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The Functional Characteristics of the Organism of Physically Inactive Students Who Have Started Regular Physical Training

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Abstract

The properties of erythrocytes strongly determine the course of the entire microcirculation and metabolism in the body. Elucidation of the state of students who had long-term low physical fitness and began to regularly perform feasible physical exercises can track the progress of optimization of erythrocyte parameters that are significant for microcirculation. The study involved 42 male students who had low physical activity throughout their future life and who began regular athletics training 3 times a week. The control group included 46 students who, for at least 7 years, regularly experienced athletics loads at least 3 times a week. The work uses standard proven biochemical, hematological, and statistical research methods. After six months of physical training in the blood of students, previously poorly physically trained, normalization of metabolites of arachidonic acid, a decrease in the amount of cholesterol and acyl hydroperoxides in erythrocytes, and an increase in the level of phospholipids in them. During these periods, the students who started training experienced an increase in the number of erythrocytes-discocytes and a decrease in the number of all altered forms of erythrocytes. For students with low physical activity, who began regular physical training, a gradual improvement in the surface properties of erythrocytes is characteristic, which facilitated the processes of microcirculation in tissues.

Keywords: Students, Athletics loads, Physical activity, Erythrocytes

Introduction

Low muscle activity is very common among young people in modern society (Filippov & Petrov, 2015; Bespalov, *et al.*, 2018). This contributes to the early development of many types of hereditary predisposition to various diseases (Drapkina & Shepel, 2015; Kotova, *et al.*, 2017). This pattern has been noticed in many social groups of the population in different countries (Skoryatina & Zavalishina, 2017; Zavalishina, 2018a). As a result of poor physical fitness in people already at a young age, the functional capabilities of the whole organism weaken, the risk of pathology increases, and the incidence of temporary disability increases (Zavalishina, 2018b; Zavalishina, 2018c). Long-term low muscle activity leads to the progression of existing diseases and the emergence of their complications (Tkacheva & Zavalishina, 2018a; Zavalishina, 2018d).

The earliest possible low muscle activity begins to negatively affect blood parameters (Carrizzo *et al.*, 2013). In this case, several functionally very disadvantageous disorders arise in the body (Zavalishina, 2018e; Zavalishina, 2018f). Poor physical fitness even among student youth can lead to microrheological changes in their blood corpuscles, contributing to the onset of hypoxia development in organs (Zavalishina, 2018g). The resulting chronic lack of oxygen weakens the anabolic processes in all parts of the body (Zavalishina, 2018h). The emerging situation contributes to the development of persistent vasospasm and disrupts the work of all cells (Tkacheva & Zavalishina, 2018b; Alamoudi, *et al.,* 2019; Van Ta, *et al.*, 2019). It is known that in the case of low physical activity, conditions often arise that contribute to an increase in the level of blood pressure with the subsequent formation of arterial hypertension (Tkacheva & Zavalishina, 2018c; Zavalishina, 2018i). In this case, the rheological parameters of the largest group of blood corpuscles - erythrocytes are violated. This can occur at a young age, contributing to the emergence of any pathology (Vorobyeva *et al.*, 2018; Zavalishina, 2018j). Because of the severity of the negative consequences of low muscle activity concerning the work of the whole organism, it is necessary to

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search for options to overcome this condition, aimed at optimizing the parameters of blood and especially erythrocytes in young people studying at universities.

The Purpose of this Work is to trace changes in the microrheological characteristics of erythrocytes in students who had previously had low physical activity and started regular jogging.

Materials and Methods

An observation group was created that included 42 male students (mean age 21.6±1.5 years). All of them have not experienced regular systematic physical exertion during their lives. These students began to run regularly at a free pace 3 times a week. The duration of the runs was at least 1 hour. The control group consisted of 46 healthy male students (mean age 21.0±1.9 years). All of them regularly trained for at least 7 years in the athletics section at least 3 times a week. The duration of each session was at least 1 hour.

Plasma levels of thromboxane B_2 and 6-keto-prostaglandin F1α were assessed in all subjects using an enzyme-linked immunosorbent assay and a kit manufactured by Enzo Life Science (USA). In erythrocyte membranes, after washing and resuspending erythrocytes by the enzymatic colorimetric method, the amount of cholesterol was determined using a set of Vital Diagnosticum (Russia), and the number of total phospholipids was determined by the amount of phosphorus contained in them (Kolb & Kamyshnikov, 1982). The state of intra-erythrocyte lipid peroxidation was determined in erythrocytes after washing and resuspension by taking into account the level of malondialdehyde and the number of acyl hydroperoxides by traditional methods (Volchegorskiy *et al.*, 2000).

The content of discoid and altered erythrocyte varieties in the blood was assessed using a light phase-contrast microscope according to traditional methods.

The observation group was examined at baseline and after 3 and 6 months of regular physical activity. The entire control group was examined once.

Statistical processing of the results observed in the work was carried out by the Student's t-test.

Results and Discussion

The students, who initially had low physical fitness, were found to have a violation of the level of metabolites of arachidonic acid. The amount of thromboxane B2 in their plasma exceeded the control level by 27.1% ($p<0.01$), while the level of 6-keto-prostaglandin F1α in them was lower than the values of the control group by 14.2% ($p<0.01$) **(Table 1)**.

In the composition of erythrocyte membranes in the observation group, the level of cholesterol initially exceeded the control values by 14.6%, and the level of total phospholipids was initially inferior to the control values by 13.6% ($p<0.01$). In physically untrained students, the initial amount of acyl hydroperoxides and malondialdehyde was higher than the same indicators in the control by 33.6% ($p<0.01$) and 35.9% ($p<0.01$), respectively.

Table 1. Dynamics of Indicators in the Survey

Blood indicators	Started training, n=42, M±m			Control, n=46, M±m
	start of observation	3 months of observation	6 months of observation	
Discoid erythrocytes, %	79.8±0.29 $p<0.01$	84.2±0.24 $p<0.05$	89.3±0.29 $p_1<0.05$	89.6±0.12
Reversibly altered red blood cells, %	11.6±0.20 $p<0.01$	10.7±0.10 $p<0.01$ $p_1<0.05$	9.6±0.07 $p_1<0.01$	9.2±0.15
Irreversibly altered erythrocytes, %	8.6±0.11 $p<0.01$	5.1±0.09 $p<0.01$ $p_1<0.05$	1.1±0.04 $p_1<0.01$	1.2±0.17
Thromboxane B_2, pg / ml	182.6±0.66 $p<0.01$	166.2±0.72 $p<0.05$	140.9±0.60 $p_1<0.01$	143.6±0.86
6-keto prostaglandin F1α, pg/ml	86.1±0.42 $p<0.01$	91.7±0.36 $p<0.05$	98.0±0.30 $p_1<0.05$	98.3±0.42
Erythrocyte cholesterol, μmol / 10^{12} erythrocytes	1.02±0.016 $p<0.01$	0.97±0.012 $p<0.05$	0.89±0.007 $p_1<0.05$	0.89±0.012
Total phospholipids of erythrocytes, μmol / 10^{12} erythrocytes	0.66±0.012 $p<0.01$	0.69±0.016 $p<0.05$	0.75±0.005 $p_1<0.05$	0.75±0.014

Acylhydroperoxide of erythrocytes, D_{233} /10^{12} erythrocytes	3.86±0.013 p<0.01	3.35±0.026 p<0.01	2.91±0.022 p_1<0.01	2.89±0.019
Malondialdehyde of erythrocytes, nmol /10^{12} erythrocytes	1.78±0.008 p<0.01	1.58±0.014 p<0.05	1.32±0.011 p_1<0.01	1.31±0.021

Note: P - reliability of differences in indicators in the observation group and the control group; p_1 - reliability of changes in the values of the indicators of the observation group in comparison with the indicators in the outcome.

Initially, in the blood of the subjects with low physical fitness, the number of discoid erythrocytes was 12.3% lower than in the control (p<0.01) **(Table 1)**. The content of reversibly and irreversibly changed variants of erythrocytes in them when taken into the study turned out to be more than in the control by 26.1% and 7.1 times, respectively (p<0.01).

Against the background of regular jogging in the observation group, there was a decrease in the imbalance of metabolites of arachidonic acid. By the end of the follow-up, the level of thromboxane B_2 in their plasma decreased by 29.5% (p<0.05). At the same time, by the end of the observation, the concentration of 6-keto-prostaglandin F1α in the observation group increased concerning the outcome by 13.8% (p <0.05).

In the composition of erythrocytes in the students of the observation group, as a result of regular muscular loads, there was a decrease in the amount of cholesterol by the end of the observation by 14.6%. At the same time, an increase in total phospholipids by 13.6% (p<0.05) developed in their erythrocytes. These changes were accompanied in students who started physical training by a decrease in erythrocytes by the end of the observation of the number of acylhydroperoxides by 32.6% (p<0.01) and a decrease in the level of malonic dialdehyde by 34.8% (p<0.01).

As a result of regular physical training, the number of erythrocytes-discocytes increased by 11.9% in the blood of students compared to the initial state (p<0.05) **(Table 1)**. The content of reversibly changed erythrocytes and the number of their irreversibly changed forms in the blood of those who started physical training decreased during the observation period by 20.8% (p<0.01) and 7.8 times (p<0.01), respectively.

Maintaining the physiological optimum in a person for a long time is possible in the case of his regular feasible physical activity (Sungurova *et al.*, 2018; Zavalishina, 2020a). In conditions of prolonged low physical activity, various pre-pathological conditions can form and obvious pathology begins (Karpov *et al.*, 2020). Of great importance in this is the negative impact of poor physical activity on blood parameters and especially its rheological characteristics.

It is known that low muscle activity leads to the appearance of various disorders of microrheological parameters of blood cells and especially their most numerous part - erythrocytes. An excessive amount of lipid peroxidation products in erythrocytes always promotes rearrangements of erythrocyte membranes and disrupts their function (Zavalishina, 2018k). The situation was aggravated by the appearance of lipid imbalance in erythrocyte membranes at low muscle activity, which further impaired the functioning of these blood cells (Zavalishina, 2020b). The resulting changes in the level of phospholipid fraction and cholesterol fraction in their membranes are undoubtedly very disadvantageous biologically (Zavalishina, 2018l). This worsens the selective permeability, the general condition of erythrocyte membranes, and negatively affects the activity of membrane proteins due to violations of their secondary and tertiary structure. This situation negatively affects the processes occurring in the membranes of a significant number of erythrocytes (Karpov *et al.*, 2021).

An increase in the number of reversibly altered erythrocytes and an increase in the number of their irreversibly transformed varieties inevitably lead to an increase in the number of aggregates from erythrocytes in the blood, which complicates microcirculation.

Under these conditions, the activity of synthesis of biologically important compounds that can affect blood cells decreases in the walls of the vessels of students with low physical fitness. There is a situation with an increase in the level of proaggregants in the blood. The developing intensification of thromboxane synthesis and depression of the generation of its functional antipode prostacyclin forms a clear imbalance of the products of the conversion of arachidonic acid. The disturbances in the microrheological properties of erythrocytes created under these conditions have a very negative effect on the implementation of microcirculation and weaken metabolism in all organs.

To improve the health of the whole organism of students in the study, who have low physical activity, they recommended regular training in the form of athletics jogging. As a result, the examined students experienced a decrease in the amount of lipid peroxidation products in their erythrocytes, which created the basis for optimizing the functions of their membranes. The positivization of the state of erythrocytes in those who started physical training was enhanced due to the positive dynamics of the lipid composition of the erythrocyte membranes. This created the conditions for very positive changes in the surface properties of erythrocytes in the blood (Zavalishina *et al.*, 2021a). Optimizing the number of phospholipids and cholesterol in erythrocyte membranes is functionally very beneficial. These changes contribute to the optimization of the level of permeability and the degree of viscosity of their membranes in erythrocytes and also increase the functionality of their membrane proteins (Zavalishina *et al.*, 2021b).

Under the conditions of systematic physical activity in the blood of students who previously had a low level of physical fitness, there was a decrease in the number of differently altered forms of erythrocytes and an increase in the level of their discoid forms. There is reason to believe that a decrease in the level of altered erythrocytes in students creates conditions for weakening the processes of erythrocyte aggregation in their blood, thereby facilitating the processes of perfusion of all internal organs.

Conclusion

Poor physical fitness is often accompanied by an increase in the level of varying degrees of altered erythrocytes. These disorders often impair capillary blood circulation, which inhibits metabolism. It was found that in university students who started jogging regularly after a long period of weak muscle activity, the processes of lipid peroxidation in erythrocytes weakened. At the same time, in the blood of those who have started training, the level of altered varieties of erythrocytes decreases, intensifying the metabolism in the tissues. Due to the complete recovery of microrheological parameters of erythrocytes after six months of running training in students who had previously had low physical fitness, it seems correct to widely recommend such physical activities to all students for their complex health improvement.

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