EAS Journal of Pharmacy and Pharmacology
Abbreviated Key Title: EAS J Pharm Pharmacol
ISSN: 2663-0990 (Print) & ISSN: 2663-6719 (Online)
Published By East African Scholars Publisher, Kenya

Volume-6 | Issue-5 | Sep-Oct- 2024 | DOI: https://doi.org/10.36349/easjpp.2024.v06i05.001

OPEN ACCESS

Original Research Article

Hematological and Biochemical Profiles of Gagnoa High School Students (Côte D'ivoire)

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Article History
Received: 18.08.2024
Accepted: 23.09.2024
Published: 03.10.2024

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: ***Objectives*:** The purpose of this study is to determine the normal hematological values and those of some biochemical parameters of the students of the city of Gagnoa (Côte d'Ivoire). ***Design et Methods*:** The study was conducted in 184 adolescents (94 girls and 90 boys), aged 11 to 18 years old, recruited in moderne high schools of Gagnoa. The hematological values were determined using an automatic analyzer (Sysmex XP3000, France). The concentrations of biochemical parameters (albumin, protein total, cholesterol total, triglycerides, calcium, magnesium, chloride, potassium and sodium) were determined by spectrophotometer (KENZA MAX BioChemis Try, France) on the venous blood samples were taken from the fold of the elbow with an empty stomach. The results were treated with the statistical analysis software XLSTAT-PRO 7.1. 2018. ***Results*:** The median values of red blood cells were 4.5,10^6/µL (girls) and 4.9,10^6/µL (boys). The median values of hemoglobin in girls was 12.3 g/dL and among boys was 13 g/dL. The median values of hematocrit girls was 35.9 % and boys was 38 %. The median values MCV were 79.3 fL (girls) and 77 fL (boys). The median values of MCH were 27.6 pg/cell among girls and 26.9 pg/cell among boys. The median values of MCHC girls 34.5 g/dL and boys 34.8 g/dL. The médians values of white blood cells were 6.1.10^3/µL among girls and 5.8.10^3/µL among boys. The median values of granulocyte were 2.2,10^3/µL among girls and 2.4, 10^3/µL among bboys. The median values of lymphocytes among girls and boys were the same (3,10^3/µL). The median values of monocyte were 0.7, 10^3/µL among girls and 0.6 10^3/µL in boys. The median values of platelet among girls and boys were equal to 247,10^3/µL and 242,10^3/µL. The median valeues of protein total among girls and boys were 68 g/L and 69 g/L. The median values of albumin were respectively 47 g/L and 45.7 g/L among girls and boys. The median values of cholesterol total in girls and boys were the same (1.3 g/L). The median values of triglycerides were the same among girls and boys (0.7 g/L). The median values of sodium were 131 mmol/L among girls and 132.5 mmol/L among boys. The median values of potassium were de 4,2 mmol/L among girls and 4.3 mmol/L among boys. The median values of calcium were 96 mg/L and 95 mg/L respectively among girls and boys. The median values of magnesium were 17.2 mg/L among girls and 17.6 mg/L among boys. The median values of chloride were 90 mmol/L among girls and 89 mmol/L among boys. ***Conclusion:*** The hematologic values have relatively low hemoglobin levels (12.4 g/dL) among girls and (13.2 g/dL) among boys. The hématological profile also reveals very low granulocyte rates (2.5,10^3/µL) and high lymphocyte rates (3.1,10^3/µL). The blood biochemical profile has been normal with exception of the cholesterol total concentratation that has been weak.

Keywords: Adolescents, students, Hématological, Biochemical, levels, concentratations, Gagnoa.

INTRODUCTION

Blood hematological and biochemical studies are frequently performed to guide complementary medical examinations essential to diagnoses. It offers valuable information since they distinguish a normal situation from a pathological situation in a multitude of conditions. The numeration of blood is the hematological study commonly carried out in the laboratory to

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determine the hematological parameters. (Sahoo *et al*., 2015). The numeration of formula provides a hemogram which consists of the establishment and in the quantitative interpretation of the different hematological parameters (Odutola *et al*., 2014). The biochemical study on peripheral blood withdrawal is a rather demanded examination set in everyday practice. It makes possible to assist different substances such as proteins, lipids and minerals contained in the plasma according to the orientation of a diaqgnosis (Shimizu *et al*., 2016). Like hematological studies, biochemical studies give valuable informations on the quality and quantity of organic and mineral molecules contained in the plasma.

The interprétation of the values of a hemogram as well as that of the results of blood boichemical analyzes is compared to normal values already established in a known healthy population. These normal values may, however, vary from one person healthy to another by age, ethnic origin, geographical and environmental situations (Aneke *et al.*, 1988; Horn & Pesce, 2002). In Côte d'Ivoire, a developing country, normal hematological and biochemical values used have not been established among local populations. In view of the above, the establishment of local hematologocal and biochemical values is necessary.

The objective of this study is to collect data to participate in the establishment of normal hematological and biochemical values in Côte d'Ivoire.

MATERIAL AND METHODS

Population and study site

This investigation is a transversal to descriptive and analytical target made in adolescents. The study population consisted of 184 students recruited voluntarily in the Gagnoa high schools. The age of subjects varied between 11 and 18 years old with an average of 14.4 ± 0.2 years. This population was composed of 94 girls (51.1%) and 90 boys (48.9%). All adolescents considered apparently healthy on the basis of the information provided by the parents, the administrations of the institutions and the medical team of the Gagnoa General Hospital were included in this study. On the other hand, students for whom we have received a refusal of consent expressed by the parents, those who have been sick one month before the collection of our data and girls during periods of menstruation were excluded from this study.

Data collection

The methodology of this study was approved by the NANGUI ABROGOUA (Côte d'Ivoire) University Ethics committee through its laboratory of physiology pharmacology and pharmacopoeia in accordance with international principles.

Sampling and dosing blood samples

Venous blood samples were taken from the fold of the elbow in each student in tubes containing an anticoagulant, acetic ethyle, the morning between 8 hours and 10 hours on an empty stomach. Those samples allowed the determination of the hemogram by using an automatic analyseur (Sysmex XP300, France). Hematological parameters considered in these studies were the erythrocyte parameters (RBC, hemoglobin, hématocrite, MCV, MCH and MCHC), leukocyte parameters (WBC, granulocytes, lymphocytes and monocytes) and platelets.

Blood samples were taken from dry tubes and also in lithium heparinate tubes and centrifuged for 5 minutes by a centrifuge (MiniSpin® plus Eppendor, France). The serums obtained from these different tubes were used for the assay of the biochemical parameters necessary for this study. These biochemical parameters were determined by the different assay and reagent techniques corresponding to each parameter. The serums obtained from the dry tubes served in the dosages of the proteins total, albumin, cholesterol total and triglycerides. The sodium, potassium, calcium, magnesium and chloride were dosed by the serums obtained from lithium heparinate tubes.

All reagents used in these studies come from laboratory Biosystems Costa Brava (Spain) and the dosage of blood biochemical parameters has been carried out, using a spectrophotometer KENZA MAX BioChemis Try (France), at the Biological Analysis Laboratory of the Gagnoa General Hospital.

Statistical Analysis

All statistical studies have been done by using the computer software XLSTAT-PRO 7.1. 2018. The results were analyzed with post hot tests of TUKEY and DUNNET. These results were describe with median values, minimum values, maximum values; averages associated with the standard deviation. The percentiles 2.5 and 97.5 used to confine normal values. During the establishment of normal values of the total population, the two adjacent groups are been merged. For all tests performed, the risk of error granted was set at 0.05.

RESULTS

Erythrocyte parameters of study population

Median minimum and maximum values

Red blood cells

Figure 1 shows the different levels of red blood cells obtained in adolescents (Figure 1A: girls and Figure 1B: boys). The median value recorded in girls is $4.5{,}10^6$/µL. The minimum value in the girls is $3.3{,}10^6$/µL and the maximum value is $5.8{,}10^6$/µL. In the boys, the median value of red blood cell levels is $4.9{,}10^6$/µL. As for the minimum value, it is $3.4{,}10^6$/µL and the maximum value $6.1{,}10^6$/µL.

Hemoglobin

The hemoglobin obtained in girls and in boys are represented respectively by figure 2A and figure 2B. The median value of the girls hemoglobin levels is 12.3

g/dL vs 13 g/dL in the boys. Minimum and maximum recorded in the girls are respectively equal to 8.9 g/dL and 15.9 g/dL. In the boys, the minimum and maximum are respectively 9.7 g/dL and 16.8 g/dL.

Hématocrit

The values of hématocrit observed respectively in girls and boys are shown in figure 3 (Figure 3A and 3B). The median, minimum and maximum recorded for the girls are respectively equal to 35.9%; 26.9% and 45.9%. Those obtained in boys are respectively equal to 38%; 27% and 49.1%.

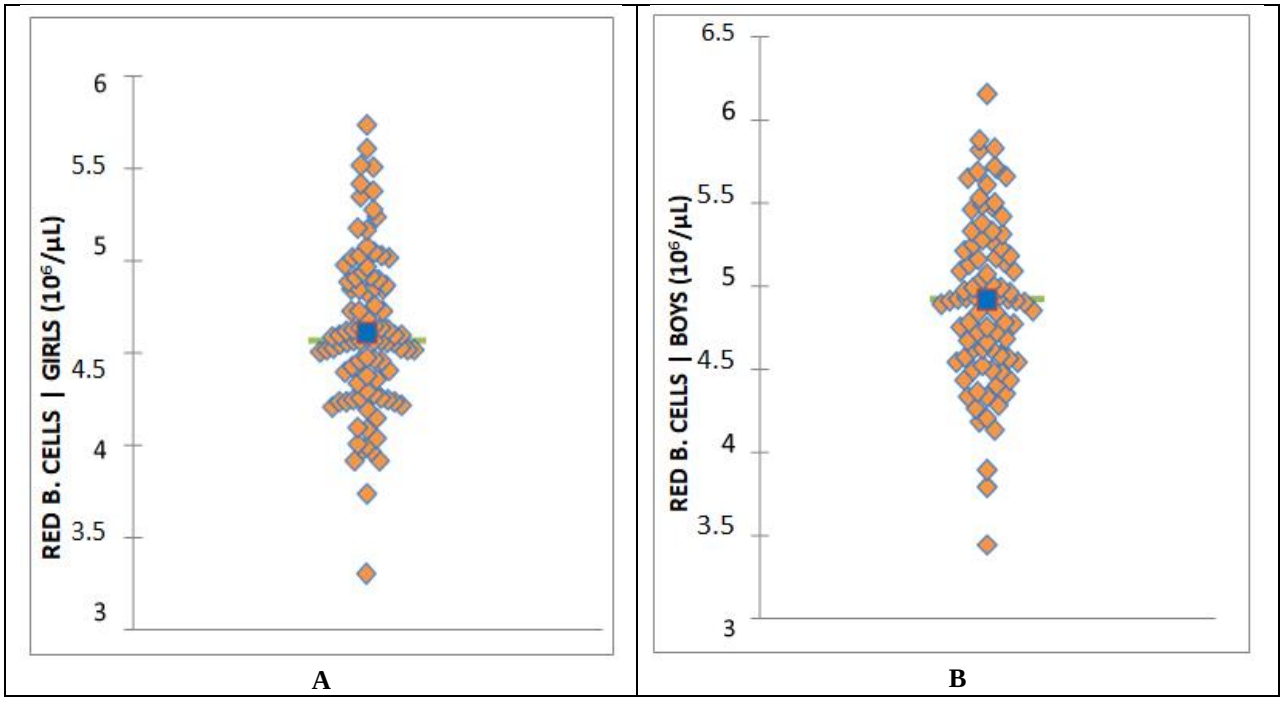

Figure 1: Red blood cell levels in girls (A) and in boys (B)

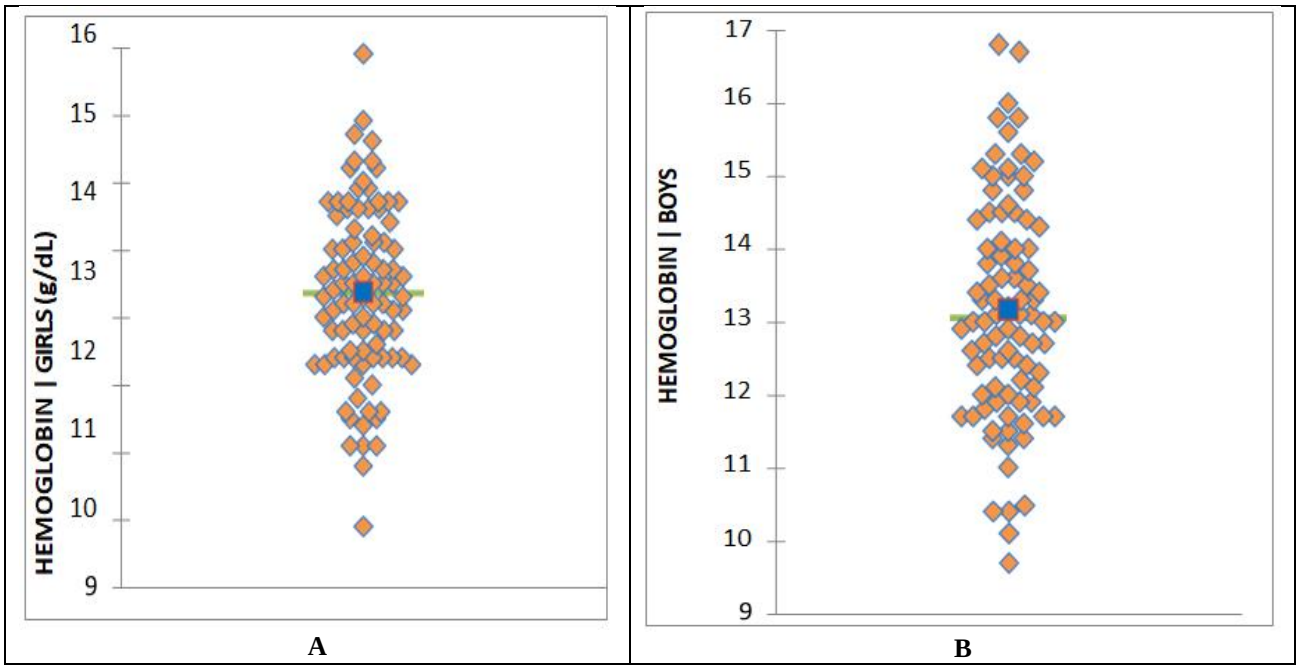

Figure 2: Hemoglobin levels in girls (A) and in boys (B)

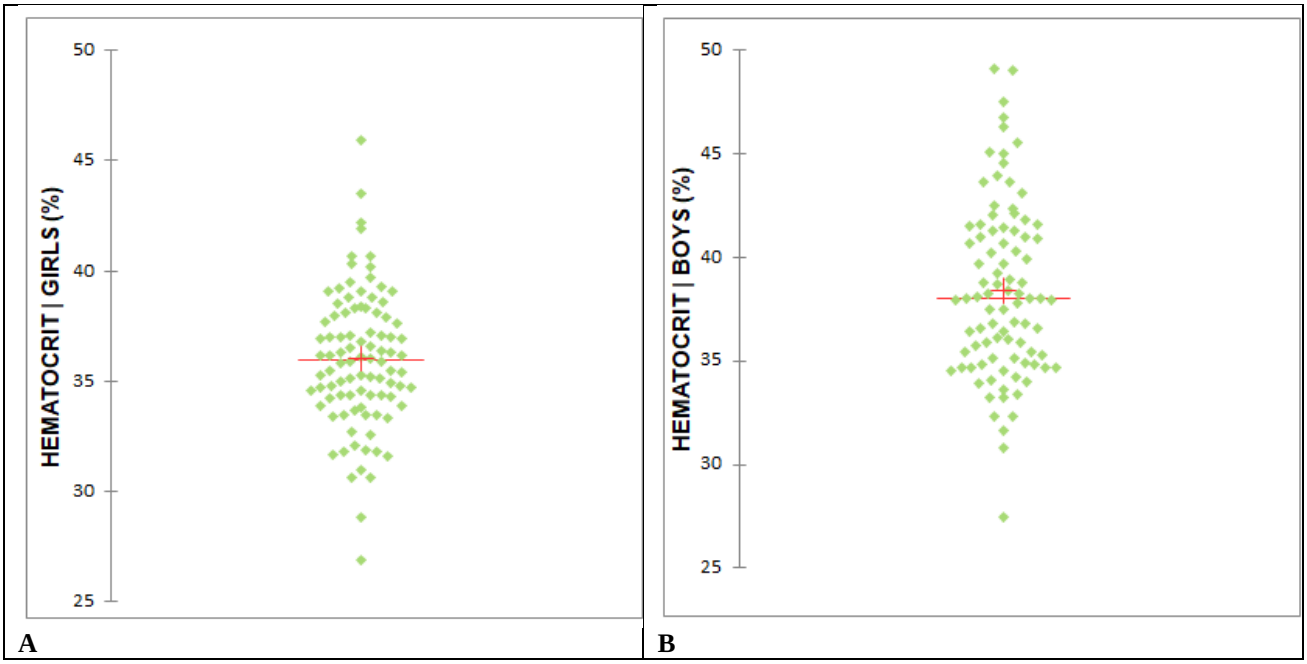

Figure 3: Hematocrit of girls (A) and boys (B)

Mean Cell Volume

Figure 4 shows the different values of mean cell volume (MCV) observed respectively in female and male adolescents. The median value of MCV is 79.3 fL in female. MCV's smallest value observed in female adolescents is 57 fL and the largest value is 89 fL (Figure 4A). At the male adolescents, the different observed MCV's values was 77 fL for median value, 64 fL for minimum value and 90 fL for maximum value (Figure 4B).

Mean Cell Hemoglobin

At the mean cell hemoglobin (MCH), different values observed respectively in female and male studentts are shown in figure 5. The median value of MCH for the girls is 27.6 pg/cell. Lower value of MCH and higher value of the girls were respectively 20.3 pg/cell and 32.4 pg/cell (Figure 5A). In the boys, median value of MCH is equal to 26.9 pg/cell. As for the minimum and maximum of MCH, they are respectively equal to 21.2 pg/cell and 31.9 pg/cell (Figure 5B).

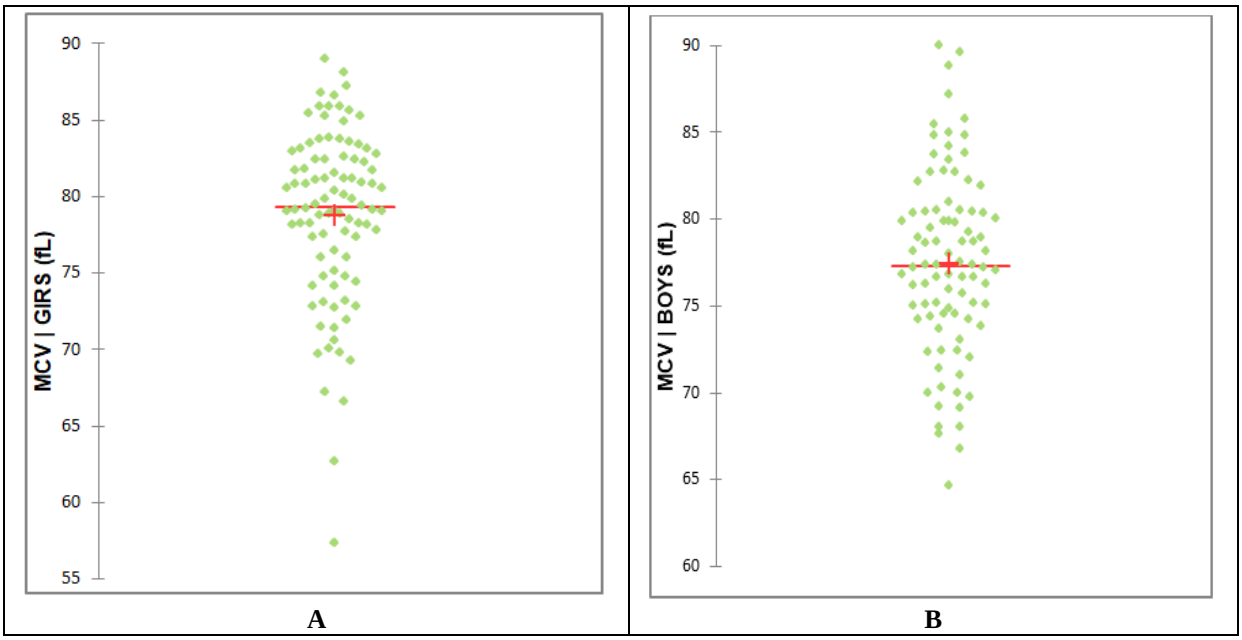

Figure 4: Mean Cell Volume of girls (A) and boys (B)

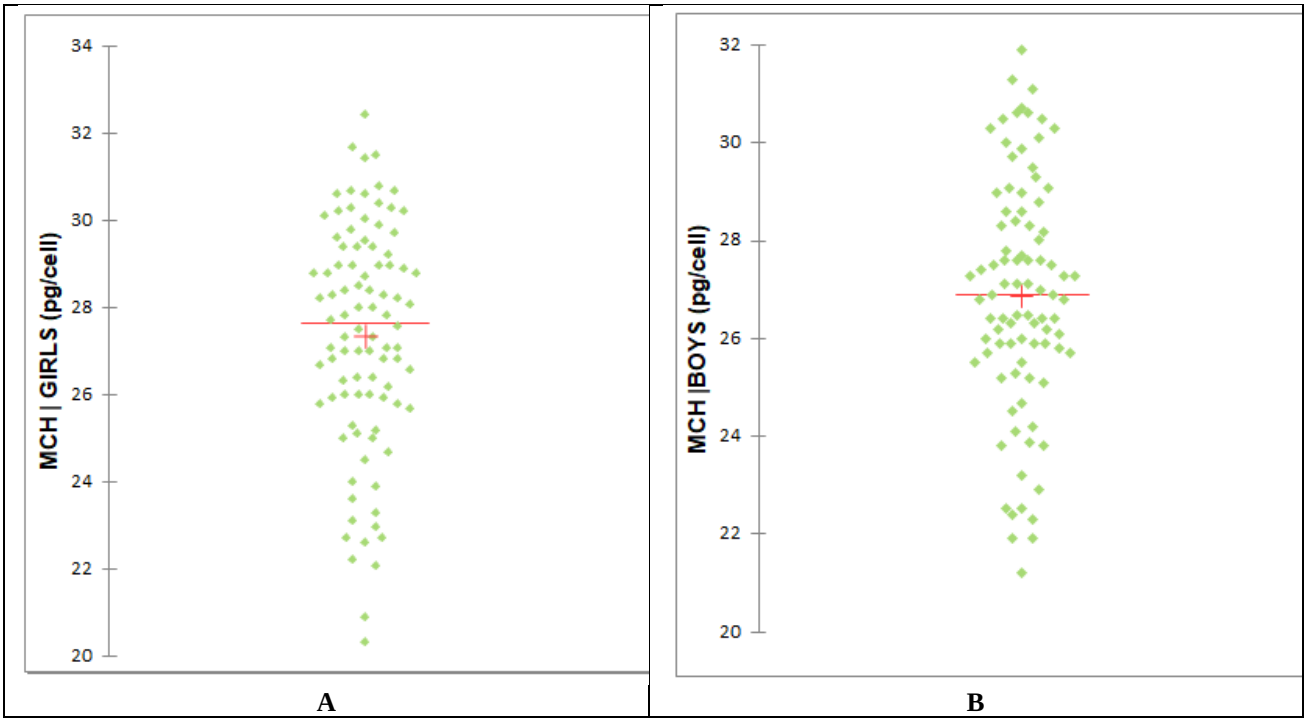

Figure 5: Mean Cell Hemoglobin of girls (A) and boys (B)

Mean Cell Hemoglobin Concentration

Concerning the mean cell hemoglobin (MCHC), Figure 6A shows that the median value of girls MCHC is 34.5 g/dL. The minimum and maximum of MCHC are respectively 30.9 g/dL and 37.6 g/dL. The values of MCHC in the boys are shown in Figure 6B where 34.8 g/dL is the median, 30.6 g/dL minimum value and 37.5 g/dL the maximum value.

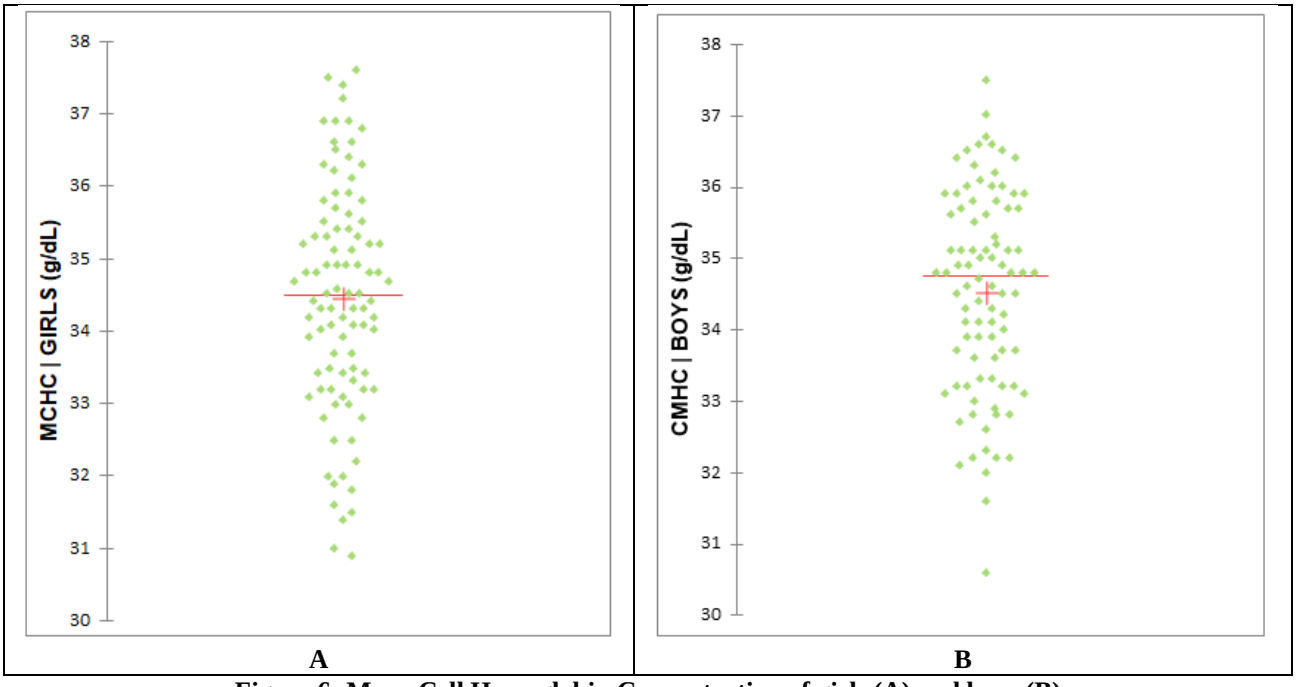

Figure 6: Mean Cell Hemoglobin Concentration of girls (A) and boys (B)

Normal values of erythrocyte parameters

Average values, the standard deviations and the reference interval values of the erythrocyte parameters of the teens in this study are recorded in table I. The average value of red blood cells in boys which is 4.9,10^6/µL (3.9 – 5.7,10^6/µL) is higher than that of girls (4.6,10^6/µL; |3.4 – 5.4,10^6/µL|). This difference is not statistically significant ($p < 0.05$). The average value of hemoglobin levels in girls is 12.4 g/dL (|10.1- 14.6 g/dL|) while the boys is 13.2 g/L (|10.5 – 15.7 g/L|). The difference between these two values is statistically significant ($p < 0.05$). A statistically significant difference ($p < 0.01$) is

between the average value of girls hematocrit and boys hematocrit. The average value of hematocrit in boys [38.7 % (30.9- 45.5 %)] is greater than that of the girls [36.0 % 28.4- 42.2 %)]. The MCV's average value in the girls (78.8 fL ; |70.4 – 88.2 fL|) is greater to that of boys (77.4 fL |69- 85.7 fL|). The difference between these averages values is not significant ($p > 0.05$). Concerning the average value of MHC of girls (27.4 pg/cellule ; |23.3- 31.9 pg/cell|), it is substantially equal to those of boys (26.9 pg/cell ; |23.3 – 30.9 pg/cell|). Finally, the average value of the CMCH of girls (34.5 g/dL ; |31.8- 37.1 g/dL|) is substantially equal to that of boys (34.5 g/dL ; |31.9 – 37.1 g/dL|).

Table I: Normal values of erythrocyte parameters of the study population

Parameters	GIRLS			BOYS			P-value P	TOTAL POPULATION		
	Average	Stand deviat	Reference interval	Average	Stand deviat	Reference interval		Average	Stand deviat	Reference interval
RBC (10^6/µL)	4.6	0.4	3.4 - 5.4	4.9	0.5	3.9 - 5.7	0.1104 NS	4.7	0.5	3.4 - 5.7
Hemoglobin (g/dL)	12.4	1.3	10.1 - 14.6	13.2	1.5	10.5 - 15.7	0.0103 S	12.8	1.4	10.1 - 15.7
Hematocrit (%)	36	3.1	28.4 - 42.2	38.4	4.2	30.9 - 45,5	0,0101 S	37,2	3,6	28.4 – 45.5
MCV (fL)	78.8	5.6	70.4 - 88.2	77.4	5.2	69 - 85.7	< 0.1162 NS	78.1	5.5	69.3 - 87.5
MCH (pg)	27.4	2.6	23.3 - 31.9	26.9	2.4	23.3 - 30.9	< 0.1234 NS	27.1	2.5	23.3 - 31.5
MCHC (g/dL)	34.5	1.6	31.8 - 37.1	34.5	1.4	31.9 - 37.1	< 0.7557 NS	34.5	1.5	31.9 - 37.1

Leukocyte parameters and platelets of the study population

Median, minimum and maximum values

White blood cells

Figure 7 shows the different values of leukocyte observed in female students (Figure 7A) and in male students (Figure 7B). The median of these WBC values in female students is equal to $6.1,10^3$/µL. The minimum value is equal to $3.2,10^3$/µL and the maximum value is $10,10^3$/µL. Figure 7B indicate that in male students the median of WBC values is equal to $5.8,10^3$/µL, the lowest value is equal to $3.7,10^3$/µL and the highest value equals to $10,10^3$/µL.

Granulocytes

The granulocytes different values obtained in girls are presented on figure 8A. The median value is $2.2,10^3$/µL. The minimum and maximum values different are respectively $1,10^3$/µL and $5,10^3$/µL. In the boys, granulocytes different values observed are presented on Figure 8B. Median value is $2.4,10^3$/µL. Minimum value is $1.3,10^3$/µL and maximum value is $5,10^3$/µL.

Lymphocytes

The différent lymphocyte values obtained during this study are presented on Figure 9A for the female students on Figure 9B for the male students. The respective median values of girls lymphocytes and boys are equal to $3,10^3$/µL. The smallest lymphocyte values recorded respectively in female students and male students are $1.3.10^3$/µL and $1,2.10^3$/µL. As the highest values of lymphocytes, they are $5,7.10^3$/µL among female students and $5,3.10^3$/µL among male students.

Monocytes

The different values of monocytes among girls shown in figure 10A. The value of the median is $0,7.10^3$/µL. The smallest value and the highest value are respectively $0.1,10^3$/µL and $1.7,10^3$/µL. At the boy, the different values of monocyte are presented in figure 10B. The median value is $0.6,10^3$/µL, the value minimum value is $0.1,10^3$/µL and the maximum value is $1.9,10^3$/µL.

Platelets

Figure 11 are shown the different values of the blood platelets obtained female (Figure 11A) and male (Figure 11B) teenagers. The median value of platelet rates recorded in girls is $247,10^3$/µL. The minimum and maximum value of girls platelet are respectively $145,10^3$/µL and $406,10^3$/µL. In male students, The median value of blood platelet rates is $242,10^3$/µL. It's smaller value is $121,10^3$/µL and it's greatest value is $450,10^3$/µL.

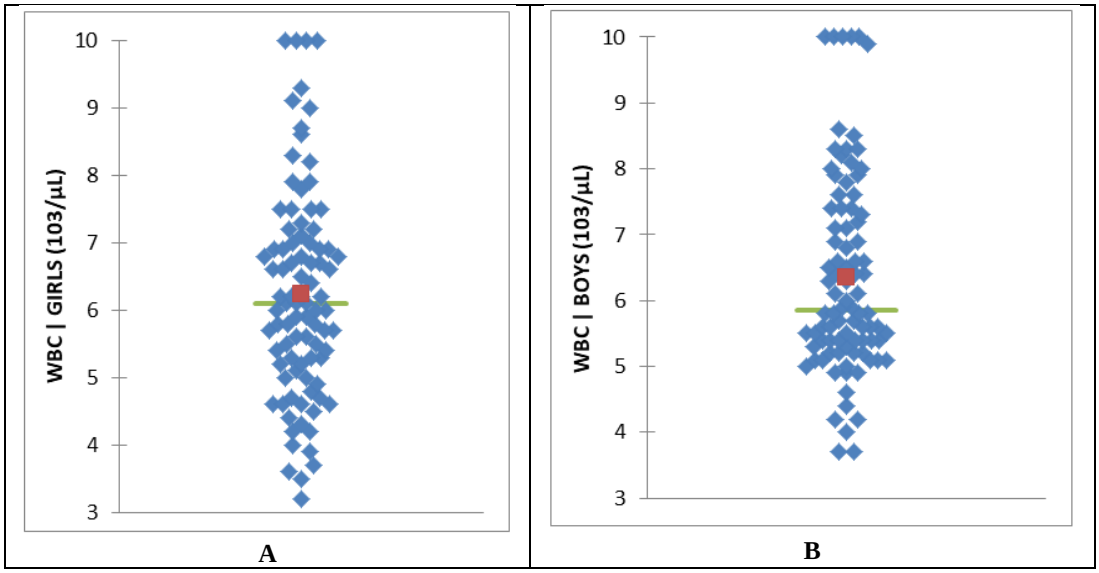

Figure 7: WBC rates of girls (A) and boys (B)

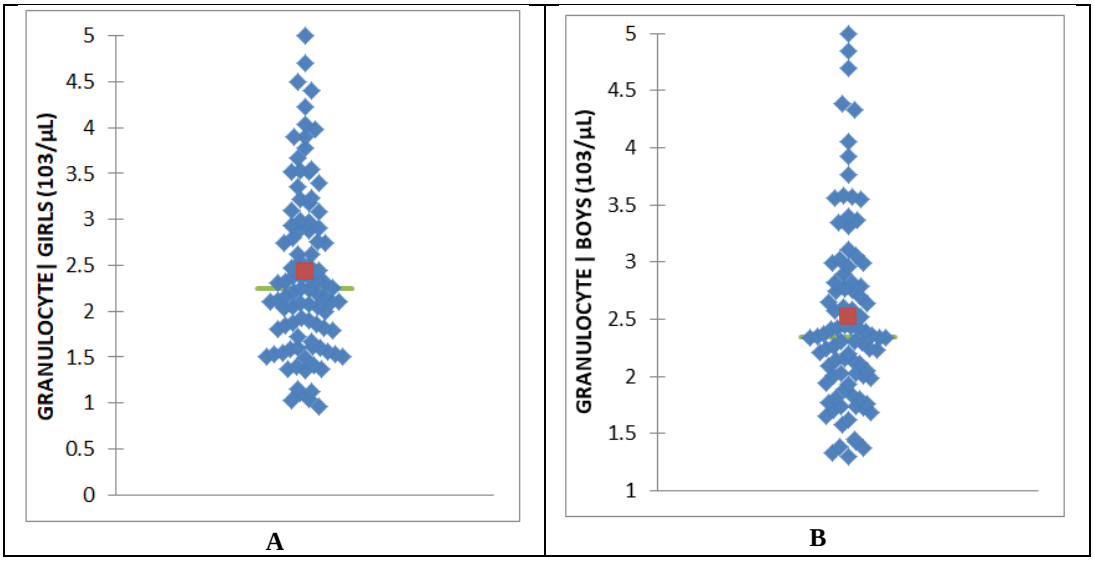

Figure 8: Granulocyte rates of girls (A) and boys (B)

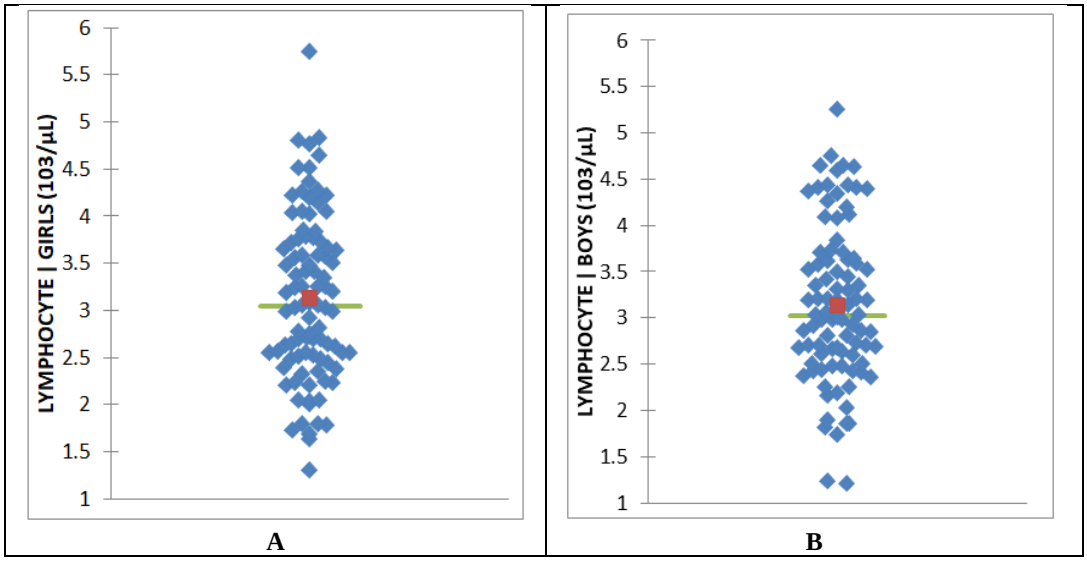

Figure 9: Lymphocyte rates of girls (A) and boys (B)

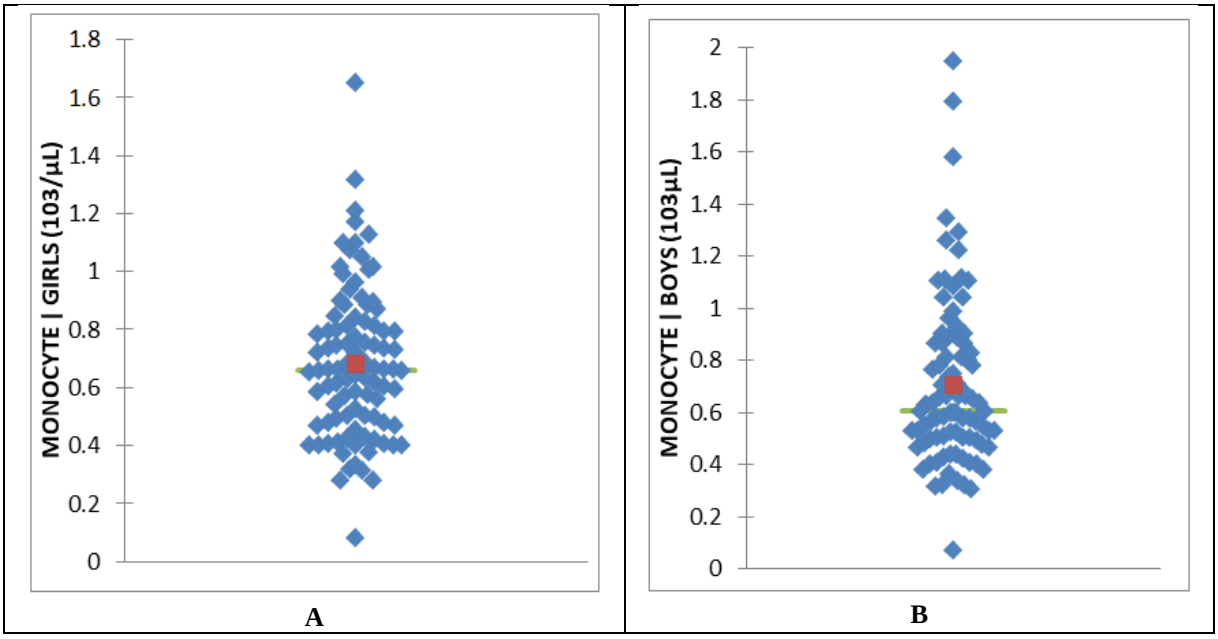

Figure 10: Monocyte rates of girls (A) and boys (B)

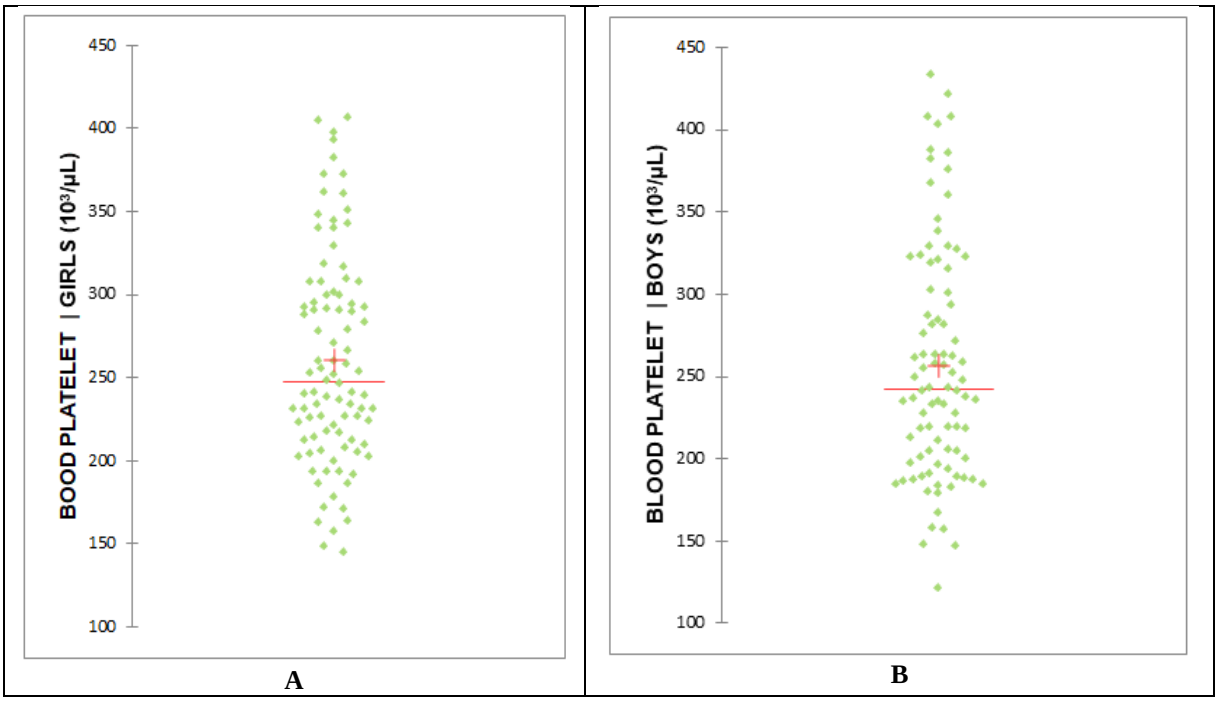

Figure 11: Blood platelet rates of girls (A) and boys (B)

Normal values of leukocyte parameters and blood platelets

The average values, the standard deviations and the reference interval values of leukocyte parameters and the blood platelets are shown in table II. The comparison of the average values of girls white blood cells against the boys' has given no significant differences ($p > 0.05$). However, the two average values show a slight difference, with $6.2,10^3/\mu L$ ($3.6- 8.6,10^3/\mu L$) in girls and $6.4,10^3/\mu L$ ($3.8- 8.9,10^3/\mu L$) among boys. For the average of granulocytes, that of female teenagers ($2.4,10^3/\mu L$; $|0.8- 3.9,10^3/\mu L|$) is lower than the male teenager's ($2.5,10^3/\mu L$; $|1.2- 3.7,10^3/\mu L|$). This difference is not statistically significant ($p > 0.05$). At lymphocytes, the average value of lymphocyte rates obtained in female students ($3.1,10^3/\mu L$; $|1.7-4.6,10^3/\mu L|$) is almost equal to that obtained in students ($3.1,10^3/\mu L$; $|1.6- 4.7,10^3/\mu L|$). The average value of monocyte levels in girls ($0.7,10^3/\mu L$; $|0.2- 1.1,10^3/\mu L|$) is similar to that of boys ($0.7,10^3/\mu L$; $|0.2- 1.1,10^3/\mu L$ |). The average value of blood platelets in girls ($260,0^3/\mu L$; $|147 – 392,10^3/\mu L|$) is greater than that of boys ($258,10^3/\mu L$; $|128 – 374,10^3/\mu L|$). This difference is no significatant statistically ($p > 0.05$).

Table II: Normal values of leukocytic parameters and teenagers platelets

Parameters	Girls			Boys			P-value P	Total population		
	Average	Stand deviat	Reference interval	Average	Stand deviat	Reference interval		Average	Stand deviat	Reference interval
WBC (10^3/µL)	6.2	1.6	3.6 - 8.6	6.4	1.5	3.8 - 8.9	< 0.7886 NS	6.3	1.5	3.7 - 8.7
Granulocyte (10^3/µL)	2.4	0.9	0.8 - 3.9	2.5	0.8	1.2 - 3.7	< 0.2625 NS	2.5	0.9	0.9 - 3.9
Lymphocyte (10^3/µL)	3.1	0.9	1.6 - 4.7	3.2	0.8	1.7 - 4.6	< 0.7886 NS	3.1	0.9	1.6 - 4.6
Monocyte (10^3/µL)	0.7	0.3	0.2 - 1.1	0.7	0.3	0.2 - 1.3	< 0.7548 NS	0.7	0.3	0.2 - 1.1
Platelets (10^3/µL)	260	63	147 - 392	258	76	128 - 374	< 0.6011 NS	258.5	67.4	138.6 - 378.6

P: p-value; NS: no significant différence between two groups of population for p > 0,05; Stand Deviat: standard deviation; WBC: white blood cells

Biochimiques parameters of study population

Median, minimum and maximum values

Serum proteins

Protein total

Figure 12 shows the different values of protein total in girls (Figure 12A) and in boys (Figure 12B). The median value of the protein total concentrations of girls is 68 g/L. The minimum value is 54 g/L and maximum value is 89 g/L in girls. In boys, median value of protein total concentration is 69 g/L. The minimum and maximum values are respectively 52 g/L and 88 g/L in boys.

Albumin

Regarding serum albumin, the different concentrations in girls and in boys are shown in figure 13. The median value of albumin concentrations determined in girls is 47 g/L against 45.7 g/L among boys. In girls, the lowest value of albumin concentration is 24 g/L and the highest value is 71 g/L. Among the boys, their minimum and maximum values are equal to 25 g/L and 67 g/L respectively.

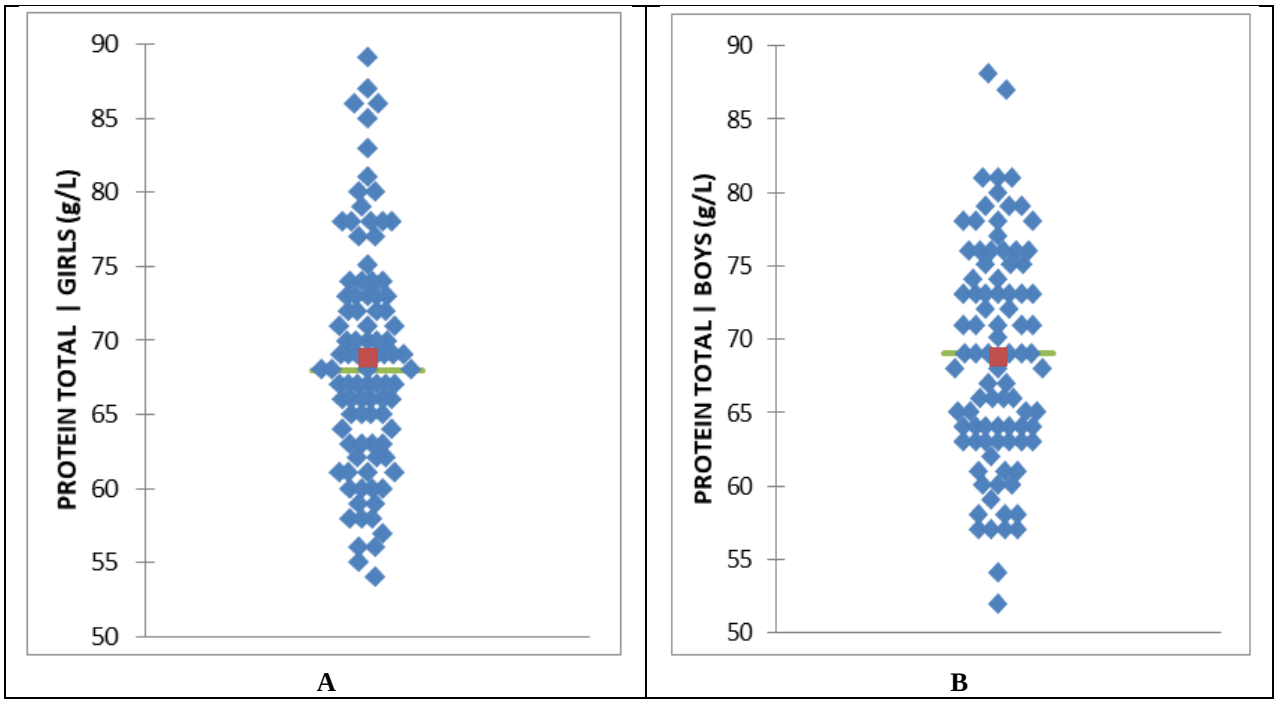

Figure 12: Protein total concentrations of girls (A) and boys (B)

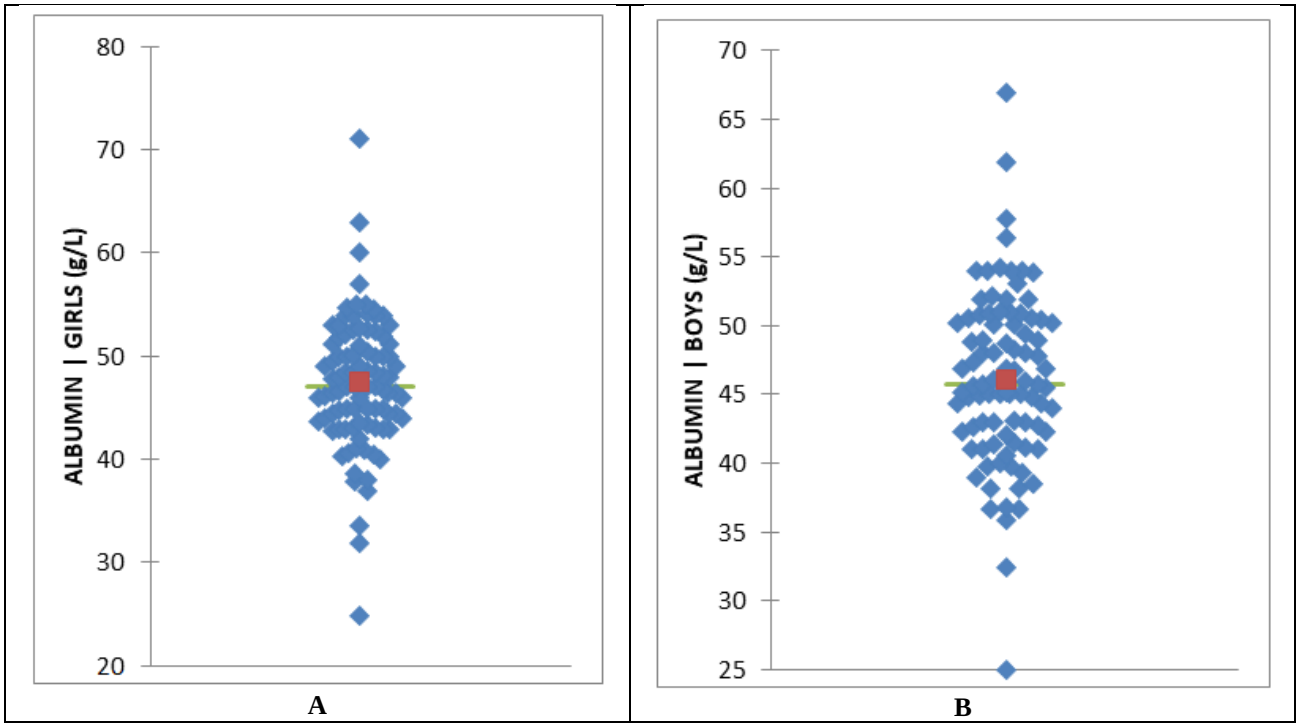

Figure 13: Albumin concentrations of girls (A) and boys (B)

Plasma lipids

Cholesterol total

The different cholesterol total values determined in Gagnoa students are presented in figure 14. In girls, the median value is 1.3 g/L. The smallest value of total cholesterol is 0.6 g/L and the greatest value is 2.3 g/L. With regarding to boys, the median value is identical to that of girls 1.3 g/L. The minimum value of total cholesterol concentrations is 0.7 g/L and the maximum value is 2 g/L.

Triglycérides

Figure 15 shows the different plasma triglycerides values in this study. The student females get a median value equal to that of boys (0.7 g/L). The smallest values are also the equal in girls and boys (0.3 g/L). The maximum value of girls (2 g/L) is higher than that of boys (1.7 g/L).

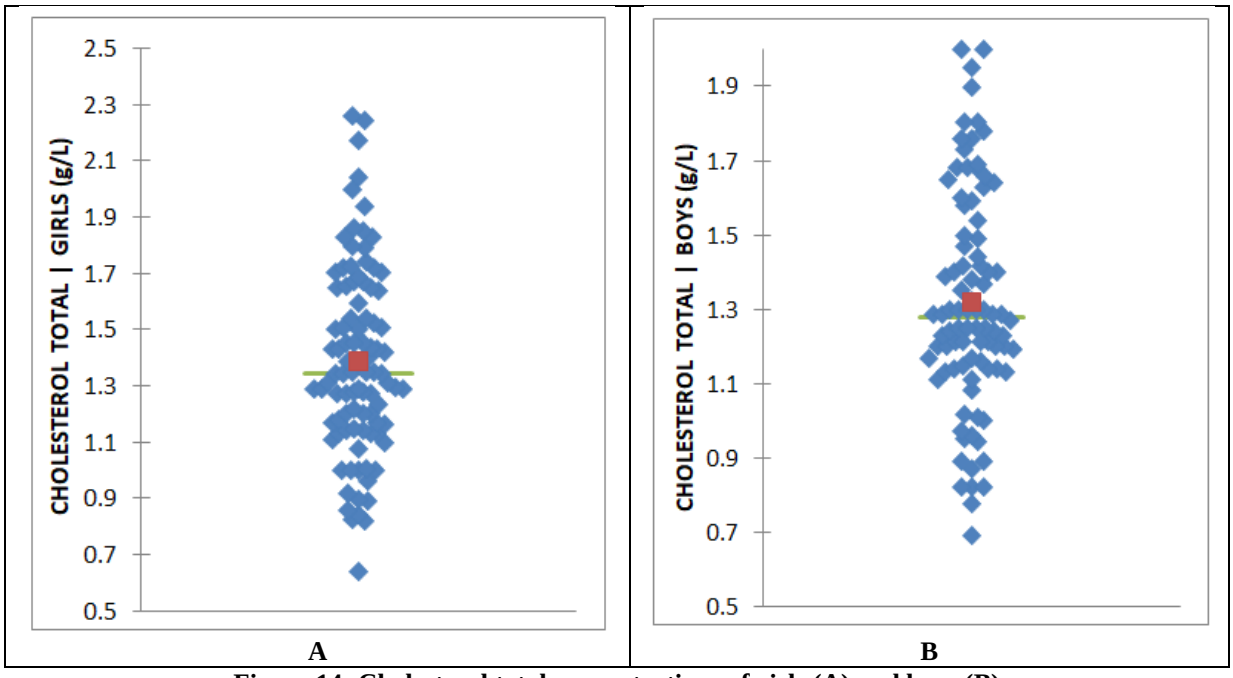

Figure 14: Cholesterol total concentrations of girls (A) and boys (B)

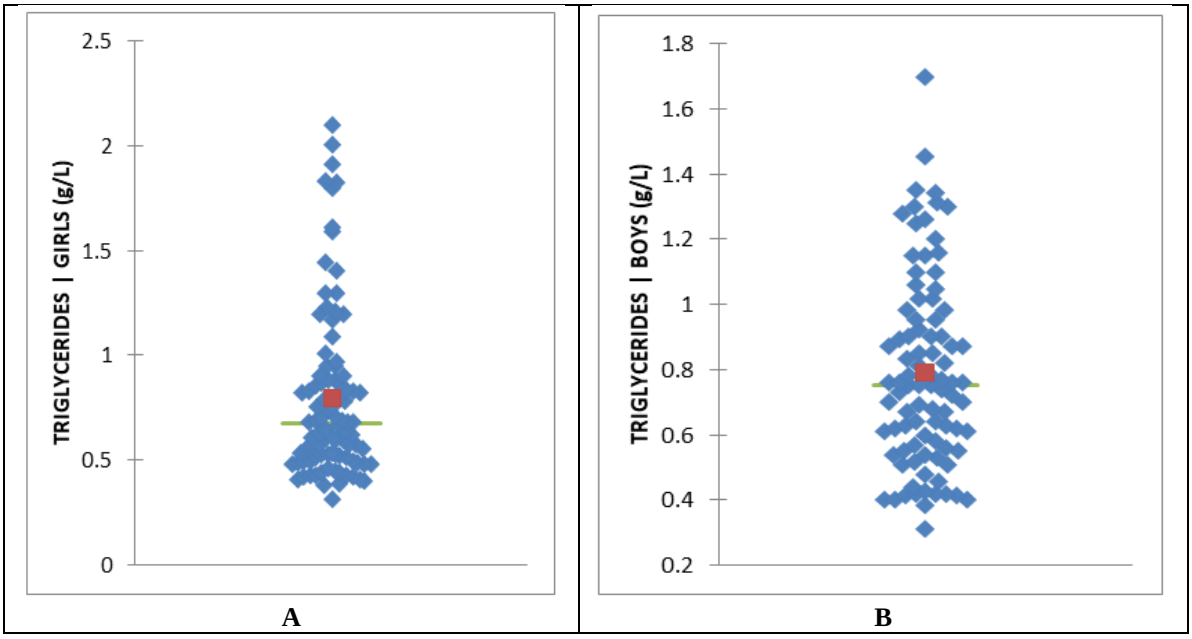

Figure 15: Triglycerides concentrations of girls (A) and boys (B)

Normal values of serum proteins and plasma lipids

The normal values of serum proteins and plasma lipids of the study population are recorded in Table III. The average of girls proteins total (68.8 g/L ; |55.4 - 82.4 g/L|) is slightly higher than boys (68.6 g/L ; |55.2 - 80.8 g/L|). The average serum albumin value of female students (47.4 g/L ; |37.3- 57.6 g/L|) is also slightly higher than boys que (46.2 g/L ; |36.1 - 56.7 g/L|). Cholesterol total's average value in girls (1.4 g/L ; [0.9 - 2 g/L]) is relatively higher than that obtained in boys (1.3 g/L ; |0.8- 1.8 g/L|). The average values of girl's triglycerides concentrations is identical to the boys (0.8 g/L ; |0.2- 1.2 g/L|).

Table III: Normal values of student biochemical parameters

Parameters	Girls			Boys			p-value P	Population Total		
	Average	Stand Deviat	Reference interval	Average	Stand deviat	Reference interval		Average	Stand deviat	Reference interval
Serum Protein										
Protein total (g/L)	68.6	7.3	55.2 - 80.8	68.8	7.6	55.4 - 82.4	0.8321 NS	68.7	7.4	55.6 - 81.4
Albumin (g/L)	47.4	6.4	37.3 - 57.6	46.2	6.3	36.1 - 56.7	0.1305 NS	46.8	6.3	36.7 - 56.9
Plasma lipid										
Cholesterol total (g/L)	1.4	0.3	0.9 - 2	1.3	0.3	0.8 - 1.8	0.1436 NS	1.3	0.3	0.8 - 1.9
Triglycerides (g/L)	0.8	0.4	0.2 - 1.2	0.8	0.3	0.2 - 1.2	0.1657 NS	0.8	0.3	0.2 - 1.2

P: p-value; NS: no significant différence between two groups of population for p > 0,05; Stand Deviat: standard deviation

Study population blood's ion parameters

Median, minimum and maximum values

Sodium

The different plasma sodium concentration values of female adolescents are shown in Figure 16A. The median value obtained is 131 mmol/L. The minimum value is 110 mmol/L and the maximum value is 157 mmol/L. In the male adolescents, the different plasma concentration sodium values are shown in Figure 16B. The median value is 132.5 mmol/L. The lowest value is 118 mmol/L and the highest value is 162 mmol/L.

Potassium

Figure 17 shows the different plasma potassium concentration value obtained respectively in girls (Figure 17A) and boys (Figure 17B). The median value in girls is 4.2 mmol/L against 4.3 mmol/L in boys. With regard to minimum and maximum values, those of the girls equal to 3 mmol/L and 6.1 mmol/L and those of boys are respectively equal to 2.9 mmol/L and 5.6 mmol/L.

Calcium

Figure 18A shows the different values of the plasma calcium concentration in adolescents. His median value is 96 mg/L. At for minimum and maximum values, they are respectively 72 mg/L and 120 mg/L. The

different plasma calcium concentration values obtained in boys are shown in figure 18B. The median value is 95 mg/L. The lowest value is 70 mg/L and the highest value is 121 mg/L.

Magnesium

At plasma concentration of magnesium, the different values obtained in girls are shown in figure 19A. The median value is 17.2 mg/L. The lowest value is 14.8 mg/L and the highest value is 23 mg/L. The different values of plasma magnesium concentration in boys are shown by figure 19B. The median value is located at 17.6 mg/L. The lowest value is equal to 14 mg/L and the highest value is 25 mg/L.

Chloride

Figure 20A shows the plasma concentration of chloride obtained among female students. His median value is located at 90 mmol/L. The maximum and minimum values are respectively located at 80 mmol/L and at 99mmol/L. The different plasma concentration values of chloride among male students are in figure 20B. The median value of chloride is 89 mmol/L. The lowest value is located at 79 mmol/L and the highest is 99 mmol/L.

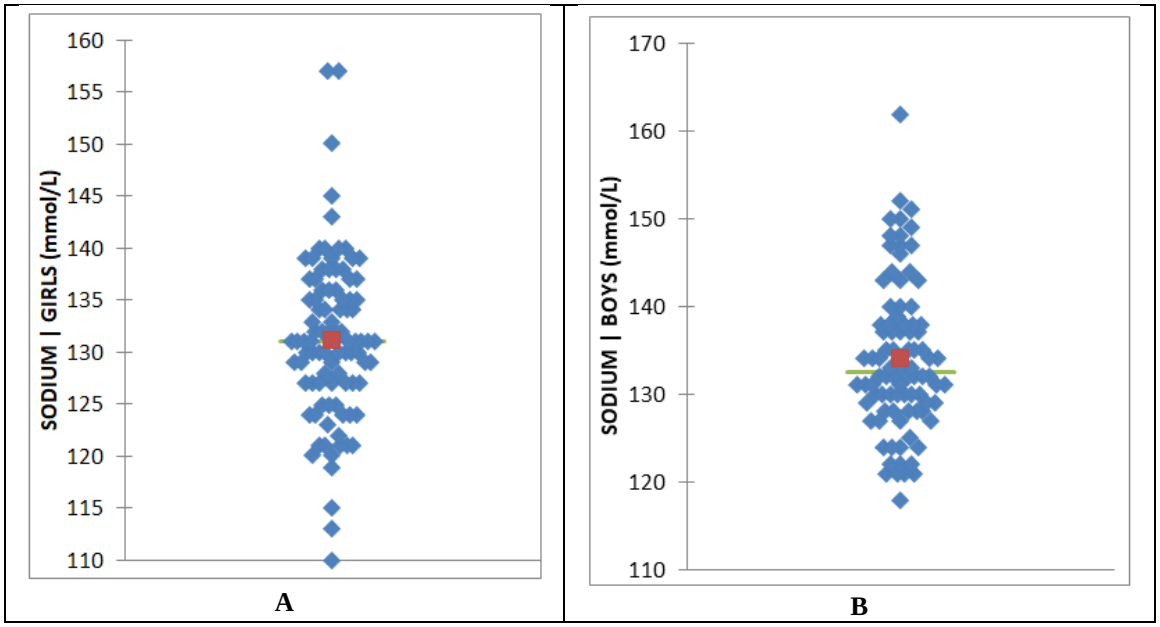

Figure 16: Plasma sodium concentrations of girls (A) and boys (B)

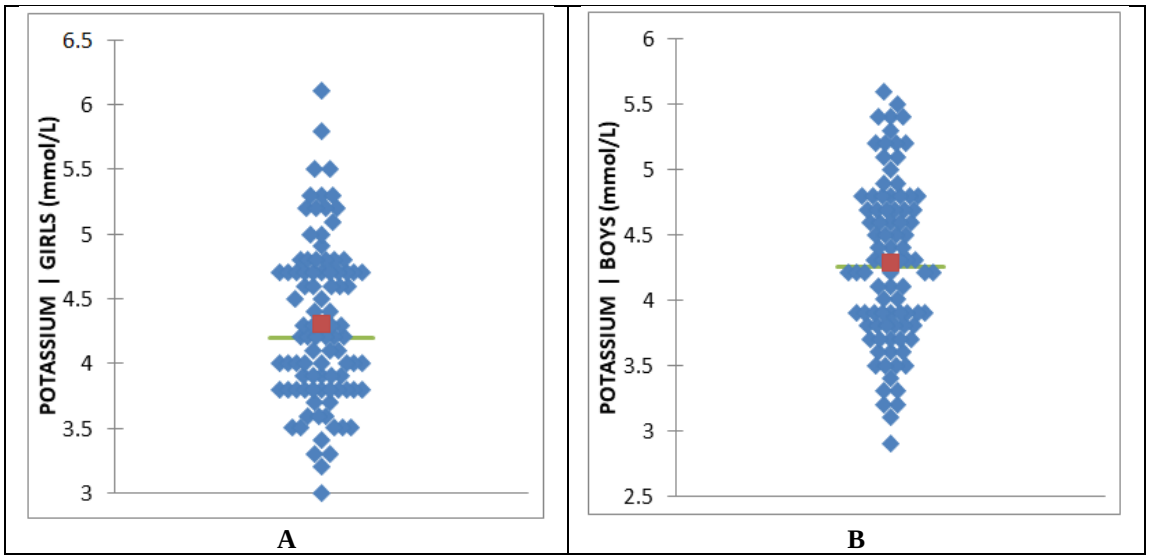

Figure 17: Plasma potassium concentrations of girls (A) and boys (B)

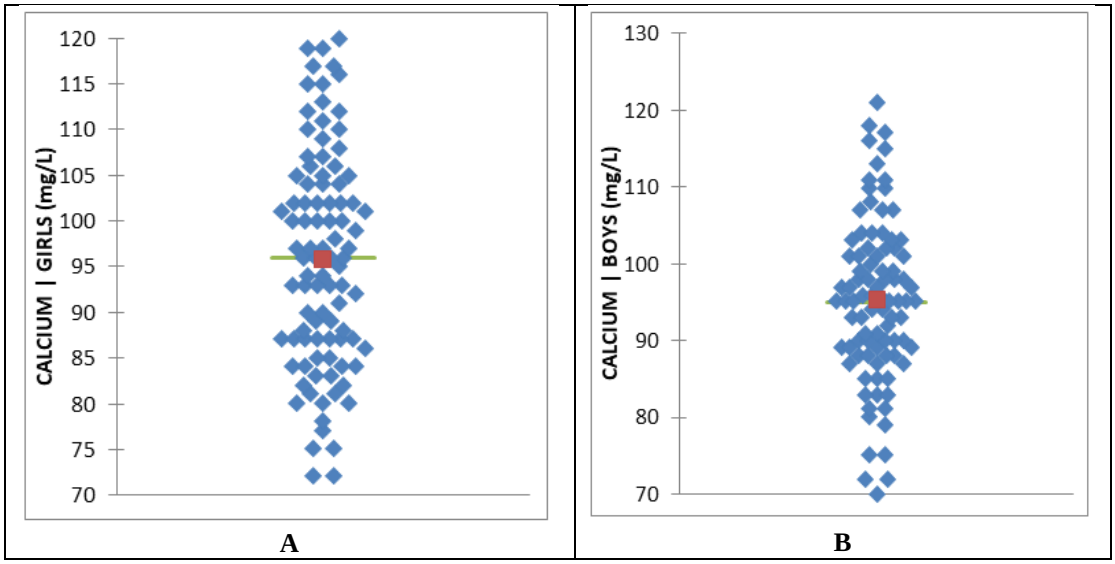

Figure 18: Plasma calcium concentrations of girls (A) and boys (B)

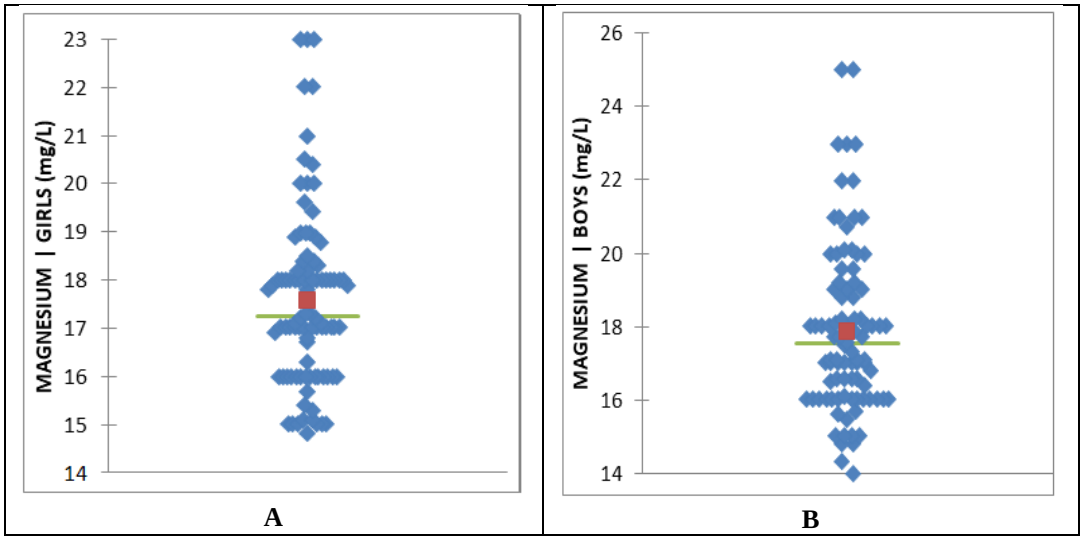

Figure 19: Plasma magnesium concentrations of girls (A) and boys (B)

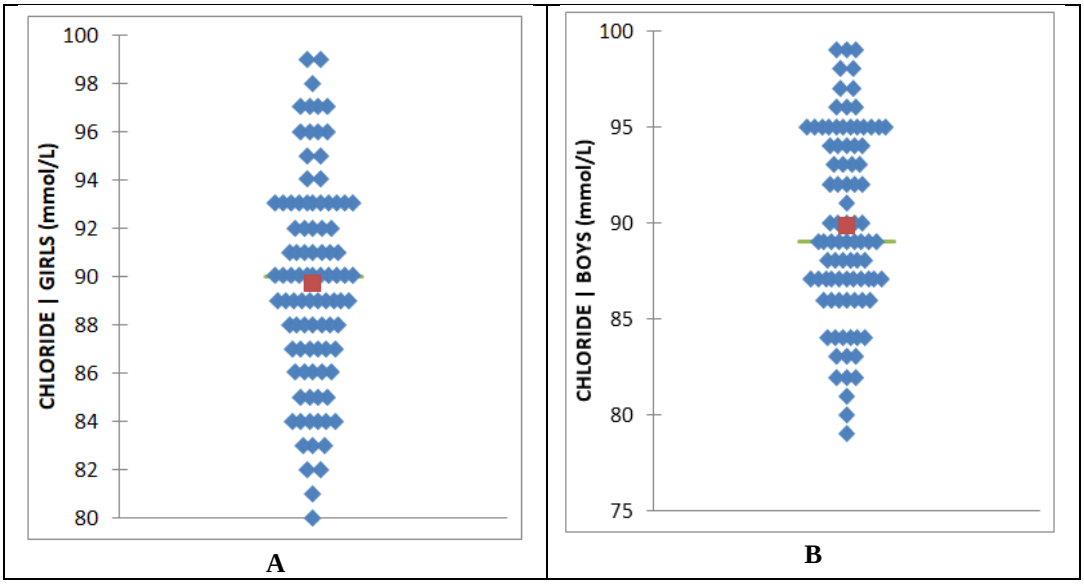

Figure 20: Plasma chloride concentrations of girls (A) and boys (B)

Normal values of plasma ions

The average plasma ion concentration values, the standard deviations and plasma ions reference intervals obtained in girls and boys are shown in table IV. The difference between average plasma sodium concentrations in girls (131.2 mmol/L |119.1 - 144 mmol/L|) and boys (134.1 mmol/L |120.5- 146.5 mmol/L|) is statistically significant ($p < 0.05$). As for the average plasma potassium concentrations obtained in girls (4.3 mmol/L |3.2- 5.3 mmol/L|) and among boys (4.3 mmol/L |3.2- 5.3 mmol/L|), they are similar. As the average value of plasma concentrations of calcium obtained in girls (95.8 mg/L |75.1- 116 mg/L|) is slightly higher than that obtained in boys (95,2 mg/L |78.3- 112.5 mg/L|). This difference is not statistically significant ($p > 0.05$). Regarding the average value of the plasma magnesium concentrations obtained girls (17.6 mg/L |14- 20 mg/L|), it is slightly lower than that obtained in boys (17.9 mg/L |13.7- 21.3 mg/L|). Fanaly, the average values of chloride plasma concentrations in female students (89.7 mmol/L |82.7- 97.3 mmol/L|) and in male students (89.8 m.mol/L ; |82.1- 99 mmol/L|) are similar.

Table IV: Normal values of plasma ions in adolescents

Parameters	Girls			Boys			p-value P	Total population		
Plasma ions	Average	Stand deviat	Normal interval	Average	Stand deviat	Normal interval		Average	Stand deviat	Normal interval
Sodium (mmol/L)	131.2	8	119.1 - 144	134.1	8	120.5 - 146.5	0.05068 NS	132.6	8	120 - 145
Potassium (mmol/L)	4.3	0.6	3.2 – 5.3	4.3	0.6	3.2 - 5.3	0.8593 NS	4.3	0.6	3.2 - 5.3
Calcium (mg/L)	95.8	11.9	75.1 - 116	95.2	10.6	78.3 - 112.5	0.8322 NS	95.5	11.3	75.7 - 113.6
Magnesium (mg/L)	17.6	1.8	14 - 20	17.9	2.3	13.7 - 21.3	0.5274 NS	17.7	2	14 - 20.6
Chloride (mmol/L)	89.7	4,3	82.7 - 97.3	89.8	5	82.1 - 99	0.9529 NS	89.8	4.6	82.4 - 97.6

P : p-value ; NS : No significant différence between two groups of population for $p > 0,05$; S : significant difference between two groups of population for $p < 0,05$; Stand deviat : standard deviation

DISCUSSION

The median values of erythrocyte parameters have been determined in students (girls and boys) of Gagnoa 1 and 2 high schools. They are the levels of red blood cells and hemoglobin, percentages of hematocrit, mean cell volume (MCV), mean cell hémoglobin (MCH) and mean cell hemoglobin concentration (MCHC). These median values are close of the reference values reported WHO (WHO, 2011). These results are similar to those obtained by Dossoo *et al.,* (2014) in Kintampo adolescents in center of Ghana. Indeed, these authors reported median values of red blood cells (RBC) rate equal to $4.50,10^6$/µL in girls and $4.66,10^6$/µL among boys, median values of hemoglobin rate equal to 12.2 g/dL in girls and 12.4 g/dL among boys, median values of hematocrit percentages equal to 36.9 % in girls and 37.4 % among boys, median values of mean cell volume equal to 83 fL in girls and 82 fL among boys, median values of mean cell hemoglobin equal to 27.2 pg /cell in girls and boys and median values mean cell hemoglobin concentration equal to 32.9 g/dL in girls and 33.1 g/dL among boys.

The averages and the normal values intervals of erythrocyte parameters of this study population were also obtained. The average values for certain erythrocytic parameters are low compared to those observed by Atto *et al.,* (2012) in adolescents living in the city of Abidjan (Côte d'Ivoire). Indeed, these authors have observed average values of hemoglobin equal to 13.1 g/dL in girls and 14.4 g/dL among boys, average values of hématocrit equal to 39.5 % in girls and 43.5 % among boys and average values of MCH equal to 85.5 fL in girls and 87.1 fL among boys. However, the results of this studies are similar to those of Yapi *et al.,* (2005), which were 11.4 g/dL (hemoglobin level), 33.59 % (hématocrit level), 73.01 fL (MCV) and 24.5 pg/cell (MCHC). In addition, the normal values intervals of the erythrocytic parameters in this studies are in accordance with the values obtained by Dosoo *et al.,* (2014). Non-significant deviations are been observed between the values of the erythrocyte parameters of girls and those of boys. In female and male teenagers, such gaps have been observed in studies in Nigeria and Kenya (Buseri *et al.,* 2010; Odhiambo *et al.,* 2015).

The median values of leukocyte parameters (white blood cell, granulocyte, lymphocyte and monocyte levels) have been determined. These values show that granulocyte rates observed in Gagnoa high school students are very low comparted to international reference values. On the contrary, the levels of lymphocytes observed are very high compared to the reference values established by the SFH (2006) which are [1.5 - 6.0 10^9/L] for neutrophils and [1.5 - 4.5 10^9/L] for lymphocytes. The rather low values of granulocyte rates could be explained by genetic neutropenia among African original populations already observed by some authors (Sharper *et al*., 1971; Ezeilo, 1974). Low levels of neutrophils as well as high levels of lymphocytes, have also been served in studies previously carried out in

Côte d'Ivoire by Danho-Bassimbié *et al.,* (1993), Atto *et al.,* (2012) and Kokoré *et al.,* (2013). This neutropenia and lymphocytosis would be consequences of infectious and inflammatory syndromes. Indeed, Côte d'Ivoire is located in highly endemic area of malaria. As a result, high levels of lymphocytes would be caused by benign *plasmodium* infections (Yapi *et al.,* 2010). According to the other authors, people of African descent genetically have a normal value of lower granulocytes than Europeans and Asians (Buseri *et al.*, 2010; Zeh *et al.*, 2011). The median values of the white blood cells of this study are similar to those obtained in the study carried out in Ghana by Dosoo *et al.* (2014) which is equal to 5.9, 10^9/L.

Regarding the average values and the intervals of normal values of the leukocyte parameters obtained in this study, they stand out from those presented as reference values from the European populations. These differences are at the level of the proportions of granulocytes and lymphocytes in total of white blood cells (SFH, 2006). Indeed, only the average values of all the white blood cells total obtained in our study are similar to those of reference values established in north America (Kratz *et al.*, 2004). The average values of white blood cell levels as well as their distributions in proportion of granulocytes, lymphocytes, and monocytes are similar those obtained in adolescents west of Nigeria and Kénya (Buseri *et al.*, 2010; Zeh *et al.*, 2011).

With regard to blood platelets, the values observed in these studies are in accordance with the values of the SFH (2006). The médianes values of platelets are included in reference interval (150 - 400.10^3/µL). But the terminals of the normal values intervals of this study are lower than the terminals of the intervals of the reference values (SFH, 2006). However, the median values of platelets are similar to the values of Dosoo *et al.,* (2014) that have been 232.10^3/µL in girls and 220.10^3/µL in boys. As for the average values of blood platelets, they are close to the values obtained by Atto *et al.,* (2012) which have been equal to 248,8.10^3/µL for the total population, 261,5.10^3/µL among girls and 230,7.10^3/µL among boys. Similar results have been reported in Nigeria, Uganda and Kenya (Azikiwe, 1984; Lugada *et al.*, 2004; Odhiambo *et al.*, 2015). The average values of blood platelets are relatively low compared to the average value obtained in Kokoré's studies that was 321,5. 10^6/L for the total population (Kokoré *et al.,* 2013). In addition, no significant difference was found between the average value of girls and boys, which is contrary to results obtained in Abidjan where the average value in girls is significantly higher than the boy's (Atto *et al.*, 2012).

The median values of some biochemical parameters that have been determined in girls and boys of Gagnoa secondary schools are the concentrations of protein total, albumin, cholesterol total and triglycerides. In addition to the average values and normal values intervals of these biochemical parameters have also been established in this study. The values show that serum concentrations of proteins total, albumin, total cholesterol and triglycerides of these teens from Gagnoa are similar to the values of the concentrations of the same biochemical parameters already established by other authors in Sub-Saharian Africa. (Yapo *et al.,* 1999; Dosoo *et al*., 2014; Buchanan *et al.,* 2015).

The median values of serum proteins total concentration in this study are comply to those obtained in Kintampo adolescents in Ghana where the values were 72.4 g/L [46.7 – 87.3 g/L] in gilrs and 71.6 g/L [45.2–86.0 g/L] in boys (Dosoo *et al*., 2014). The average values of proteins total and albumin concentration are also similar to those observed in Abidjan by Yapo *et al.,* (1999). Indeed, in the studies carried out in a young population in Côte d'Ivoire, these authors have obtained the average values of 73,6 g/L in girls against 72,8 g/L among boys for serum concentrations of protein total and 39,06 g/L in girls and boys for serum concentration of'albumin. However, normal values of proteins total for this Gagnoa's teenage population are slightly lower than those of adolescents from the Kilimandjaro region in Tanzania established by Buchanan *et al.,* (2015). These authors have previously established the median values and the normal values of teenagers, aged 13 to 18 years old, serum proteins total concentration at 73 g/L [67 - 84 g/L] in girls and 75 g/L [68 - 84 g/L] among boys while those of the teenagers of the secondary schools of Gagnoa are 68 g/L [55.2- 80.8 g/L] in girls and 69 g/L [55.4 - 82.4 g/L] among boys.

The médian values of cholestérol total plasma concentrations (1.3 ± 0.3 g/L) observed in these studies are very low compared to the North American's reference values that have set the boundaries of normal values of cholesterol total between 4.40 and 5.18 g/L (Arcara, 2012). In addition, average values of cholestérol total and triglycérides obtained in Gagnoa high school students are also lower than the cholesterol total and triglycerides values reported by Yapo *et al.*, (1999) in ivoirian children aged at 0 to 15 years old. These authors have observed average values of cholestérol total equal to 3,56 mmol/L in girls and 3,46 mmol/L among boys. In addition, the median values and interval of normal values of cholesterol total in these studies are also lower than those observed in Ghana and Tanzania (Dosoo *et al.*, 2014; Buchanan *et al.*, 2015). These authors have respectively indicated average values equal to 3 g/L [1.8 à 4.6g/L] and 3.46 g/L (2.15 - 4,56) for cholestérol total in girls and boys. The average values of triglycérides of Gagnoa students are relatively low to those of Yapo *et al.*, (1999). These authors observed triglycerides concentrations equal to 0.79 mmol/L in girls and 0.78 mmol/L among boys. Finaly, the médian values and normal values of this study were also lower than the values established in the studies of Dosoo *et al.*, (2014) and Buchanan *et al.*, (2015) which were obtained respectively 0.8 g/L [0.40 à 1.70] g/L and 0.83 g/L [0.35-

1.96 g/L] for the plasma concentrations of triglycérides in girls and boys.

These studies have made it possible to establish median, medium and normal values intervals of certain plasma ions. These median values and average values of plasma ions of study population, overall, are lower than the reference values of developed countries as reported in USA by Colantonio *et al.*, (2012). These authors set the references values intervals of children and adolescents at [91 - 106 g/L] for calcium and [20.9 – 28.7 g/L] for magnesium while the normal values of our studies are [75.7 – 113 g/L] for calcium and [14 – 20.6 g/L] for magnesium. In fact, with the exception of plasma sodium concentrations that have gone closer to WHO reference values of plasma concentrations of potassium, calcium, magnesium and chloride have been different from national reference values. The values of these studies are as low as Yapo *et al.*, (1999) previously realized in Côte d'Ivoire. Indeed, Yapo *et al.*, (1999) have observed average values of sodium concentrations equal to 138.8 mmol/L in girls against 138.6 mmol/L among boys, potassium concentrations equal to 4,38 mmol/L in girls against 4,39 mmol/L among boys, calcium concentration equal to 2,47 mmol/L in both sex and magnesium concentrations equal to 0.85 mmol/L in girls against 0.87 mmol/L among boys.

The median values of the plasma chloride, potassium and sodium concentrations of the teenagers of Gagnoa secondary schools are slightly lower than the median values of studies carried in Ghana in 2014 and Tanzanie in 2015. In Ghana, the median values were set at 107 mmol/L for chloride, 4.5 mmol/L for potassium and 145 mmol/L for sodium (Dosoo *et al.*, 2014). In Tanzania, the médian values were 101 mmol/L for chloride, 4.3 mmol/L for potassium and 137 mmol/L for sodium (Buchanan *et al.*, 2015). In addition, the values of normal value intervals Gagnoa high school students are also slightly lower than those of the teenage population in Ghana. (Dosoo *et al.*, 2014) are established the normal interval values of their studies at [95 - 117 mmol/L] for chloride, [3.6 - 6.1 mmol/L] for potassium and [132 - 156 mmol/L] for sodium plasma. According to these authors, no significant differences have been found between the values of female and male adolescents. Similar results for plasma potassium and sodium values have also been reported by Palacpac *et al.*, (2014) during its studies in rural population in northern Uganda.

CONCLUSION

The hematological values of Gagnoa high school students have relatively low hemoglobin levels (12.4 g/dL in the girls and 13.2 g/dL in boys). The hematological profile also reveals very low values of granulocytes ($2.5.10^3$/µL) and high lymphocyte levels ($3,1.10^3$/µL).

The blood biochemical profile presented values of concentrations of protein total, albumin, triglycerides, sodium, potassium, calcium, magnésium and chloride in these studies are similar to values previously established in other adolescent populations in Côte d'Ivoire. As the values of plasma cholestérol total equal to 1.3 g/L and plasma triglycerides concentrations equal to 0.8 g/L have been low compared to previously established values in sub- saharian Africa.

Thanks

We thank:

- The directors of the high schools of the city of Gagnoa,
- The directors and the staff of the Laboratory Biological Analysis of Gagnoa General Hospital,
- The students and parents who contributed greatly to the realization of this study.

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Cite This Article: Yao N'Guessan Blaise, N'dia Kouadio Frédéric, Yapo Angoué Paul (2024). Hematological and Biochemical Profiles of Gagnoa High School Students (Côte D'ivoire). *EAS J Pharm Pharmacol*, *6*(5), 182-198.