaranta JP, Pesce A, Cassuto JP. 1990. Haemogram. Masson, Paris, pp: 83-105.

Rakoto AO, Ratsitoralina M, Pfister P, Laganier R, Dromigny JA. 2000. Haemogramm normal values in Madagascar. Archives de l'Institut Pasteur de Madagascar **66,** 68-71.

Savage D, Gandgaidzo I, Lindenbaun J, Kiire C, Mikiibi JM, Moyo A, Gwanzura C, Mudenge B, Bennie A, Sitima J, Stabler SP, Allen RH. 1994. Vitamin B12 deficiency is the primary cause of megaloblastic anaemia in Zimbabwe. British Journal of Haematology **86,** 844–850.

Saxena S, Wong ET. 1990. Heterogeneity of common hematologie parameters among racial, ethnic and gender subgroups. Archives of Pathology & Laboratory. Medicine **114,** 715–719.

Schneider RG. 1973. Development in Laboratory Diagnosis. In: Sickle Cell Disease: Diagnosis, Management, Education and Research, Abramson, H., J.F. Bertles and D.L. Wethers (Eds.). Mosby, Louis, 230–243.

Shiga S, Koyanagi I, Kannagi R. 1990. Clinical reference values for laboratory hematology tests calculated using the iterative truncation method with correction: Part 1. Reference values for erythrocyte count, hemoglobin quantity, hematocrit and other erythrocyte parameters including MCV, MCH, MCHC and RDW. Rinsho Byori **38,** 93-103.

FSH (French Society of Haematology-Pedagogical committee). 2006. Hémogramme : indications et Haemogram: Indication and interpretation-Evaluation, 121-145.

Straetmans N. 2002. Anemias: Dignosis and etiology. Louvain Médical **121,** S54-S59.

Suharno D, West CE, Muhila, Karyadi D, Hautvast JG. 1993. Supplementation with vitamin A and iron for nutritional anaemia in pregnant women in west Java, Indonesia. Lancet **342,** 1325–1328.

Taylor MR, Holland CV, Spencer R, Jackson JF, O'Connor GI, O'Donnell JR. 1997. Haematological reference ranges for schoolchidren. Clinical and Laboratory Haematology **19,** 1–15.

Turconi SJ, Turconi VL. 1992. Iron deficiency anaemia: Impact on child population. Pediatria Moderna **28,** 107-112.

UNCEF/UNU/WHO. 2001. Iron deficiency aneamia: assessment, prevention, and control. WHO/NHD/01.3 Geneva,Switzerland: WHO. U.N.C.E.F. /U.N.U./W.H.O. Iron deficiency aneamia: assessment, prevention, and control. WHO/NHD/01.3 Geneva, Switzerland: WHO.

Wajcman H, Lantz B, Girot R. 1992. Diseases of the Red Cell. INSERM Medecine-Sciences, Paris, 81-456.

Williams WJ. 1983. Examination of blood. In: Hematology, Williams, W.J., E. Beutler, J. Ersslev and M.A. Licntman (Eds.). McGraw-Hill, New York, 36-44.

WHO. 2001. Iron deficiency anemia: assement prevention and control-a guide for programme managers. NHD01 Geneva WHO.

Yip R, Dallman P. 1988. The role of inflammation and iron deficiency as causes of anemia. American Journal of Clinical Nutrition **48,** 1295-1300.