

The system dynamics of white and red blood in children, living in areas with high anthropogenic load

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ABSTRACT

Aim: The aim of the work is to study the features of dynamics of quantitative indicators of peripheral red and white blood in children during the first 2.5 years of life. **Methods:** Peripheral blood sampling for clinical analysis was carried out by medical personnel on the 1st day of the life of newborns in the conditions of the maternity department of Gubkin Central District Hospital (first inspection), all the others (second-fifth) in the laboratory of children's polyclinic no. 2 of Gubkin. **Results and Discussion:** The article presents an analysis of the dynamics of indicators of the white and red blood system, identified from birth to 2.5 years of life in children living in the Kursk Magnetic Anomaly zone with the industrial development of iron-containing ores in an open way. Anemia was found in newborns – 24.0% of girls and 18.0% of boys, but only 6.0% of girls had a lower amount of red blood cells; in 3 months – 29.0% of girls and 30.0% of boys; and in 6 months – 22.0% of girls and 6% of boys. Up to 2 years old, the hemoglobin level in the blood corresponded to the lower limit of the norm, and in boys, it was higher ($P < 0.05$). **Conclusion:** In 25.6% of 1 year old and 17.1% of 3 months and 2-year-old girls, the number of red blood cells was below norm. In healthy 6 months old, 24.0% of boys and 20.0% of girls had erythrocyte sedimentation rate higher than the age norm. The formula of leukocytes in newborns was age-appropriate, but among them were children with leukocytosis: physiological in 26% of girls and 16% of boys; pathological - in 16.0% of girls and 20.0% of boys; neutrophils - from 1–17% of rod and 45–80% of segment neutrophils. The average values of the lymphocytic index in girls and boys were 0.38 ± 0.01 and $0.37 \pm 0.01\%$, respectively.

KEY WORDS: Anemia of newborns, Hemoglobin, Heterochromic anemia, Leukocyte formula, Leukocytosis of newborns, Lymphocytic index, White and red blood system

INTRODUCTION

An up-to-date problem of our time is the growth of unsatisfactory indicators of children's health, with a decrease in the number of healthy children among them and an increase in chronic pathology and/or disability.^[1-3] The child's body is highly sensitive to any environmental influences. Relatively weak stimuli that do not change the activity of the adult organism can significantly change the functional state of the child, and in prolonged exposure, they are able to disrupt its functions, to inhibit the growth and development of the child. Functionally, the blood system is one of the most rapidly reacting physiological systems of the body, realizes the function of the coordinating link in the implementation of adaptive-compensatory reactions

of the body, directed to maintaining the parameters of homeostasis and formation of immune protection at the cellular and humoral levels.^[4-6]

At the initial stages of post-embryonic development, the child's body, for various reasons, is influenced by various environmental factors that can have a negative impact on its processes of life, growth, and development.^[5] It is known that even relatively weak stimuli, which do not change the functional state of an adult organism, can cause significant changes of physiological functions in a growing organism at the background of intensive metabolic processes associated with high energy and plastic material consumption.^[7,8]

Diagnostic clinical parameters of red and white blood allow to judge objectively of the current functional status of an organism taking into account their deviations from age norms.^[4,5] Despite a large number of clinical and laboratory studies of the blood system, obtaining new knowledge about the variability of

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quantitative indicators of the peripheral blood system during the first 2.5 years of life in children living in an area with high anthropogenic load is relevant.

The aim of the work is to study the features of dynamics of quantitative indicators of peripheral red and white blood in children during the first 2.5 years of life.

RESEARCH MATERIALS

Initially, for the formation of two groups – boys and girls outpatient cards of children – 50 girls and 50 boys, of the same age was studied. All children from the moment of birth, including the period of early childhood, lived in Gubkin, Belgorod region (Russia). The territory of Gubkin is referred to as the zone of Kursk Magnetic Anomaly with industrial development of iron-containing ores by the open method. The professional activity of the adult population is mainly associated with the activities of the Lebedinsky ore concentration plant, including the world's largest Lebedinsky quarry.

METHODS

Peripheral blood sampling for clinical analysis was carried out by medical personnel on the 1st day of the life of newborns in the conditions of the maternity department of Gubkin Central District Hospital (first inspection), all the others (second-fifth) in the laboratory of children's polyclinic no. 2 of Gubkin. Using standard unified methods, blood was taken in the morning on an empty stomach from 7.30 to 8.30^[4,6] in the following sequence: Second examination of infants – in 3 months of life before the first vaccination, third – in 6 months, fourth – in 1 year, and fifth – in 2.5 years old.

We analyzed and evaluated the dynamic series of indicators of the general blood test in children by their individual values established in each child from birth to 2.5 years old inclusive. On the basis of initially identified clinical parameters of the blood system, its information parameters were calculated.^[4,5] The average content of hemoglobin in the red cell was determined by the ratio of the total content of hemoglobin (g/l) in the peripheral blood the number of erythrocytes ($\times 10^{12}/l$). This indicator in a healthy child normally up to 1 year is 28–35 pg per erythrocyte, from 1 to 3 years – 28–32 pg.^[7] Lymphocytic index is a quantitative ratio of the number of lymphocytes to neutrophils.^[5] In the available scientific literature, the values of this index for given above age groups of children have not been established.

Revealed during the study, the indicators of the red and white blood system were studied taking into account age physiological norms.^[7-9] The primary data

were processed with the help of modern methods of mathematical statistics using a package of computer programs “Statistica 6.”

RESULTS AND DISCUSSION

Quantitative average indicators of peripheral red blood, established in newborns on the 1st day of life, corresponded to age-sexual norms [Table 1]. However, according to individual values of hemoglobin content, 24.0% of girls and 18.0% of boys had less than 180 g/l (lower limit of physiological norm), despite the fact that only 6.0% of girls had a low number of red blood cells against the age norm.^[10]

In boys, these indicators compared with their severity in girls were more variable and significantly high ($P < 0.05$). This result showed that the examined population of newborn girls was more adapted to the conditions of hypoxia. The high content of hemoglobin and the number of red blood cells in boys can be regarded as the development and manifestation of compensatory reactions aimed at overcoming the state of hypoxia with their transition to an independent air-breathing regime.^[11]

The average values of hemoglobin in one erythrocyte in newborn girls and boys were 34.9 and 35.2 pg/cell, respectively [Table 1], exceeding the upper limit of the physiological norm of this indicator established for an adult healthy person – 25.4–34.6 pg/cell.

The color index was lower than 1 only in 8.0% of girls, and the rest showed within the age norm – from 1 to 1.3. Its individual values in boys were observed in a wider range from 0.94 to 1.20.

The content of platelets was manifested within the limits of the physiological norm, averaging $303.8 \times 10^9/l$, $313.4 \times 10^9/l$, respectively, in boys and girls. However, in girls, the individual values of platelet content were more variable – from $196 \times 10^9/l$ to $355 \times 10^9/l$, compared with their range of fluctuations in boys – from $236 \times 10^9/l$ to $352 \times 10^9/l$.

Table 1: Quantitative indicators of peripheral red blood in newborns

Indicators, conv. units	M±m	Min.	Max.
Girls			
Hemoglobin, g/l	188.7±1.84	158	220
Red blood cells, $\times 10^{12}/l$	5.4±0.05	4.7	6.3
Color indicator	1.01±0.03	0.95	1.10
Platelets, $\times 10^9/l$	303.8±5.06	196	355
Hemoglobin, pg/cell	34.9±0.19	32	38.3
Boys			
Hemoglobin, g/l	198.8±2.87*	153	245
Red blood cells, $\times 10^{12}/l$	5.6±0.07	4.6	7.0
Color indicator	1.03±0.00	0.94	1.20
Platelets, $\times 10^9/l$	313.4±3.53	236	352
Hemoglobin, pg/cell	35.2±0.24	30.0	40.0

In newborns, the content of leukocytes in the blood corresponded to the norm. In 26.0% of girls and 16.0% of boys established physiological leukocytosis with the number of leukocytes in the range of 20–25×10⁹/l [Table 2]. Pathological leukocytosis with the number of leukocytes more than 25×10⁹/l was established in 16.0% of girls and 20.0% of boys. The number of rod- and segment-cored neutrophils corresponded to physiological norms equal to 1–17% and 45–80%, respectively, indicating neutrophil leukocytosis. This type of leukocytosis may be due to the humoral pathway-entering the body of the child through the placenta of maternal hormones, or blood thickening, resorption of interstitial hemorrhages, assimilation of the decay products of cellular structures due to insufficient intake of nutrients into the body of the child.^[12] The content of eosinophils in children of both sexes was manifested in the range from 1 to 3%, corresponding to the average values of the lower limit of the age norm (0.5–6%).

The content of agranulocytes was manifested within physiological norms equal to 12–36% for lymphocytes and 2–12% for monocytes [Table 2]. The average values of the lymphocytic index in girls and boys were 0.38 ± 0.01 and 0.37 ± 0.01%, respectively.

Table 2: Quantitative indicators of white blood in newborns on the 1st day of life

Indicators, conv. units	M±m	Min.	Max.
Girls			
Leukocytes, ×10 ⁹ /l	20.35±0.95	9	36.8
Eosinophils, %	1.08±0.08	0	3
R/cored, %	8.22±0.41	1	12
S/cored, %	58.72±0.35	51	65
Lymphocytes, %	24.66±0.38	20	31
Monocytes, %	6.92±0.21	4	15
Boys			
Leukocytes, ×10 ⁹ /l	18.61±0.95	8	32
Eosinophils, %	1.16±0.06	1	3
R/cored, %	8.92±0.42	1	13
S/cored, %	58.64±0.46	49	73
Lymphocytes, %	24.2±0.53	20	37
Monocytes, %	6.58±0.13	3	8

Thus, in general, the average indicators of leukocyte formula established in newborns corresponded to the physiological norms established for healthy children on the 1st day of life.

Three months later, compared with the 1st day of life, the level of hemoglobin in children of both sexes decreased sharply and averaged 118.0 g/l, manifesting the lower limit of the age norm [Tables 1 and 3]. The analysis of individual values of hemoglobin showed that 29.0% of girls and 30.0% of boys had anemia. These children had hemoglobin levels below 115 g/l. From 6 months to 2.5 years old, the average hemoglobin content in girls remained within the same low age limits, but in boys, its level gradually increased and was significantly higher (*P* < 0.05).

The lowest content of hemoglobin in the blood of 6-month-old children, especially in girls, was physiologically natural, associated with a sharp decrease in their body's supply of iron, necessary for the synthesis of hemoglobin. This is indicated by a decrease in the variability of individual values of hemoglobin in children of this age. Individual indicators of hemoglobin in the blood of boys were observed in a narrower range against the first study.

Pathologically low hemoglobin level (anemia) was found in 6% of boys and 22% of girls. In girls, the lowest individual hemoglobin levels in the blood decreased to 40 g/l during the entire study period. In boys of the 2nd year of life, the range of individual values of hemoglobin level was higher than in girls and did not decrease below 50 g/l. Similar changes in the number of red blood cells were observed: At the age of 3 months and 2.5 years old in boys. Compared with girls, it was constantly more significant in boys (*P* < 0.05). In 25.6% of 1 year old and 17.1% of 3 month old and 2.5-year-old girls, the number of red blood cells was below the normal age. Accordingly, throughout the study period, the average hemoglobin

Table 3: Dynamics of quantitative indicators of the red blood system, M±m

Indicator, unit	Survey			
	2-e	3-e	4-e	5-e
Girls				
Hemoglobin, g/l	118.00±1.24	116.16±1.46	118.92±1.32	118.46±1.27
Red blood cells×10 ¹² /l	3.60±0.05	3.62±0.04	3.71±0.04	3.66±0.03
Color indicator	0.94±0.00	0.92±0.00	0.93±0.00	0.94±0.00
Platelets, ×10 ⁹ /l	256.12±7.37	238.00±6.10	228.69±3.78	225.92±2.94
ESR, mm/h	8.34±0.74	9.00±0.64	9.10±0.62	8.64±0.62
Boys				
Hemoglobin, g/l	118.00±1.34	120.84±1.23	123.60±1.56	124.18±1.30
Red blood cells×10 ¹² /l	3.72±0.05	3.77±0.04	3.80±0.04	3.87±0.04
Color indicator	0.93±0.00	0.94±0.00	0.95±0.00	0.95±0.00
Platelets, ×10 ⁹ /l	226.80±2.91	235.64±3.2	230.31±2.79	235.85±2.74
ESR, mm/h	7.98±0.80	8.64±0.49	9.60±0.85	9.78±0.94

ESR: Erythrocyte sedimentation rate

content in one erythrocyte in boys was higher than in girls [Figure 1].

The average value of the color index in all groups of children corresponded to the physiological norm, but its individual values in seven girls and two boys were below age limits, indicating hypochromic anemia, due to a simultaneous decrease in their number of red blood cells and hemoglobin content in the blood by 3 months of life.

The average erythrocyte sedimentation rate (ESR) was within the upper limit of the age norm, but its individual values varied over a wide range, especially in 6-month-old children of both sexes. In 24.0% of boys and 20.0% of girls of this age ESR exceeded the age norm, equal to an average of 4–10 mm/h. We assume that the cause is the increase in plasma levels of globulins in response to increased insemination of the child's body by antigens of different nature.

The average number of platelets in the peripheral blood of children by 3 months of life [Table 3] decreased and in the subsequent period of observation was established at a level that is close in value to the indicator of a healthy adult. In 3-month-old girls and 2.5-year-old boys, it was higher

($P < 0.05$). Individual indicators of the number of platelets were more marked in newborns and in girls aged 3 months, less variable in children over the age of 1 year.

Compared with newborns in all children by 3 months of age, the number of leukocytes decreased almost 3 times ($P < 0.05$) against 1 day of age, and in the subsequent period remained within the lower limit of the age norm [Table 4].

The content of eosinophils increased by an average of 2 times in all children, but it was more significant in boys.

In the observed period in children of both sexes, the number of rod and segmented neutrophils decreased and was higher from 3 months of age to a year [Table 4]. However, in 3-month-old children of both sexes the percentage of lymphocytes, on the contrary, significantly increased by an average 2.4 times. At the age of 6 months, the percentage of lymphocytes decreased by 3–4%, and in the next year and a half remained at a steady level.

The relative decrease of neutrophils and the increase of lymphocytes were more significant in the first 3 months of life. At the same time, the number of

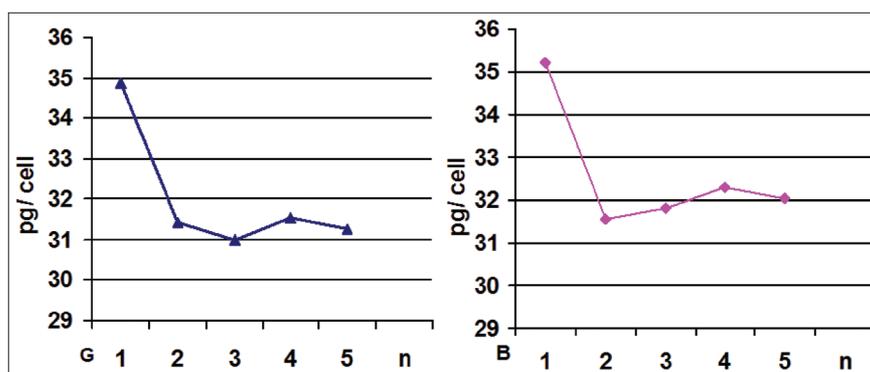


Figure 1: Dynamics of hemoglobin level in one erythrocyte: Left – girls, right – boys; n is the number of the survey

Table 4: Dynamics of quantitative indicators of the white blood system in children of the first 2 years of life, M±m

Indicator	Survey			
	I	II	III	IV
Girls				
Leukocytes, $\times 10^9/l$	6.30±0.24	6.72±0.20	6.20±0.18	6.50±0.19
Eosinophils, %	2.10±0.22	2.44±0.21	2.88±0.30	2.78±0.24
R/cored, %	2.94±0.23	3.02±0.22	3.24±0.19	3.18±0.21
S/cored, %	31.40±0.87	34.64±1.11	32.50±0.83	35.98±1.16
Lymphocytes, %	58.16±0.83	55.68±1.08	57.06±0.79	53.88±1.08
Monocytes, %	4.50±0.28	5.12±0.89	4.42±0.27	4.26±0.26
Boys				
Leukocytes, $\times 10^9/l$	6.21±0.19	6.97±0.20	6.77±0.22	6.84±0.24
Eosinophils, %	2.14±0.17	2.54±0.26	2.62±0.29	3.18±0.51
R/cored, %	3.18±0.19	3.00±0.21	3.44±0.24	3.30±0.28
S/cored, %	32.56±1.16	36.60±1.31	36.84±1.24	36.66±1.28
Lymphocytes, %	56.56±1.23	53.56±1.31	52.44±1.31	52.36±1.31
Monocytes, %	5.32±0.30	4.64±0.26	4.44±0.20	4.92±0.26

lymphocytes reached a maximum, and neutrophils, on the contrary, a minimum [Figure 2].

According to the scientific data, the physiological intersection of the curves of the percentage of neutrophils and lymphocytes in the blood revealed in children within the 1st month of life, indicates the balancing of the quantitative ratio of these groups of leukocytes, and is a consequence of the activation of the humoral immune mechanism. We believe the observed dynamics of increase in blood lymphocytes indicates the active beginning of the formation of humoral immunity in children, because by this moment maternal antibodies locating in the child's body begin to lose their activity, and the level of contact of the child with the environment increases.

The established gradual decrease of lymphocytes and increase of neutrophils in children of the 2nd year

of life corresponds to the general directions of the mechanism of formation of their immunity.

Compared with the 1st day of life in 3-month-old children, the percentage of monocytes significantly is decreased – in girls 1.5 times and in boys 1.2 times. In the subsequent period, it practically did not change and on average manifested within 4–5%. Age-related changes in the values of the lymphocytic index in the available literature have not been established, so the analysis of the dynamics of its individual and average calculated values was carried out [Figure 3]. In newborns, the lymphocytic index was the least marked and closes in value. It was 0.38 conv. units in boys and 0.37 in girls [Figure 3].

In the subsequent age period, the lymphocytic index increased significantly and in 1-year-old children, it was the highest ($P < 0.05$) in both groups. In the

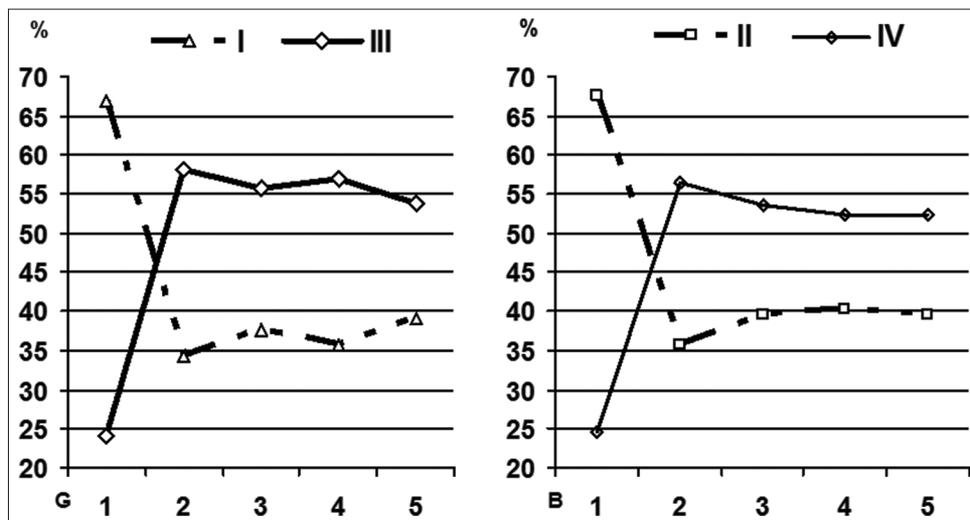


Figure 2: Dynamics of neutrophils (I, II) and lymphocytes (III, IV) in children during the first 2.5 years of life: G – girls – I, III, B – boys – II, IV; n – survey number

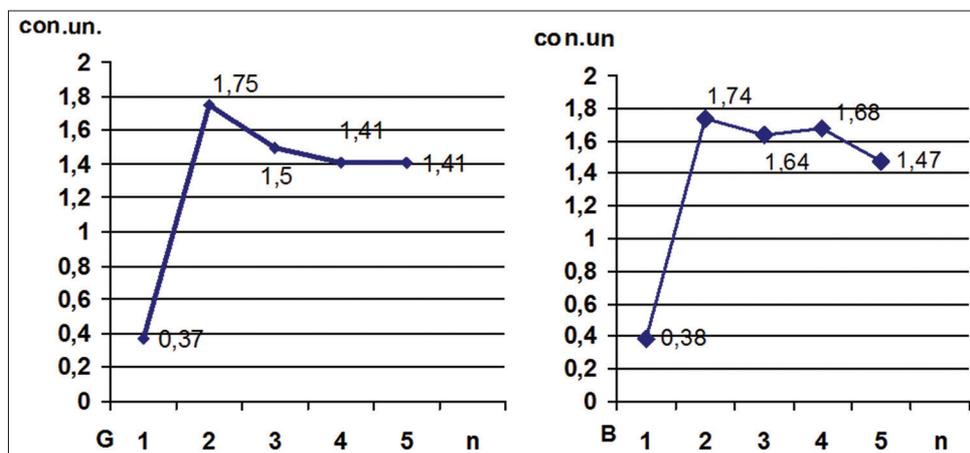


Figure 3: Dynamics of average values of the lymphocytic index in children from the 1st day of life to 2.5 years old: G – girls; B – boys; n – is the number of the survey

period from 1 year to 2.5 years old, the values of this index decreased, but in boys, they were constantly unreliably higher than in girls. The obtained number of values of the lymphocytic index during the next 2.5 years of life allowed to evaluate adequately the level of the functional impact of anthropogenic load on the growing organism.

CONCLUSION

Thus, as a result of the research of the system of white and red blood of children living in the territory with high anthropogenic load, the following main conclusions were formulated:

1. In newborns of the 1st day of life and in children from 3 months to 2.5 years of life, the number of red blood cells and platelets, the value of color index, the content of hemoglobin in the blood corresponded to the age norm, but in boys their values were higher ($P < 0.05$) and more variable than in girls, and the number of red blood cells – in 3 months and 2 years of age
2. Anemia was diagnosed in 24.0% of newborn girls and 18.0% of newborn boys but in only 6.0% of girls, the number of erythrocytes was below the norm; 3 months – 29.0% of girls and 30.0% of boys; and 6 months 22.0% of girls and 6% boys
3. In newborns it is revealed: Physiological leukocytosis – in 26.0% of girls and 16% of boys; pathological – in 16% of girls and 20% of boys; and neutrophil – 1–17% of rod and 45–80% of segmental neutrophils
4. The averaged values of the lymphocytic index in girls (0.38 ± 0.01) and boys (0.37 ± 0.01) indicated weak immune properties of blood
5. The most significant changes in the leukogram of all children were manifested during the first 2 years of life against their severity in newborns: At the age of 3 months the number of leukocytes decreased by almost 3 times ($P < 0.05$); the percentage of eosinophils and lymphocytes increased by

2 and 2.4 times, respectively, and neutrophils, on the contrary, gradually decreased, especially in the period from 3 months to a year old. The lymphocytic index increased from birth to 2 years; its increase was the most significant at the age of 3 months ($P < 0.05$).

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