

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

Ilya Nikolaevich Medvedev\*, Vladimir Yurevich Karpov, Maxim Viktorovich Eremin, Alexander Sergeevich Boldov, Vladimir Ilyich Shalupin, Natalia Nikolaevna Voronova, Andrey Valentinovich Malyshev

Received: 31 March 2021 / Received in revised form: 15 May 2021, Accepted: 20 May 2021, Published online: 21 June 2021  
© Biochemical Technology Society 2014-2021  
© Sevas Educational Society 2008

### 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 and Petrov, 2015; Bespalov, *et al.*, 2018). This contributes to the early development of many types of hereditary predisposition to various diseases (Drapkina and Shepel, 2015; Kotova, *et al.*, 2017). This pattern has been noticed in many social groups of the population in different countries (Skoryatina and 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 (Zavalishina, 2018d; Tkacheva and Zavalishina, 2018a).

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 (Alamoudi, N. M., *et al.*, 2019; Van Ta, T., *et al.*, 2019) (Tkacheva and Zavalishina, 2018b). 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 (Zavalishina, 2018i; Tkacheva and Zavalishina, 2018c). 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 (Zavalishina, 2018j; Vorobyeva, *et al.*, 2018). Because of the severity of the negative consequences of low muscle activity concerning the work

**Ilya Nikolaevich Medvedev\***, Vladimir Yurevich Karpov, Maxim Viktorovich Eremin  
Faculty of Physical Education, Russian State Social University, 129226, Moscow, Russia.

**Alexander Sergeevich Boldov**  
Department of Physical Education and Fundamentals of Life Safety, Moscow State University of Psychology and Education, 127051, Moscow, Russia.

**Vladimir Ilyich Shalupin**  
Department of Physical Education, Moscow State Technical University of Civil Aviation, 125993, Moscow, Russia.

**Natalia Nikolaevna Voronova**  
Department of Physical Education, Sechenov First Moscow State Medical University, 119991, Moscow, Russia.

**Andrey Valentinovich Malyshev.**  
Department of Service and Food Industry, Sochi State University, 354000, Sochi, Russia.

\*E-mail: ilmedv1 @ yandex.ru

of the whole organism, it is necessary to 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  $21.6 \pm 1.5$  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  $21.0 \pm 1.9$  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<sub>2</sub> and 6-keto-prostaglandin F1 $\alpha$  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 and 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 B<sub>2</sub> in their plasma exceeded the control level by 27.1% ( $p < 0.01$ ), while the level of 6-keto-prostaglandin F1 $\alpha$  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 $\pm$ m			Control, n=46, M $\pm$ m
	start of observation	3 months of observation	6 months of observation	
Discoid erythrocytes, %	79.8 $\pm$ 0.29 $p < 0.01$	84.2 $\pm$ 0.24 $p < 0.05$	89.3 $\pm$ 0.29 $p_1 < 0.05$	89.6 $\pm$ 0.12
Reversibly altered red blood cells, %	11.6 $\pm$ 0.20 $p < 0.01$	10.7 $\pm$ 0.10 $p < 0.01$ $p_1 < 0.05$	9.6 $\pm$ 0.07 $p_1 < 0.01$	9.2 $\pm$ 0.15
Irreversibly altered erythrocytes, %	8.6 $\pm$ 0.11 $p < 0.01$	5.1 $\pm$ 0.09 $p < 0.01$ $p_1 < 0.05$	1.1 $\pm$ 0.04 $p_1 < 0.01$	1.2 $\pm$ 0.17
Thromboxane B <sub>2</sub> , pg / ml	182.6 $\pm$ 0.66 $p < 0.01$	166.2 $\pm$ 0.72 $p < 0.05$	140.9 $\pm$ 0.60 $p_1 < 0.01$	143.6 $\pm$ 0.86
6-keto prostaglandin F1 $\alpha$ , pg/ml	86.1 $\pm$ 0.42 $p < 0.01$	91.7 $\pm$ 0.36 $p < 0.05$	98.0 $\pm$ 0.30 $p_1 < 0.05$	98.3 $\pm$ 0.42
Erythrocyte cholesterol, $\mu$ mol / 10 <sup>12</sup> erythrocytes	1.02 $\pm$ 0.016 $p < 0.01$	0.97 $\pm$ 0.012 $p < 0.05$	0.89 $\pm$ 0.007 $p_1 < 0.05$	0.89 $\pm$ 0.012

Total phospholipids of erythrocytes, μmol / 10 <sup>12</sup> erythrocytes	0.66±0.012 p<0.01	0.69±0.016 p<0.05	0.75±0.005 p <sub>1</sub> <0.05	0.75±0.014
Acylhydroperoxide of erythrocytes, D <sub>233</sub> /10 <sup>12</sup> erythrocytes	3.86±0.013 p<0.01	3.35±0.026 p<0.01	2.91±0.022 p <sub>1</sub> <0.01	2.89±0.019
Malondialdehyde of erythrocytes, nmol /10 <sup>12</sup> erythrocytes	1.78±0.008 p<0.01	1.58±0.014 p<0.05	1.32±0.011 p <sub>1</sub> <0.01	1.31±0.021

Note: P - reliability of differences in indicators in the observation group and the control group; p<sub>1</sub> - 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<sub>2</sub> 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 F<sub>1α</sub> 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 positization 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.

**Acknowledgments:** The team of authors thank the administration of the Russian State Social University for the opportunity to research its basis.

**Conflict of interest:** None

**Financial support:** The study was conducted at the expense of the authors.

**Ethics statement:** The study was approved by the local ethics committee of the Russian State Social University on September 15, 2018 (protocol №11).

## References

- Alamoudi, N. M., El-Ashiry, E. A., Allarakia, R. M., Bayoumi, A. M., & El Meligy, O. A. (2019). Adipose Tissue and Bone Marrow-Derived Mesenchymal Stem Cells Role in Regeneration of Cleft Alveolus in Dogs. *International Journal of Pharmaceutical Research and Allied Sciences*, 8(1), 146-157.
- Bespalov, D. V., Kharitonov, E. L., Zavalishina, S. Yu., Mal, G. S., & Makurina, O. N. (2018). Physiological Basis for The Distribution of Functions in The Cerebral Cortex. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(5), 605-612.
- Carrizzo, A., Puca, A., & Damato, A. (2013). Resveratrol improves vascular function in patients with hypertension and dyslipidemia by modulating NO metabolism. *Hypertension*, 62(2), 359-366.
- Drapkina, O. M., & Shepel, R. N. (2015). Physical inactivity is a disease of the century: low physical activity as a risk factor for diseases of the cardiovascular system and premature aging. *Cardiology: news, opinions, training*, 3(6), 53-58.
- Filippov, E. V., & Petrov, V. S. (2015). Analysis of low physical activity among the working-age population of the Ryazan region (according to the Meridian-RO study). *Clinician*, 9(3), 22-27.
- Karpov, V. Y., Zavalishina, S. Y., Bakulina, E. D., Dorontsev, A. V., Gusev, A. V., Fedorova, T. Y., & Okolelova, V. A. (2021). The Physiological Response of the Body to Low Temperatures. *Journal of Biochemical Technology*, 12(1), 27-31.
- Karpov, V. Yu., Zavalishina, S. Yu., Komarov, M. N., & Koziakov, R. V. (2020). The Potential of Health Tourism Regarding Stimulation of Functional Capabilities of the Cardiovascular System. *Bioscience Biotechnology Research Communications*, 13(1), 156-159.
- Kolb, V. G., & Kamyshnikov, V. S. (1982). *Clinical Chemistry Handbook*. Minsk: Belarus publishing house, 367.
- Kotova, O. V., Zavalishina, S. Yu., Makurina, O. N., Kiperman, Ya. V., Savchenko, A. P., Skoblikova, T. V., Skripleva, E. V., Zacepin, V. I., Skriplev, A. V., & Andreeva, V. Yu. (2017). Impact estimation of long regular exercise on hemostasis and blood rheological features of patients with incipient hypertension. *Bali Medical Journal*, 6(3), 514-520.
- Skoryatina, I. A., & Zavalishina, S. Yu. (2017). Ability to aggregation of basic regular blood elements of patients with hypertension and dyslipidemia receiving non-medication and simvastatin. *Bali Medical Journal*, 6(3), 521-528.
- Sungurova, N., Sysoeva, N., Glamazdin, I., & Kryukovskaya, G. (2018). Internet technologies as a means of establishing informative preferences and motivational attitudes of natural sciences specialties students. 10th International Conference on Education and New Learning Technologies (EDULEARN). Palma, SPAIN. JUL 02-04, 8898-8907.
- Tkacheva, E. S., & Zavalishina, S. Yu. (2018a). Physiology of Platelet Hemostasis In Piglets During The Phase Of Newborns. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(5), 1912-1918.
- Tkacheva, E. S., & Zavalishina, S. Yu. (2018b). Physiological Aspects of Platelet Aggregation In Piglets Of Milk Nutrition. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(5), 74-80.
- Tkacheva, E. S., & Zavalishina, S. Yu. (2018c). Physiological Features of Platelet Aggregation In Newborn Piglets. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(5), 36-42.
- Van Ta, T., Nguyen, H. B. T., & Tran, H. T. (2019). Evaluating the Association of Red Blood Cell Parameters and Glycemic Control in Type 2 Diabetic Patients at Tien Giang General Hospital. *Archives of Pharmacy Practice*, 10(4), 153-160.
- Volchegorskiy, I. A., Dolgushin, I. I., Kolesnikov, O. L., & Tseilikman, V. E. (2000). Experimental modeling and laboratory assessment of the adaptive reactions of the body. *Chelyabinsk: publishing house of the Chelyabinsk State*

- Pedagogical University, 167.*
- Vorobyeva, N. V., Mal, G. S., Zavalishina, S. Yu., Glagoleva, T. I., & Fayzullina, I. I. (2018). Influence of Physical Exercise On The Activity Of Brain Processes. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 240-244.
- Zavalishina, S. Y., Bakulina, E. D., Eremin, M. V., Kumantsova, E. S., Dorontsev, A. V., Petina, E. S. (2021a). Functional Changes in the Human Body in the Model of Acute Respiratory Infection. *Journal of Biochemical Technology*, 12(1), 22-26.
- Zavalishina, S. Y., Karpov, V. Y., Zagorodnikova, A. Y., Ryazantsev, A. A., Alikhojin, R. R., Voronova, N. N. (2021b). Functional Mechanisms for Maintaining Posture in Humans during Ontogenesis. *Journal of Biochemical Technology*, 12(1), 36-39.
- Zavalishina, S. Yu. (2018a). The Functional State of Vascular Hemostasis In Calves During The Neonatal Phase. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 1507-1512.
- Zavalishina, S. Yu. (2018b). Physiology of Antiaggregatory Manifestations Of The Vascular Wall In Newborn Calves With Iron Deficiency, Receiving Metabolic Significant Effects. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 1530-1536.
- Zavalishina, S. Yu. (2018c). The Functional State of Primary Hemostasis In Newborns Calves With Dyspepsia. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 1543-1549.
- Zavalishina, S. Yu. (2018d). Dynamics of The Functional State of Platelet Functions in Newborn Calves Receiving Correction for Dyspepsia. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 1566-1572.
- Zavalishina, S. Yu. (2018e). Functional Features of Primary Hemostasis in Newborns Calves with Functional Disorders of the Digestive System. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*. 9(6), 1630-1636.
- Zavalishina, S. Yu. (2018f). Elimination of platelet dysfunctions in newborn calves with functional digestive disorders. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 1650-1656.
- Zavalishina, S. Yu. (2018g). Prevention of Violations of the Functional Status of Platelet Hemostasis in Newborn Calves with Functional Disorders of the Digestive System. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 1672-1678.
- Zavalishina, S. Yu. (2018h). Physiological Mechanisms of Hemostasis in Living Organisms. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(5), 629-634.
- Zavalishina, S. Yu. (2018i). Physiological Control of the Vascular Wall Over Platelet-Induced Aggregation in Newborn Calves with Iron Deficiency. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 1601-1606.
- Zavalishina, S. Yu. (2018j). Functional Activity of Primary Hemostasis in Calves during the First Year of Life. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 1575-1581.
- Zavalishina, S. Yu. (2018k). Physiological Features of Primary Hemostasis in Newborns Calves with Functional Digestive Disorders. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 1514-1520.
- Zavalishina, S. Yu. (2018l). Functional Features of Hemostasis in Calves of Dairy and Vegetable Nutrition. *Research Journal of Pharmaceutical, Biological, and Chemical Sciences*, 9(6), 1544-1550.
- Zavalishina, S. Yu. (2020a). Functional Activity of the Cardiorespiratory System and the General Level of Physical Capabilities Against the Background of Regular Physical Exertion. *Bioscience Biotechnology Research Communications*, 13(4), 2327-2331.
- Zavalishina, S. Yu. (2020b). Functional Features of Hemostasis in Weakened Newborn Calves Treated with Aminosol. *Bioscience Biotechnology Research Communications*, 13(3), 1251-1256.