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# Relationship of indicators of oxygen-containing blood elements with the duration of systematic triathlon training for amateur athletes

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***Purpose:*** *to investigate the nature of changes in the indicators of oxygen-containing blood elements in amateur athletes with different duration of systematic triathlon training.*

***Material & Methods:*** *peripheral blood taken from 96 physically active men examined was considered as an object of study. Indicators of oxygen-containing blood elements were determined using an automatic hematological analyzer (MicroCC-20 Plus, США).*

***Results:*** *amateur athletes showed a link between the duration of regular triathlon classes and red blood indicators, in particular, a significant increase in the content of red blood cells and hematocrit was shown in the sixth month of triathlon training for non-athletes. Revealed a significant decrease in the average red blood cell volume in the blood of amateur athletes for 12 months of triathlon training compared to untrained individuals.*

***Conclusion:*** *most pronounced changes in oxygen-containing blood parameters are observed in amateur athletes in the first 4–6 months and depend on the duration of systematic aerobic exercise. With the duration of systematic classes of 1 year, there is a stabilization of indicators, which may be associated with the achievement of the optimal level of functioning of the blood system. The decrease in oxygen-containing blood parameters during long periods of systematic training may be associated with inadequate intensity of training loads or intense competitive activity.*

**Keyword:** *amateur athletes, indicators of oxygen-containing blood elements, triathlon.*

## Introduction

Today, one of the most priority directions of state policy in Ukraine is the formation and preservation of public health [9; 18]. Evidence of a certain state attention to this problem is the approval of the National Doctrine of Development of Physical Culture and Sports [22], the State Targeted Social Program for the Development of Physical Culture and Sports for the Period up to 2020 [20] and others. The need to adopt these documents is due to a steady trend in recent years to a decrease in the level of public health, primarily in combination with other adverse factors, associated with a lack of physical activity. Despite the fact that the analysis of the level of coverage of mass sports in the world shows that, unfortunately, the Ukrainians are several times inferior to the leading countries of the world in this indicator [9], it is noteworthy that in modern Ukrainian society the interest of citizens in a healthy lifestyle is increasing [18].

World experience shows that systematic exercise in an optimal way provides for improving the state of human health, increasing its general working capacity and endurance, improving the functional state [24; 27; 34; 39; 41]. The study of the direction of motor activity of members of fitness clubs revealed that amateur athletes have a kind of fitness priorities, which are caused by real circumstances, opportunities, requirements, as well as individual tastes [2]. However, it should be noted that the beginning of recovery after a long break, or intensive training in amateur sports clubs, despite their absolute benefits, is a stress for the unprepared to perform intense physical activities of the human body. To prevent training for beginner athletes and individuals engaged in recreational physical culture, serious testing, and the task of medical control during sports and wellness training is an objective assessment of the functional state and functional capabilities of the body of this category of people. In addition, the effectiveness of classes in any form of physical exercise (from professional sports in medical physical culture) largely depends on the degree of fitness for physical activity and the adequacy of their dosage. It also needs to take into account the age, gender and individual characteristics of the body of those involved. Only the coordination of the functioning of organs and systems of different levels, their adaptation to the conditions of active life, makes it possible to talk about an adequate response of the body to physical exertion of different volume and intensity [1; 13].

At the moment, the question of the possibility and between the use of indicators of peripheral blood to assess the effect of physical activity on the human body in scientific literature remains open. The basic ideas about the diagnostic significance of hematological indicators in the physiology of sports activities are that in general they are within the normal range for healthy individuals, and their quantitative changes can be related to a number of specific and nonspecific factors, in particular, professional, as well as individual tolerance of various hematological indicators to a certain type of muscular activity [8].

It is known that the systematic implementation of physical exercises aimed at the development of endurance, lead to adaptive changes in many physiological systems of the body. According to modern concepts, the blood system is not only directly involved in the energy supply of intense muscular activity, but also occupies one of the leading places in the complex of physiological systems that form nonspecific adaptive reactions of the body and provide both the ability to perform these loads and the very existence of the organism [13]. This is due to its ability to quickly respond to various effects of changes in its morphological composition due to the presence of reflex and humoral pathways of blood formation, significant cellular reserves, as well as various functions of blood cells [3; 6; 17].

It should be noted that the scientific literature mainly presents data obtained as a result of studying the effect of physical exertion on blood parameters in individuals who have a long, systematic sports experience and specialize in a particular sport. It is known that the training of athletes is conducted according to a specific program aimed at achieving personal or team results. At the same time, a fairly large category of people involved in sports with recreational and recreational purposes. This kind of training has a slightly different training regime, and, consequently, a different nature of the body's reactions. In addition, data on the medical and biological assessment of the morphological or functional state of such a group of people in the literature are practically absent.

The study of the influence of sports training on various parts of the blood system today is relevant because, on the one hand, amateur athletes sometimes achieve such intensity of training as qualified athletes, and on the other, they do not recover enough after training and competitive loads, which can negatively affect on the functional state of their body as a whole [11].

**Purpose of the study:** to investigate the nature of changes in the indicators of oxygen-containing blood elements in amateur athletes with different lengths of systematic triathlon classes.

## Material and Methods of the research

The study involved 96 physically active men – amateur athletes, average age 32,0 (23,0–51,0) years old, who began to engage in triathlon and long-distance running on the highway. Of these, 40 beginners constituted a control group that had not previously been involved in specialized sports training, or in fitness and recreation activities, and 52 people who were divided into groups depending on the duration of training: Group I – amateur athletes who worked for 2 months; II, III and IV – 4, 6, 8 months, respectively; V, VI and VII – amateur athletes who were engaged in 1, 2 and 3 years respectively.

Amateur athletes who participated in the study were healthy, as evidenced by health certificates from medical institutions. In addition, all persons were informed about the content of the tests, measurement procedures and gave their consent to conduct testing and to use their personal data in scientific research. Examination of amateur athletes was carried out in compliance with the international principles of the Helsinki Declaration of the World Medical Association [23; 46], the UNESCO Universal Declaration on Bioethics and Human Rights (2005) [4] and in accordance with the Law of Ukraine "Fundamentals of Ukrainian Legislation on Healthcare" [7] on ethical norms and rules for conducting biomedical research involving human.

The study was conducted after a day of rest with a standardized food and drinking regime. Capillary blood sampling was carried out in the morning on an empty stomach before training. Determination of the quantitative and percentage content of erythrocyte levels in a sample (hemoglobin (HGB) erythrocytes (RBC), hematocrit (HCT), as well as determination of the mean cell volume (MCV), mean cell hemoglobin (MCH), mean hemoglobin concentration in the erythrocyte (MCHC)) was performed using an automatic hematology analyzer (MicroCC-20 Plus, USA).

Statistical processing of the research results was performed using generally accepted methods of variation statistics [21]. Used non-parametric research methods. Statistical significance adopted at $p<0,05$. For the analysis and interpretation of data, the application package GrafPad Prism 4.0 (GrafPad SowtwareInc., USA) was used.

## Results of the research

Analysis of the erythrocyte link of the hemogram in the obtained samples showed that in amateur athletes they are within the limits of the physiological norm [16]. The results are shown in the table.

When analyzing the data obtained, it was found that in group I amateur athletes there is a decrease in the content of HGB, MCHC and MCV by 3,3%, 4,5% and 4,2%, respectively, compared to the control group, with almost unchanged red blood cell content. With a decrease in hemoglobin there was a decrease in MCH of more than 11% compared with the control group. It should be noted that the difference between these indicators compared with the control group was not reliable ($p>0,05$).

**Indicators of the erythrocytic link of the hemogram of amateur athletes, depending on the duration of systematic training (x±SD)**

| Indicators | Control group | I (n=7) 2 months | II (n=8) 4 months | III (n=7) 6 months | IV (n=8) 8 months | V (n=11) 12 months | VI (n=8) 24 months | VII (n=3) 36 мic. |
|---|---|---|---|---|---|---|---|---|
| HGB, g $l^{-1}$ | 153,8±11,01 | 148,8±5,74 | 153,7±11,68 | 153,2±15,97 | 153,3±8,33 | 153,5±11,40 | 152,8±10,44 | 153,2±10,53 |
| RBC, $x10^{12}/l$ | 4,98±0,53 | 5,04±0,50 | 5,20±0,22 | 5,40±0,47* | 5,31±0,10 | 5,29±0,20 | 5,24±0,20 | 5,20±0,15 |
| HCT, % | 45,50±3,35 | 47,38±3,26 | 47,77±3,61 | 48,51±2,93* | 47,77±1,65 | 45,57±2,58 | 44,93±2,77 | 44,08±1,34 |
| MCV, fL | 91,79±6,36 | 87,90±5,73 | 90,17±1,86 | 90,14±3,50 | 89,97±1,55 | 87,01±4,74* | 88,46±4,31 | 87,72±2,61 |
| MCH, pg | 31,21±3,14 | 27,65±1,37 | 29,60±1,25 | 28,56±3,37 | 28,20±1,13 | 29,00±1,79 | 28,80±2,22 | 29,1±2,66 |
| MCHCg/l | 340,1±27,07 | 324,8±15,63 | 328,3±13,58 | 326,7±33,96 | 324,0±7,00 | 333,0±20,98 | 329,3±23,30 | 337,6±22,61 |

***Remark.*** ** – p≤0,05 compared to the control group.*

It is shown that in group II of amateur athletes there is a tendency to increase in the content of HGB relative to the corresponding indicator in group I, followed by its unchanged content in groups III, IV, V as compared with the control. In group VI, the average HGB content decreased in comparison with the V group. An increase in the RBC content in the II and III groups by almost 4.5% and more than 8% (p<0,05), respectively, relative to the control group, followed by a decrease in the IV, V, VI, and VII groups compared to group III was also detected. At the same time, the concentration of HCT grew in groups I, II and III by more than 4%, 5% and 6,6% (p<0,05) compared with the control, followed by a decrease in IV, V and VI and VII groups compared with group III.

It was shown that MCV decreases, starting from group III to group VII by almost 2% in Groups II, III and IV, respectively, by 5,2% (p<0,05), 3,6% and 4,4% in V, VI and VII groups, respectively, for control. The same trend is observed in changes in the MCH and MCHC indicators, but there was no significant difference between these indicators.

## Conclusions / Discussion

In analyzing our data, a reduction in hemoglobin in the blood during the second month of occupation (group II) was shown among amateur athletes, with the level of erythrocytes almost unchanged. A decrease in the hemoglobin content on the background of relatively unchanged values of the mean values of erythrocytes in the blood may be due to the presence of interconnection of the average hemoglobin content in erythrocytes with hemoglobin in the blood, which most likely indicates a deficiency in the body of plastic materials (protein and / or iron). Iron deficiency can be caused by loss of it as a result of sweating, while the amount of exogenous iron is inadequate to the growing needs of the body. The presence of the relationship of the average hemoglobin content in erythrocytes with the concentration of erythrocytes probably indicates an excess of the rate of formation of erythrocytes over the rate of hemoglobin stimulation.

It is known that the correct training system contributes to the gradual growth of training, but in order to have a training effect, the training load must be sufficiently long. This concerns both individual physical exercises in the training session, the training session itself, and the training cycle as a whole. The intensity and duration of training loads and their relationship with the training effect depends primarily on the orientation of the sports training. It is proved that the total threshold duration of physical activity, in which the training effect is manifested, namely, there are signs of an increase in the level of training, is 3–4 months [10].

An increase in the mean values of hemoglobin, erythrocyte hematocrit and a decrease in MSV, MCH and MCHC, beginning with group II (4 months of classes), and a significant increase in group III (6 months of classes) compared to control indicates a gradual increase in fitness. Amateur athletes probably need more time to achieve a training effect.

It is known that important factors for maximum aerobic capacity and physical performance are blood volume, hemoglobin content and mass of red blood cells. During muscular activity, especially when performing exercises of primarily aerobic nature, the body's need for oxygen increases dramatically, which is satisfied by an increase in blood flow velocity, as well as a gradual increase in the amount of hemoglobin in the blood due to a change in the total blood mass [15; 36]. Thus, endurance training leads to a significant increase in circulating blood volume, while the higher this indicator, the greater the blood flow rate and the longer the red blood cell is in the microcirculation, the smaller the blood supply to the internal organs and the working muscles, which ultimately leads to an increase in the buffer capacity blood [6]. An increase in hemoglobin concentration in the blood can legitimately be associated with a true increase in the volume of circulating plasma and a subsequent increase in the hemoglobin content in erythrocytes, which constitutes a sequential chain of adaptive shifts that occur under the influence of aerobic exercise [3; 12; 14]. Increased hematocrit is associated with an increase in hemoglobin concentration caused by physical exertion, due to the transfer of a portion of plasma from the vascular bed to the extracellular space [30]. The increase in hematocrit concentration is aimed at increasing the oxygen capacity of the blood to ensure the energy needs of the body of athletes. However, a significant increase in oxygen capacity leads to an increase in blood viscosity, an increase in blood flow resistance and a further voltage of other blood circulation subsystems, and may be accompanied by activation of cardiac activity. [30].

J. A. Pierez G. et al. [38] showed that in the group of healthy women over 55 years of age, after a four-month program of aerobic physical training, a significant increase in hemoglobin, hematocrit, MSV, MCH and maximum oxygen consumption was observed. However, there were no significant changes in the content of red blood cells and MCHC.

Mayr A. et al. [37] when comparing changes in the blood indices of skaters and non-athletes, no significant difference was found between these groups. It was shown that in the group of sportsmen MSV was large, the MCH also increased, but not significantly in relation to the group of people who did not play sports. At the same time, there was a decrease in MCHC in the blood in the group of athletes compared with the control group. An increase in MSV and a decrease in MCHC in the blood can probably be the result of changes in the erythrocyte membrane properties caused by acidosis and increased osmolarity during exercise.

It should be noted that with the growth of the intensity of endurance training in the tissues of the body, the oxygen demand increases, thereby increasing the load on the system of oxygen supply to the body. In stressed endurance exercises, hemodilution occurs, which results in a reduction in hemoglobin, hematocrit and deficiency, or a disruption of the functioning of the erythrocytes due to their structural damage, despite an increase in the total mass of hemoglobin [32; 43]. The decrease in hemoglobin in the blood of athletes, despite the increase in the total mass of hemoglobin in athletes [26], is called sports anemia [35]. Such a phenomenon is considered to be a normal physiological response to intense loads [29; 37]. There were several hypotheses [40] that explain sports anemia in athletes who develop endurance: increased iron loss or reduced iron absorption [33; 45], a decrease in erythropoiesis [31] and an increase in plasma volume [31]. These processes in the body of a person involved in sports, due to the presence of one of the possible ways of the reaction of the blood system to training loads. The data we obtained on a slight decrease in the content of hemoglobin and erythrocytes in amateur athletes after long systematic studies confirm the above literature data.

It should be noted that in the scientific literature data on changes in the indices of the red blood of individuals for a long time train endurance, contradictory and relate in most cases to professional athletes. So, F. Sanchis-Gomar et al. [42] showed that an increase in physical activity may justify a significant decrease in the content of red blood cells and hemoglobin. On the other hand, Schumacher et al. [44] reported that training did not cause changes in hemoglobin in the blood of athletes compared with untrained individuals. However, in a study by Yu. A. Petrov [19], it has been shown that athletes, who endurance training compared with those not involved in sports, reduced the number of red blood cells and hemoglobin. Bojadjiev and Taralov [28] have shown that chronic (that is, more than one year) high intensity exercise reduces hemoglobin content in a mature male population. In the works of other authors it was shown [25] that the values of hemogolobin values decreased in athletes engaged in cycling in the competitive period compared with the values of this indicator before the start of training and / or competitions. Different focus of the results may be related to conducting research at different stages of the training process and gender-age differences of the contingent under study.

The results of this study show that the most pronounced changes in blood parameters are observed in amateur athletes in the first 4–6 months and depend on the duration of systematic aerobic exercises. With the duration of systematic classes of one year, the indicators stabilize, which may be due to the achievement of the optimal level of functioning of the blood system. Reduced blood counts during long periods of systematic training may be associated with inadequate intensity of training loads or intense competitive activity.

**The prospect of further research** may lie in the study of the individual characteristics of changes in peripheral blood indices of amateur athletes, taking into account the increase in fitness in the dynamics of systematic triathlon classes.

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