THE INFLUENCE OF TRAINING YEAR MACROCYCLE ON THE STATE OF ERYTHRON PERIPHERAL COMPONENT IN YOUNG TAEKWONDOKAS

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Introduction. It is known that the intensity and direction of sports training affect changes in the blood composition, which reflects the functional status of the whole organism [1, 4]. The integrative function of blood includes oxygen transport, protective, energy supplying and regulatory ones [3, 7, 8].

The purpose of the study was to determine the parameters of the erythron peripheral component in young taekwondokas in a year training macrocycle**.**

Materials and methods. 30 athletes aged 15-16, having I-II degrees and training experience of not less than 4 years, were involved in the study. The control group consisted of 16 boys of the I and II health groups, schoolchildren training in compliance with the basic program (3 physical education classes per week). During the training process taekwondokas participate in sports competitions simultaneously with training. Planning of the training process involves splitting year cycles into three phases: pre-season preparatory, competition (season) and transition (off-season) [6].

Erythron peripheral component indicators were determined in the Center of Advanced medical technologies using an automatic hematology analyzer Cell-Dyn 3700.

Results and discussion.

Table 1 shows the indicators of the erythron peripheral component in young taekwondokas in the year training macrocycle**.**

According to Table 1, the level of red blood cells of young taekwondokas increased by 14.20% ($p<0.001$) during the pre-season preparatory phase in comparison to the control group. It is to be noted that simultaneously with the increase of red blood cells and under the influence of physical loads the absolute and relative number of reticulocytes increased insignificant by 12.50% and 8% respectively, as well as along with the increase of the number of red blood cells their distribution width increased by 5% ($p<0.05$) and the mean corpuscular volume indicators increased insignificantly.

During the **competition** phase the red blood cell concentration of young taekwondokas increased by 16.31% ($p<0.001$) in comparison to the control one; absolute and relative number of reticulocytes increased by 25% ($p<0.01$) and 24.36% respectively ($p<0.001$) in comparison to the control one, the red

blood cell concentration increased slightly, while absolute and relative number of reticulocytes exceeded the indices of the pre-season preparatory phase by 11.11% (insignificantly) and 15.47 ($p<0.01$) respectively. During the competition phase the red blood cell distribution width and their mean corpuscular volume hardly changed as compared to the pre-season preparatory phase; the red blood cell distribution width increased by 6% ($p<0.05$) in comparison to the control indices. These data indicate a slight macrocytosis that plays a compensatory-adaptive role in the conditions of increased physical load.

In the **transition** (off-season) phase the red blood cell concentration and absolute and relative number of reticulocytes decreased insignificantly by 6.9%, 20% and 8% respectively as compared to the previous period; however in comparison to the control indices the red blood cell concentration increased significantly by 8.30% ($p<0.05$), and the absolute and relative number of reticulocytes reached the control values. In the same period the distribution width of red blood cells and their mean corpuscular volume decreased insignificantly compared to the competition phase by 4% and 2% and normalized as compared with the control values.

During physical activity in the pre-season preparatory and competition phases the oxygen demand of tissues and organism as a whole increases. A similar pattern was observed by other researchers. L.V. Vorgova, Yu.M. Zakharov (1990) believe that the increase in the general circulation of red blood cells (GCRBC) is due to the development of hypoxia during intense exercise that in its turn stimulates the synthesis of erythropoietin in the kidneys [3]. Besides erythropoietin, erythropoiesis is also stimulated by decay products.

The increase of reticulocytes was influenced by the increased tissue oxygen demand. It can also be assumed that physical loads applied caused an increase in the intensity of erythropoiesis, possibly due to the hormone called erythropoietin.

Sports specialization (taekwondo) and physical load characteristics associated with it would cause various adaptive changes in the erythron peripheral component.

Hemoglobin concentration indicates that hemoglobin is a respiratory pigment of blood and is found in red blood cells and is involved in the oxygen and carbon dioxide transport. **Hematocrit** is the ratio of the volume of formed elements to blood plasma. Hematocrit is commonly thought to reflect the ratio of the volume of red blood cells to blood plasma as red blood cells mainly constitute the volume of formed elements of blood. **MCH (Mean Corpuscular Hemoglobin)** is the average hemoglobin amount per red blood cell - the ratio “hemoglobin/number of red blood cells”. **MCHC** is the average hemoglobin concentration in a red blood cell that reflects the degree of hemoglobin saturation in a red blood cell.

During the pre-season preparatory phase the hemoglobin concentration was significantly higher than the control values by 8.08% ($p<0.001$) (Table 1). The index of blood hematocrit of young taekwondokas also changed slightly by 3.31% ($p>0.05$) as compared to the control values.

In the pre-season preparatory phase the average hemoglobin amount per red blood cell of young taekwondokas did not change compared to the control indices (insignificantly). It clearly indicates that the ratio of hemoglobin to the amount of red blood cells has not changed, although, as evidenced by the data in Table 1, the number of red blood cells and the change in the hemoglobin concentration of athletes was higher by 16.14% ($p<0.001$) and 8.08% ($p<0.01$) respectively. The average hemoglobin concentration in a red blood cell increased by 4.21% ($p<0.01$) as compared with the control indices for young taekwondokas. These data confirm that the degree of hemoglobin saturation in a red blood cell of young taekwondokas in the pre-season preparatory phase is higher than that in the athletes of the control group.

In the **competition** phase the hemoglobin concentration in the blood of young taekwondokas was slightly increased compared to the pre-season preparatory phase, and in comparison with the control index of the hemoglobin concentration in the competition phase exceeded it by 8.24% ($p<0.001$). The hematocrit index in the same period increased by 6.15% ($p<0.05$) compared with the control data and slightly exceeded the hematocrit concentration in the previous period (3%, $p>0.05$). The average hemoglobin amount per red blood cell in the blood of young taekwondokas increased by 6.20% ($p<0.05$) compared with the control data and slightly exceeded the corresponding indicators in comparison with the pre-season preparatory phase. The average concentration of hemoglobin in a red blood cell exceeded the control data by 7.23% ($p<0.05$) and the indices of the pre-season preparatory phase by 6% ($p<0.01$).

Thus, in response to increased load during the competition phase the hemoglobin and hematocrit concentration, the average hemoglobin amount per red blood cell and the degree of hemoglobin saturation in a red blood cell increase significantly in the blood of young taekwondokas.

During the **transition** (off-season) phase the hemoglobin concentration in the blood of young taekwondokas decreased by 3.20% ($p<0.01$) as compared with the competition phase and exceeded the control values by 5% ($p<0.01$). The hematocrit level dropped by 6.9% ($p>0.05$) compared with the competition phase, it was also insignificantly reduced in the blood of young taekwondokas compared to the control values - by 1.18% ($p>0.05$). In the transition (off-season) phase the average hemoglobin amount per red blood cell decreased by 4.33% ($p<0.01$) as compared with the previous period, and normalized in comparison with the control data, i.e. the degree of hemoglobin saturation in a red blood cell significantly decreased in the blood of young taekwondokas in the transition (off-season) phase as compared with the competition phase. The average hemoglobin amount per red blood cell exceeded insignificantly by 4.6% ($p>0.05$), while it normalized as compared with the control values.

It is well known that hemoglobin carries out the oxygen transport function in a red blood cell by means of iron that binds oxygen. In case of physical load the body's oxygen demand increases and in order to meet its increased oxygen demand the blood velocity should increase along with the hemoglobin concentration.

Similar results were obtained by A.G. Dembo, E.V. Zemtsovsky (1989), who showed that during the "endurance training" the hemoglobin value changed to 140 g/l, and during "muscle strength" training - to 146 g/l [2].

Table 1. *Performance of the erythron peripheral component in young taekwondokas in the year training macrocycle (M±m)*

Indicators **Series**	**Red blood cell count x10^{12}/l**	**Reticulocyte count x10^{12}/l**	**Reticulocytes percentage %**	**Average red blood cell volume fL**	**Red blood cell distribution width %, CV**	**Hemoglobin concentration, g/l**	**Hematocrit, %**	**Average hemoglobin concentration, (MCHC), g/l**	**A h c a e (**
I control, n=12	4.23±0.09	0.040±0.001	0.78±0.03	85.17±0.51	14.97±0.22	137.42±0.46	0.423±0.01	338.75±1.02	0
II pre-season preparatory phase, n=12 **P_I-P_{II}**	4.83±0.12 <0.001	0.045±0.003 >0.05	0.84±0.04 >0.05	85.78±0.42 >0.05	15.92±0.23 <0.05	148.52±0.37 <0.001	0.437±0.01 >0.05	353.00±2.12 <0.01	0 >
III competition phase, n=12 **P_I-P_{III}** **P_{II}-P_{III}**	4.92±0.05 <0.001 >0.05	0.050±0.002 <0.01 >0.05	0.97±0.03 <0.001 <0.01	87.07±0.52 >0.05 >0.05	15.92±0.34 <0.05 >0.05	148.75±0.33 <0.001 >0.05	0.449±0.02 <0.05 >0.05	358.70±2.14 <0.05 >0.05	0 < <
IV transition (off-season) phase, n=12 **P_{III}-P_{IV}** **P_I-P_{IV}**	4.58±0.08 >0.05 <0.05	0.040±0.005 >0.05 >0.05	0.80±0.06 >0.05 >0.05	85.60±0.44 >0.05 >0.05	15.30±0.43 >0.05 >0.05	144.00±0.48 <0.01 <0.01	0.418±0.04 >0.05 >0.05	340.30±2.11 <0.001 >0.05	0 > >

Note: the significance of the differences from the corresponding control values calculated using the Student's t-test.

The increase of the hemoglobin count in red blood cells can be explained by an increase in the hemoglobin synthesis by erythroid bone marrow cells of taekwondokas which significantly increased the hemoglobin concentration.

So, the analysis of the data obtained suggests quantitative changes, and above all, an increase in the number of red blood cells and the hemoglobin concentration in the blood of young taekwondokas under increased load. The physiological mechanism of this phenomenon is executed by exit of red blood cells from blood pool the function of which is performed by the spleen. A qualitative shift is also traced in red

blood of young taekwondokas during physical exercise. It is manifested in a significant increase of reticulocytes in the peripheral blood. The activation of the peripheral part of the erythron that we observed is a natural consequence of the amplification of the erythropoietic function. The adaptive-compensatory response of red blood during strenuous muscular activity also manifests itself in the increased rate of return of O_2 to tissues by increasing the content of 2,3-diphosphoglycerate in red blood cells and at the expense of young forms of red blood cells - reticulocytes that give O_2 easier.

Under an increased physical load the organism of an athlete experiences some hypoxia. A. Erslev et al. (1985) showed that tissue hypoxia leads to increased production of erythropoietin in a few hours which is effective on the bone marrow for 4-5 days, contributing to production of reticulocytes and red blood cells [9]. These authors believe that the compensatory erythrocytic mechanisms maintain oxygen pressure in the capillaries and delivery of O_2 needed for cells and tissues. Tissue hypoxia is fully compensated with the restoration of hemoglobin concentration to normal levels. Tissue hypoxia includes other compensatory mechanisms as well. These include bioenergetic processes of cardiorespiratory, hematological and metabolic origins [5].

Increased physical load provokes adaptive changes in an athlete's body, accompanied by the increase in hemoglobin concentration per unit of blood volume and red blood cells. This is an indicator of iron deficiency in the body and the activation of hematopoiesis. Interconnection between hematocrit and hemoglobin is associated with the level of erythropoietin in plasma that accelerates the synthesis of hemoglobin in all erythroid cells including reticulocytes.

Conclusion

Thus, a significant increase was observed in the red blood cell and reticulocyte count and hemoglobin concentration in whole blood, average concentration of hemoglobin in red blood cell, hemoglobin saturation in a red blood cell compared to the control data of young taekwondokas during load increase from the pre-season preparatory to the competition phase of the training microcycle, while from the pre-season preparatory to the competition phases the number of red blood cells and hemoglobin concentration did not increase. Such an activation of the erythron peripheral component indicates the activation of erythropoiesis and oxygen transport to tissues when they are especially needed, i.e. the formation of adaptive organism's reactions to physical load during the training macrocycle.

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