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Functional Changes in the Body of Young Men Who Started Regular Physical Activity

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Abstract

Under observation were taken 39 young men studying at the university, throughout their lives, who had low muscle activity and started systematic volleyball training 3 times during the week. The control group included 35 young men studying at the university, who for at least the last 2 years systematically participated in volleyball training at least 3 times a week. During the study, traditional biochemical, thematic, and statistical methods for obtaining scientific information were used. After six months of regular physical training in the blood of young men, there was a normalization of the content of products synthesized from arachidonic acid, a decrease in the content of cholesterol molecules, and acyl hydroperoxides in the erythrocyte membranes with an increase in the number of phospholipids. By the end of the observation in the blood of young men who started volleyball training, there was an increase in the number of discoid erythrocytes and a decrease in the content of erythrocytes with a changed shape. It can be assumed that with an increase in the level of muscle activity due to systematic volleyball training, previously physically untrained young men develop optimization of the surface characteristics of erythrocytes, which can facilitate microcirculation and metabolism throughout the body.

Keywords: Volleyball, Muscle activity, Erythrocytes, Microcirculation

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Introduction

In modern society, males often have low physical activity (Bespalov *et al*., 2018a; Karpov *et al*., 2020a). This situation leads to the accelerated development of a large number of different variants of hereditary predisposition to many types of pathology (Amelina & Medvedev, 2009; Medvedev & Savchenko, 2010; Algahtani, 2020; Zavalishina *et al*., 2021a). This pattern has been confirmed in various categories of the population and different conditions of existence (Skoryatina & Zavalishina, 2017; Mikhaylova *et al*., 2021c). In addition, in the case of low physical fitness, already at a young age, the overall functional reserves of all organs decrease and various dysfunctions begin to form in them (Bespalov *et al*., 2018c; Santa-Rosa *et al*., 2018; Karpov *et al*., 2020b). Long-term preservation of low muscle activity contributes to the transition of pre-pathological processes into overt pathology with the development of several complications (Makhov & Medvedev, 2018b).

Almost always, low muscle activity negatively affects many blood parameters (Medvedev *et al*., 2009; Tkacheva & Medvedev, 2020b). Under conditions of hypodynamia, a large number of very biologically unfavorable changes occur in the body (Kotova *et al*., 2017). A low level of motor activity already in youth leads to a deterioration in the microrheological properties of blood cells, causing hypoxia in the body (Glagoleva & Medvedev, 2020; Karpov *et al*., 2021a). The oxygen deficiency formed in these conditions in the body weakens the metabolic processes in all its tissues and organs (Bespalov *et al*., 2018b; Makhov & Medvedev, 2018c). This situation leads to the appearance and gradual intensification of vasospasm and weakens

the reactivity of all body cells (Medvedev, 2018c; Mal *et al*., 2020).

Under conditions of weak muscle activity in the body, conditions have often formed that lead to the gradual development of an increase in blood pressure with the risk of arterial hypertension in these people (Medvedev, 2018a; Skoryatina & Medvedev, 2019). Under these conditions, the rheological parameters of the most numerous group of blood cells, erythrocytes, worsen. Such disorders are observed already in young people, contributing to the development of any persistent dysfunctions in them (Mikhaylova *et al*., 2021b; Zavalishina *et al*., 2021b). Quite often, low physical activity is observed among university students due to their high academic load and the need for a long stay in a sitting position, negatively affecting their health. Due to the high frequency of low physical activity among university students and the high severity of negative consequences for their bodies, it remains very relevant to search for approaches to get them out of this state while simultaneously normalizing their blood parameters important for microcirculation (Adiga, 2019).

The purpose of the study was to evaluate the dynamics of several blood parameters significant for microcirculation in physically untrained young men who started systematic volleyball training.

Materials and Methods

To carry out this work, the authors formed a study group consisting of 39 young men (their average age is 19.5±0.8 years) studying at the university. All those examined earlier during their lives did not experience significant regular muscle loads on the body. All examined from this group started regular volleyball training at least 3 times a week. The duration of one training session was not shorter than one hour. The control group consisted of 35 healthy young men (their average age was 19.8±1.0 years) studying at the university. The boys of the control group regularly participated in volleyball training sessions for at least 1 hour each at least 3 times a week for at least 3 years at least 3 times a week.

The young men of both groups taken into the study were examined with an assessment of the level of thromboxane B and 6-keto-prostaglandin $F_{1\alpha}$ in their plasma using a standard enzyme immunoassay method, using a standard set of reagents produced by EnzoLifescience (USA).

The erythrocytes were washed and resuspended. Using the enzymatic colorimetric method of research with a kit from Vital Diagnosticum (Russia), the level of cholesterol was determined in the membrane structures of erythrocytes. According to the level of phosphorus contained in erythrocytes in the examined young men, the quantitative content of total phospholipids in them was determined.

The intensity of intraerythrocyte processes of lipid peroxidation was detected by assessing the concentration of malonicdialdehyde in erythrocytes and the number of acyl hydroperoxides after their washing and resuspension using standard methods.

The levels of discoid-shaped erythrocytes and erythrocytes with an altered shape in the blood were detected using a light phase-contrast microscope according to the standard method (Medvedev *et al*., 2009).

The study group was examined, according to the stated methods, initially, after three months and six months of systematic volleyball training. The boys in the control group were examined once.

Mathematical processing of the indicators obtained during the study of all young men taken under observation was carried out using Student's t-test.

Results and Discussion

In all young men in the study group, when taken under observation, a physiologically unfavorable change in the number of metabolites of arachidonic acid was found. The content of thromboxane B_2 in their blood was higher than its level in the control group by 27.0% ($p<0.01$). The amount of 6-keto-prostaglandin F1α in the blood of the representatives of the study group was 13.8% ($p<0.05$) lower than that of the boys in the control group **(Table 1)**.

In the erythrocyte membranes of the young men in the study group, the content of cholesterol molecules at the beginning of the observation was higher than the control level by 17.0%. The content of phospholipid molecules in the erythrocytes of the study group at the first examination was lower than the control level by 16.9% ($p<0.05$). In young men with low muscle activity at the beginning of the study, the content of acyl hydroperoxides and the amount of malondialdehyde in their blood erythrocytes were higher than in the control group, respectively, by 39.0% ($p<0.01$) and 40.3% ($p<0.01$).

Table 1. The values of the estimated indicators in the observed boys

Indicators for the surveyed	Enrolled in volleyball, n=39, M±m			Control group, n=35, M±m
	Before starting training	3 months of training	6 months of training	
The amount of thromboxane B_2, pg/ml	184.3±0.73 $p<0.01$	168.1±0.67 $p<0.05$ $p_1<0.05$	145.2±0.52 $p_1<0.01$	145.1±0.81

Amount of 6-keto-prostaglandin $F_{1\alpha}$, pg/ml	87.0±0.36 p<0.05	92.6±0.32 p<0.05	99.6±0.27 p_1<0.05	99.0±0.45
Cholesterol content in erythrocytes, μmol/10^{12} erythrocytes	1.03±0.019 p<0.05	0.95±0.015 p<0.05	0.88±0.011 p_1<0.05	0.88±0.010
The content of total phospholipids in erythrocytes, μmol/10^{12}erythrocytes	0.65±0.016 p<0.05	0.70±0.018 p<0.05	0.76±0.010 p_1<0.05	0.76±0.012
Erythrocytes having a discoid shape, %	78.1±0.18 p<0.05	83.8±0.22 p<0.05	89.4±0.32 p_1<0.05	89.7±0.16
Erythrocytes with reversibly changed shape, %	12.3±0.16 p<0.01	10.9±0.15 p<0.05 p_1<0.05	9.8±0.09 p_1<0.01	9.3±0.12
Erythrocytes with an irreversibly changed shape, %	9.6±0.14 p<0.01	5.4±0.07 p<0.01 p_1<0.01	0.8±0.06 p_1<0.01	1.0±0.10
The amount of acyl hydroperoxides in erythrocytes, $D_{233}/10^{12}$erythrocytes	3.92±0.015 p<0.01	3.26±0.020 p<0.01 p_1<0.01	2.88±0.024 p_1<0.01	2.82±0.017
The amount of malondialdehyde in erythrocytes, nmol/10^{12} erythrocytes	1.81±0.011 p<0.01	1.54±0.012 p<0.05 p_1<0.05	1.30±0.017 p_1<0.01	1.29±0.025

Note: p – the significance of differences in indicators in the boys of the study group and the control group; p_1 – the significance of changes in the levels of indicators of the study group during the observation process.

When taken under observation in the blood of young men who had previously avoided significant physical exertion, the content of erythrocytes having a discoid shape turned out to be 14.8% less than in the control **(Table 1)**. The levels of erythrocytes, which had reversible and irreversible disorders of their shape, in physically inactive young men in the outcome were higher by 32.2% and 9.6 times, respectively than in the control (p<0.01).

As a result of regular volleyball training in the blood of the representatives of the study group, a gradual decrease in the severity of the imbalance of arachidonic acid metabolism products was observed. After six months of training in the young men of this group, the amount of thromboxane B_2 in the blood decreased by 26.9% (p<0.01). At the same time, during the observation period, the content of 6-keto-prostaglandin $F_{1\alpha}$ in the blood of the young men in the study group increased by 14.5% compared to the first examination (p<0.05).

In the membrane structures of erythrocytes in the boys of the study group under the conditions of systematic six-month volleyball training, a decrease in cholesterol content by 17.0% developed. At the same time, their erythrocytes showed an increase in the content of total phospholipids by 16.9% (p<0.05). These changes in young men who began regular volleyball training occurred simultaneously with a decrease in the content of acyl hydroperoxides and malondialdehyde in the structures of erythrocytes. After six months of observation, the number of erythrocytes in the young men in the study group decreased by 36.1% (p<0.01) and 39.2% (p<0.01), respectively.

Under the conditions of systematic volleyball loads in the blood of the young men in the study group, there was an increase in the content of erythrocytes having a discoid shape by 14.5% compared to the level before training (p<0.05) **(Table 1)**. The number of erythrocytes with a reversibly changed shape and the content of erythrocytes with an irreversibly changed structure in the blood of those who started volleyball training decreased during the study period, respectively, by 25.5% (p<0.01) and 12.0 times (p<0.01).

Long-term stable maintenance of homeostasis parameters in the human body can be achieved only against the background of its constant dosed motor activity (Boldov *et al*., 2018c; Ansari *et al.*, 2019; Agronina *et al*., 2020). In the case of a long period of low muscle activity, regardless of its cause, biologically unfavorable dysfunctions occur in the body, which is prepathological conditions in various organs (Medvedev *et al*., 2010; Zavalishina *et al*., 2021c). Of serious importance for the whole organism are the negative effects of weak motor activity concerning the characteristics of blood and, first of all, its rheological properties (Paiva *et al*., 2016; Tkacheva & Medvedev, 2020a).

It has been noted that prolonged low muscle activity leads to the development of negative changes in the microrheological properties of all blood cells, including their most numerous group, erythrocytes (Medvedev, 2021; Thalla *et al*., 2021). Excessive formation of lipid peroxidation products in the structures of erythrocytes during hypodynamia leads to negative changes in erythrocyte membranes and weakens their function. This is further exacerbated by the development of an imbalance in the molecules of various fats in the composition of erythrocyte

membranes under conditions of low motor activity, which additionally disrupts the vital processes in these blood cells (Makhov & Medvedev, 2018a; Karpov *et al*., 2021b). The upcoming quantitative changes in the content of phospholipids and cholesterol molecules in the composition of erythrocyte membranes create an extremely biologically unfavorable situation for them (Tkacheva & Medvedev, 2020c). This negatively affects the permeability and stability of erythrocyte membranes and impairs the functioning of proteins located in them (Glamazdin *et al*., 2021; Medvedev *et al*., 2021b). The current situation inhibits the implementation of all biological processes in the membranes, the main part of the erythrocytes in the blood, which negatively affects the processes of gas exchange in the lungs and tissues, and weakens the vital processes of the whole organism (Makhov & Medvedev, 2018d; Oshurkova & Medvedev, 2018a).

An increase in the level of erythrocytes with a changed shape always leads to an increase in their irreversible aggregation, negatively affecting the course of microcirculation (Makhov & Medvedev, 2021; Medvedev *et al*., 2021a) **(Figure 1)**.

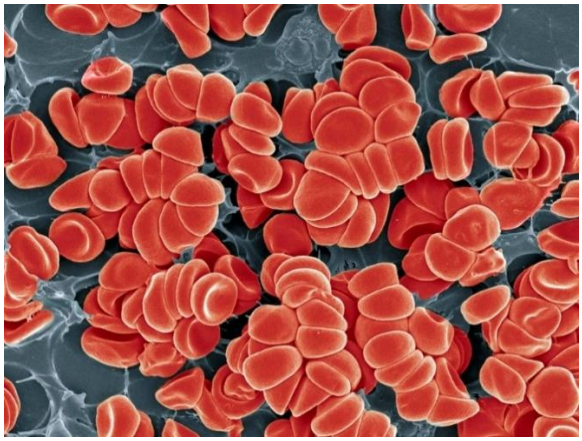

Figure 1. Aggregated erythrocytes (https://www.verywellhealth.com/thmb/_MCKIdD5QBX0c4BUqcbr8_F9058=/1998x1501/filters:fill(87E3EF,1)/GettyImages-85757728-59c2ac75054ad9001148fff8.jpg)

This is exacerbated by changes in the spectrum of biologically active substances synthesized in the body of physically inactive people. When maintaining low physical activity for a long time, even in young men, the production of substances that can affect blood cells is disrupted (Medvedev, 2018d; Oshurkova & Medvedev, 2018b). In conditions of physical inactivity in the blood, there is an increase in substances with a clear proaggregant activity (Mikhaylova *et al*., 2021a). The upcoming increase in the formation of thromboxane and inhibition of the production of prostacyclin lead to the creation of additional conditions for irreversible erythrocyte hyper aggregation (Makhov & Medvedev, 2019). Increased aggregation of erythrocytes in the blood worsens the flow of microcirculation in capillaries and creates phenomena of increasing hypoxia in various tissues.

For the general improvement of the whole organism in the work done, the young men who had initially poor physical fitness were provided with systematic volleyball training **(Figure 2)**.

Figure 2. The process of volleyball training (https://old.mofv.ru/wp-content/uploads/2016/10/DSC_5867-1.jpg)

Against their background, these young men experienced a decrease in the level of lipid peroxidation products in the membranes of their erythrocytes, which contributed to the restoration of the structure of their membranes. Positive changes in erythrocytes in those who started volleyball training deepened due to the optimization of the lipid composition of their membranes. This led to an improvement in the state of the surface characteristics of the bulk of erythrocytes freely circulating in the blood (Medvedev, 2018b). The optimization of the content of phospholipids and the amount of cholesterol in the peripheral blood erythrocytes of young men achieved during volleyball training can be considered biologically very beneficial. The changes in the lipid composition achieved in the examined patients ensured the normalization of the viscosity, permeability, and stability of their membranes in erythrocytes, contributing to the optimization of the functioning of these cells.

In the case of systemic muscle training in the blood of initially physically untrained young men, a significant decrease in the content of erythrocytes with a disturbing shape and an increase in the number of erythrocytes with an optimal discoid shape for microcirculation were noted **(Figure 3)**.

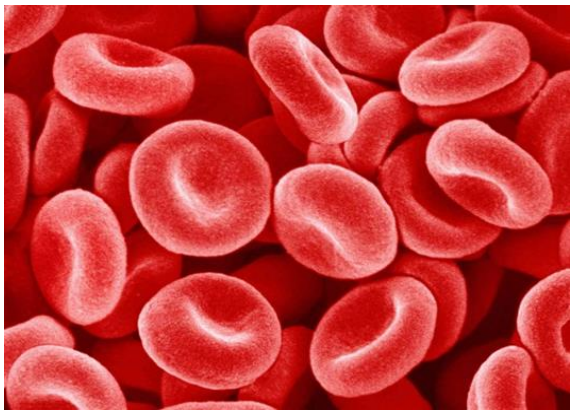

Figure 3. Normal red blood cells (https://www.verywellhealth.com/thmb/o-AXQiUTGf12BzL7umtUrFbHM70=/1999x1500/filters:no_upscale():max_bytes(150000):strip_icc()/GettyImages-636211536-58d3d02e5f9b5846831a4b82.jpg)

It becomes clear that a decrease in the number of erythrocytes with a changed shape in the blood of young men who have started volleyball training reduces the number of cases of irreversible intravascular erythrocyte aggregation, thereby improving the flow of blood supply to all organs (Medvedev, 2018e; Medvedev *et al*., 2021c).

Conclusion

A low level of physical development is accompanied by an increase in the blood, even in adolescence, in the number of red blood cells, which have changed shape to varying degrees. Such changes in the shape of erythrocytes always worsen the processes of blood circulation, especially in the capillaries, which negatively affects all types of metabolism. It has been established that in young men studying at the university, as a result of the start of regular volleyball classes to eliminate their low muscle activity, the processes of lipid peroxidation were inhibited in the structures of peripheral blood erythrocytes. Those who started regular volleyball training showed a decrease in the number of forms of erythrocytes with structural disorders and an increase in the number of discoid erythrocytes. Under the conditions of the achieved optimization of the microrheological properties of erythrocytes circulating in the blood, the observed young men formed the conditions for optimizing the metabolism in tissues. The obtained results give grounds for a broad recommendation for young men studying at the university, regular volleyball training to overcome their often low physical activity. They can provide a comprehensive recovery for students by normalizing the parameters of erythrocytes.

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