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Influence of Motor Activity Level on the Resistance of Students' Erythrocytes Membranes

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ABSTRACT

The problem of reducing the motor activity of young students in the conditions of the modern educational process is more relevant than ever in connection with the trend towards a decrease in the quality of youth health. The purpose of this research was to study the influence of physical activity level of Pedagogical University female students on the resistance properties of erythrocytes. Methods for studying osmotic and peroxide resistance of erythrocytes and catalase activity were used. The background values of osmotic, peroxide resistance in the test groups did not have a significant difference, although the resistance of erythrocyte membranes to peroxide radicals is somewhat more pronounced in the group of girls with conditionally low activity. In the group of girls with reduced motor activity, the level of activity of the catalase enzyme was slightly lower than that in the blood of girls involved in physical exercises. There were no obvious differences in the resistance characteristics of the erythrocyte membrane in the groups of female students with different levels of motor activity at rest. The use of the step test revealed a difference in the structural and functional state of erythrocyte membranes - during exercise, a decrease in the osmotic and peroxide resistance of the erythrocyte membranes of girls from the group with conditionally low motor activity was shown, and a more stable structural and functional state of erythrocytes of girls from the group with a regime of high motor activity . There were no changes in catalase activity against the background of the step test in groups of girls with different levels of motor regimen.

Keywords: Resistance, Erythrocytes, Membranes, Hypodynamia, Women Students, Physical Activity.

INTRODUCTION

The complex impact of innovative educational loads with a high level of psycho-emotional and intellectual stress, the intensification of the modern educational process, and most importantly, the violation of the motor regime, negatively affect the functional capabilities of the students' organism. This leads to a decrease in adaptive reserves, the emergence of a mismatch in the mechanisms of regulation of vegetative functions. Increasing the functional capabilities and working capacity of the body of students in the conditions of the modern educational environment seems to be a very urgent task at this time. To solve these problems, it is necessary to train a new generation of specialists with integration knowledge and approaches to resolve various non-standard situations. Preserving and strengthening the health of young people, the full development of the individual, the training of competent specialists are an integral part of the modern educational process in higher education (Egorychev, 2006). To preserve and strengthen the health of young people, their full development, modern integrative forms of stimulation of motor activity are necessary, as a necessary physiological need for the harmonious development and

realization of the mental and physical potential of young people in the process of studying at the university (Malyshev, 2002; Dorofeeva, 2006).

The situation is similar on an international scale, and research into the problem of the physical activity characteristics of student youth is being conducted in many countries around the world (Gorelov, 2008; Dorofeeva, 2006; Clarkson, 2000). A recent study reviewed and analyzed the prevalence of university students participating in physical activity at levels sufficient to derive health benefits. According to these data, more than half of university students in the US and Canada are not active enough to reap health benefits. Furthermore, female students are among the least active, and students living off-campus are more active than those living on-campus. Insufficient physical activity is a serious health concern among university students (Irwin, 2004). Student life can be a source of stress, as students report higher levels of stress than their non-student peers (Pereira, 2018), and high levels of stress impact quality of life (Ribeiro, 2018).

University students often suffer from stress-related physiological and psychological health problems, which can negatively impact their academic performance. On the other hand, physical activity can reliably alleviate these problems. Publications devoted to the study of physical activity, stress and academic performance of university students have shown a positive relationship between activity and academic performance, a negative relationship between movement and stress, apparently indicating a gap in research concerning the relationship between physical activity, academic performance and stress in university students (Wunsch, 2021).

Physical activity and exercise are known to be stress-mitigating factors, as regular activity can mitigate the negative impact of stress on health [Gerber, 2009]. Overall, physical activity is known to have several positive effects on stress-related physiological and psychological parameters. It has been shown that sedentary participants with high stress levels had increased incidence of illness, while physically active participants with high stress levels had decreased incidence of stress-related illness (Brown, 1988). Furthermore, levels of stress, anxiety, and depression increased in university students as their sedentary time increased (Lee, 2019).

Interest in various aspects of this problem is due to the relationship between motor activity and human health, which is especially clearly seen in the period of the final maturation of the body (Larouche, 2014; Arngrimsson, 2012). Physical activity has a positive effect on academic performance, as more active students perform better (Vaez, 2008; Talib, 2012). Despite the research being conducted, the relevance of the problem of increasing the physical activity and performance of students in the context of an increasingly complex educational process in the modern educational environment has increased, since the majority of university students do not meet the recommendations for physical activity (Clemente, 2016). So far, there have been almost no studies of the body's motor activity at the level of biological membranes of cells, indicators of antioxidant status, changes in blood parameters. The study of the influence of the level of motor activity on the resistance of blood erythrocytes, antioxidant status (catalase activity) in modern female students is of particular scientific and practical interest. The results obtained will make it possible to find ways and means of correcting disorders caused by the impact of limited motor activity, and will also make it possible to prevent possible dysfunctions of the body systems in case of hypokinesia.

MATERIALS AND RESEARCH METHODS

The student volunteers of Abay KazNPU acted as the object of study: female students with conditionally low physical activity (Institute of Pedagogy and Psychology, hereinafter - IPP) and students with a relatively high level of physical activity (Institute of Arts, Culture and Sports, specialty "Physical Education and Sports", hereinafter - PES). Blood was collected by taking the venous blood of student volunteers in special test tubes treated with EDTA under conditions of physical rest and after the Harvard step test. The erythrocyte fraction was obtained by centrifugation of blood samples for 10 min at 1000g. Plasma and leukocyte fraction were removed. Erythrocytes were washed twice with incubation medium containing 150 mM NaCl, 5 mM Na2HPO4 (pH 7.4). Before using in the experiment, erythrocytes were preliminarily diluted 10 times with the incubation medium and incubated at 37°C for 5 min. The osmotic resistance of erythrocytes was determined by the degree of hemolysis in NaCl solutions of various concentrations (0.35-0.9 g/100 ml) in an incubation mode of 20 min at 37°C. The peroxide resistance of erythrocytes was studied according to the method of Pokrovsky (1964), modified by Murzakhmetova et al. (Miroshina, 2002).

Erythrocyte catalase activity was determined using the Korolyuk method (1988). A 1 mM hydrogen peroxide solution was added to the erythrocyte suspension. Samples were incubated for 10 minutes and 1 ml of 4% ammonium molybdate solution was added. The optical density of the solution was recorded at a wavelength of 410 nm. Catalase activity was calculated as a percentage based on the amount of hydrogen peroxide destroyed.

The obtained results were statistically processed using the Microsoft Excel program, taking into account the Fisher-Student criterion, the registered changes in indicators were considered significant at $p \leq 0.05$.

RESULTS AND DISCUSSION

The study of the level of osmotic resistance of erythrocyte membranes in girls with different levels of physical activity revealed that when erythrocytes were incubated in 0.45 g/100 ml of sodium chloride, the difference between the groups was 6.5%. In other media, the osmotic resistance of red blood cells in both groups had no significant differences.

As for the peroxide resistance of erythrocyte membranes of girls with different types of motor activity, the resistance of erythrocyte membranes to peroxide radicals is somewhat more pronounced in the group of girls with conditionally low activity - by 3.7% than in female students included in the group with conditionally high motor activity.

Enzymes that selectively catalyze the destruction of hydrogen peroxide molecules are of great importance in the antioxidant protection of cell membranes. A significant role is given to catalase, a heme-containing enzyme localized mainly in cell peroxisomes, which destroys hydrogen peroxide without the participation of oxygen acceptors. Catalase, which is found in red blood cells, eliminates the production of oxygen released as a result of the oxidation of hemoglobin.

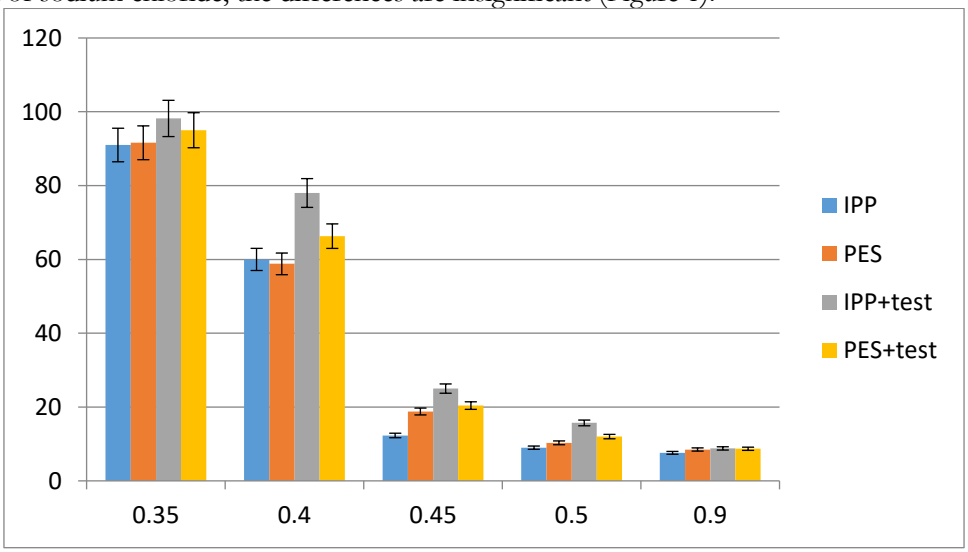
In this regard, it was of interest to study the activity of this enzyme in the erythrocytes of girls with reduced motor activity and actively involved in sports. Catalase activity was evaluated by the amount of destroyed hydrogen peroxide in solution and expressed as a percentage.

In the group of girls with reduced motor activity, the level of activity of the catalase enzyme was slightly lower than that in the blood of girls involved in physical exercises - by 4.6%, which can be seen from the amount of erythrocyte hemolysis.

Thus, there were no significant differences in the resistance characteristics of the erythrocyte membrane in the groups of female students with different levels of motor activity at rest.

Further, we carried out an analysis of changes in the resistance of erythrocytes in female students of the above groups under conditions of physical stress. The classic Harvard step test was used as a physical test.

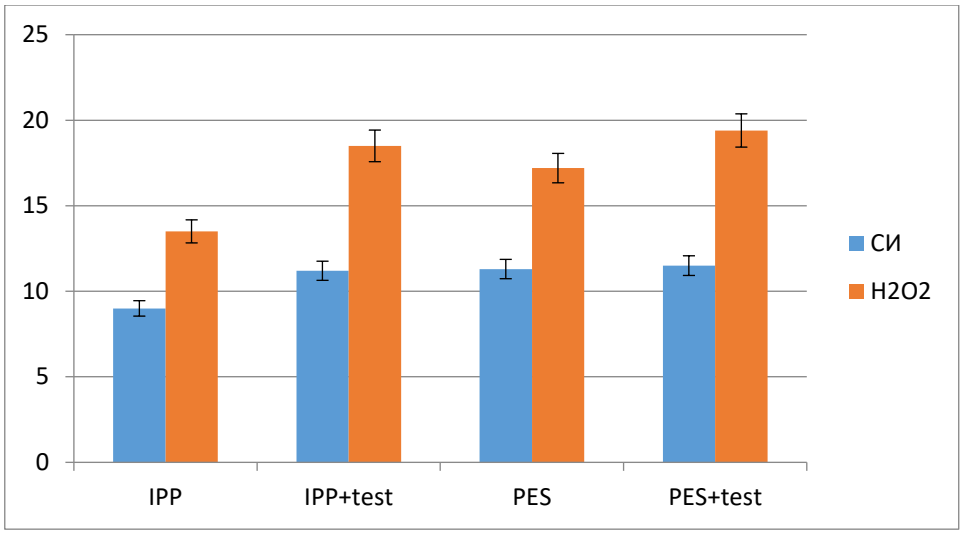
If the background changes in the osmotic resistance of erythrocytes are insignificant between the studied groups of female students, then the use of the step test revealed a difference in the structural and functional state of the erythrocyte membranes. So, in hypotonic solutions of sodium chloride, the value of hemolysis of erythrocytes in girls with reduced motor activity in the control group is higher than that in the group that passed the step test, by 7.2% when cells are incubated in 0.35 g/100 ml of NaCl solution, by 18% - in 0.4 g/100 ml NaCl solution. With an increase in the concentration of the NaCl solution to 0.45 g/100 ml, the resistance decreased by 12.7%, in 0.5 g/100 ml of the NaCl solution - by 6.7%. In the group of PES students against the background of the step test, the level of decrease in erythrocyte resistance also repeats the changes observed in the group of students of IPP. When comparing both groups, there is a more significant decrease in the resistance properties of erythrocyte membranes in the group of girls with reduced motor activity than in the group of PES students - by 3.2% in 0.35 g/100 ml of NaCl solution, by 11.7% in 0.4 g/100 ml of NaCl solution, with a further increase in the concentration of sodium chloride, the differences are insignificant (Figure 1).



Y-axis: hemolysis value in %; abscissa: NaCl concentration, g/100ml; groups of subjects: 1 - IPP students, control group, 2 - PES students, control group, 3 - IPP students, test group, 4 - PES students, test group.

Figure 1. Osmotic resistance of female students' erythrocytes with different levels of physical activity under the influence of the Harvard step test.

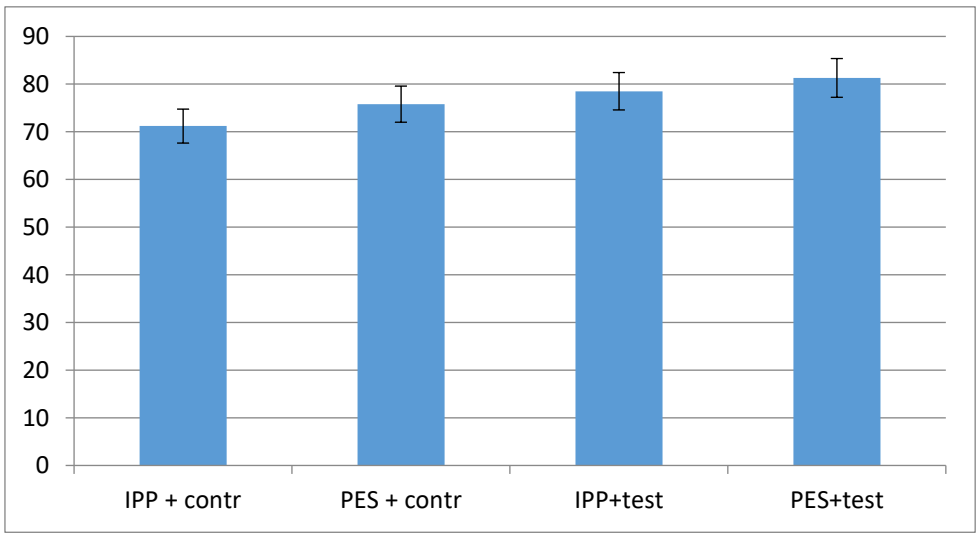
Increased hemolysis of erythrocytes during peroxidation was 5% in the group of girls IPP, 2.2% - in the group of female students of the PES. The difference between the groups does not exceed 1%, so we can talk about the almost identical effect of the test on the state of erythrocytes when exposed to peroxide radicals (Figure 2).



Y-axis: hemolysis value, %; abscissa: groups of students.

Figure 2. Peroxide resistance of erythrocyte membranes in the blood of female students with low and high physical activity during the step test.

Next, the activity of the catalase enzyme in the test groups after passing the step test was investigated. The results are shown in Figure 3.



Y-axis: catalase activity, %; along the abscissa: groups of female students.

Figure 3. Catalase activity of erythrocyte membranes in girls with different levels of motor activity.

After the test, the level of catalase activity in the group of female students of IPP increased by 7.3%, in the PES group - by 5.5%. Enzyme activation is more intense in girls with reduced motor activity - by 1.8%, although this difference is not significant. In this case, we can talk about almost the same effect of the load on the activity of the enzymatic antioxidant system.

It should be noted that many researchers have shown that adequate physical activity increases the body's resistance to oxidative stress of any nature due to an increase in the functional capacities of oxygen transport systems, the mitochondrial system, as well as the development of adaptive changes in the LPO-AOS system (Meyerson, 1988).

At the same time, it is well known that the activation of lipid peroxidation processes that accompanies intense physical activity can cause significant disruptions in the functioning of various organs and systems, and thereby neutralize the positive effect of physical activity on health, and the main reasons for the initiation of lipid peroxidation processes during intense muscle work are insufficient supply of tissues with oxygen and excessive

activation of the sympathoadrenal system. The change in the indicators of the "lipid peroxidation - antioxidant protection" system reflects changes in the overall metabolism, therefore, a thorough study of the patterns of the impact of various physical activities on the balance of the "lipid peroxidation - antioxidant protection" system in the body is required (Irshad, 2002).

CONCLUSION

In our work, it was found that the background values of osmotic resistance in both groups of studied female students practically did not differ, while physical activity in the form of the Harvard step test revealed a significant decrease in the resistant properties of erythrocyte membranes in the group of girls with reduced motor activity. All this affects the functional properties of erythrocyte membranes and, possibly, in the future will lead to the emergence of pathological processes in the body.

Enzymes that selectively catalyze the destruction of hydrogen peroxide molecules are of great importance in the antioxidant protection of cell membranes. A significant role is given to catalase, a heme-containing enzyme localized mainly in cell peroxisomes, which destroys hydrogen peroxide without the participation of oxygen acceptors. Catalase located in erythrocytes eliminates the production of oxygen released as a result of hemoglobin oxidation (Zikic, 1996; Ilyukha, 2001).

In this regard, it was of interest to investigate the activity of this enzyme in the erythrocytes of students with reduced motor activity and those actively involved in sports. The study of the catalase activity of the erythrocyte membranes of girls with different levels of motor activity revealed a lower level of enzyme activity in the group of female students who do not go in for any sports. At the same time, physical activity did not reveal any significant fluctuations in enzyme activity in both groups. It is likely that in this case, female sex hormones, estrogens, have a protective effect, stabilizing the functional state of erythrocyte membranes without significant activation of enzymatic protection.

Thus, during physical activity, a decrease in the osmotic and peroxide resistance of blood erythrocyte membranes was found in female students from the group with conditionally low motor activity and a more stable structural and functional state of erythrocytes in girls from the group with high motor activity.

The solution to the problem of optimizing the physical activity of female students studying at a pedagogical university should be implemented by including in the educational and daily activities of this category of students various forms of physical education classes of various focus, providing the opportunity for daily pedagogical regulation of their physical activity

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