Scientific Notes of Crimean V. I. Vernadsky Federal University
Biology. Chemistry. Vol. 8 (74). 2022. No 2. P. 49–55.

***UDK 612***

# AGE-RELATED FEATURES OF THE NONSPECIFIC IMMUNOLOGICAL RESISTANCE OF THE BODY OF YOUNG SWIMMERS WITH DIFFERENT METABOLIC FATIGUE FACTORS

***Epishkin I. V.***

***V. I. Vernadsky Crimean Federal University, Simferopol, Russia***
***E-mail: EpishkinIV@cfuv.ru***

The article is presented the results of the study the age-related features of nonspecific immunological resistance, which is formed in swimmers in response to metabolic fatigue factors during swimming physical load. The studies were carried out on swimmers aged 9–10, 11–13, 14–16 years old using hematological, biochemical, pulsometric and statistical methods. The results showed that with an equal total pulse value of swimming physical loads among swimmers 9–10, 11–13 and 14–16 years old, the differences in lactic acid production after training sessions and responses of a non-specific link of the blood immune system were determined. A similar intensity of swimming loads among 11–16 years old swimmers contributed to an increase in general immunological resistance and the formation of nonspecific adaptive reactions at the level of increased activation.
***Keywords:*** young swimmers, immunological resistance, the age-related features, blood immune systems, swimming physical load, lactic acid.

## INTRODUCTION

Increasing the level of adaptation and general body resistance to environmental stress factors has the paramount importance today due to the persisting conditions of a high degree of spread of viral infections [1, 2]. Under the circumstances, high health risks have people with prerequisites for a decrease in the overall body resistance – people of critical age periods, as well as people whose living conditions are associated with a pronounced impact of additional external factors on the body [3, 4]. Also, according to some authors, the incidence of viral infections in children, adolescents and young adults is increasing, which on the one hand does not reduce the relevance of the problem of increasing the resistance of the body of children, and on the other hand requires the identification of effective preventive measures [1, 2].

It is known that physical education and sports help to strengthen the immune system and in particular its non-specific link. However, physical activity, with its inadequate dosage capabilities of the child's body, can have the opposite effect, therefore create prerequisites for fatigue, against which the functions of the main systems, including the immune system, will decrease. Moreover, it is convincingly shown that the incidence of acute respiratory viral infections (ARVI) among athletes in childhood, adolescence and youthful age is practically the same with peers who do not go in for sports. Many experts associate this fact with the effect of fatigue, due to the use of excessive physical load on

the children's body, which is typical for different sports Therefore, the largest number of publications on the morbidity of child athletes is devoted to swimmers. It is shown that it is sports swimming that "leads" among many sports in the risk of developing SARS and bronchial asthma, which is associated with the specific features of the training environment in the water. At the same time, a high degree of health risk is associated to a greater extent with the temperature factor of water, and also does not reduce the role of the negative impact of the chemical factor (the chemical composition of water) on the body. Also, a large number of scientific works are devoted to the health-improving effect of sports swimming, which is expressed first of all in the effect of hardening the body and increasing its general resistance. However, the main contradiction between the established positive and negative effects of swimming on the children's body still hidden in the dosage of physical load, which is often tedious for young swimmers and therefore require objective control at the stages of sports improvement [5]. It is known that the main adaptation mechanism is the process of maintaining the stability of homeostasis, in the implementation and regulation of which, a significant role is assigned to the immune system of the blood, and in particular, its non-specific component [6, 7]. Also, during adapting to physical load, maintaining a certain level of homeostasis occurs against the background of increasing metabolic factors of fatigue and energy needs, which in turn significantly disrupts the stability of homeostasis and requires an adequate compensatory and adaptive response from the immune system [6-9]. In this case, the process of adaptation of swimmers of different age groups to swimming physical load can be used to track the severity of compensatory and adaptive reactions and the characteristics of the response of the nonspecific component of the blood immune system to metabolic fatigue factors that arising in the aquatic environment, which is often recommended for children to promote health [9]. In turn, the information obtained during tracking can be used to control the general resistance of the body of children, adolescents and young men by dosing swimming loads that cause a certain degree of metabolic fatigue [6, 7].

Thereby, the aim of our work was to study the age-related features of non-specific adaptive reactions of the blood immune system in the body of swimmers in the conditions of adaptation to swimming physical load.

**MATERIALS AND METHODS**

The study involved 75 male swimmers at the age of 9 to 16 years who gave voluntary informed consent. The test swimmers were divided into three age groups (9–10, 11–13, 14-16 years). The external and internal characteristics of swimming physical activity in the preparatory period within two and a half months were assessed by: the volume of swimming (km); the total intensity of the training session, which was determined palpationally by the heart rate (HR) using the method of pedagogical pulsometry; duration (in minutes) of the training session. Hematological studies included the determination of the leukocyte formula and erythrocyte sedimentation rate (ESR) [8, 9]. Adaptive responses were assessed by the ratio of leukocytes in the leukogram (eosinophils, monocytes, lymphocytes, neutrophils of rod and segmentonuclear cells), which was determined by counting leukocytes in an automatic counter. The concentration of lactic acid in the peripheral blood was determined by the biochemical method by reaction with

paraoxydiphenyl using a biochemical analyzer. Blood samples from the finger were taken immediately after training sessions [8, 9]. All the studied indicators were studied weekly. For statistical processing of the data of the study results was used a standard statistical analysis in which, first of all, the normal distribution was checked, then the mean values, the mean errors and the significance of the differences were determined, which was calculated by the Student's t-test at $p < 0.05$. In turn, a correlation analysis to determine the relationship between the studied indicators was used with the help of which the Pearson correlation coefficient was calculated.

**RESULTS AND DISCUSSION**

It is known that the ratio of different forms of leukocytes in the leukogram determines the level of general resistance of the body. The informative value of the assessing changes in the leukogram parameters is also determined by the presence of a significant correlation between the functional state of cells and the level of tissue metabolism, and also specific correlative interactions of blood cells with somatic cells, in particular, with myocytes and cardiomyocytes Moreover, in the process of adaptation to physical loads of considerable intensity, which takes place in sports, a concomitant factor is psychoemotional stress The effect of stress on the body is revealed in a change in the quantitative composition of the blood leukocyte formula, accompanied by a strain on the mechanisms of homeostatic regulation. In particular, this is expressed in distinct shifts in leukocyte. Some leukocytes are destroyed, the number of eosinophils is sharply reduced, and the number of granular leukocytes in the general blood flow increases. At the same time, adaptive shifts in leukocytes are evaluated in terms of stimulating nonspecific immunological resistance.

The conducted studies showed that the compensatory and adaptive responses of the non-specific component of the blood immune system to physical load among swimmers of different ages differed both in the degree of severity and in the effectiveness of the immune response. Moreover, the effectiveness of this response depended on the strength of the external influence. Thus, physical load among swimmers of the three age groups was carried out with a total intensity, at which the heart rate on average did not significantly differ in the weeks of the study period and was in the range from $165.7 \pm 2.39$ to $166.5 \pm 3.17$ beats/min ($p > 0.05$). In turn, the duration and volume of the swimming had significant reliable static differences. In swimmers 9–10 years old, the average duration of water training was $55.2 \pm 5.15$ minutes, and the swimming volume reached 1.5 km. In 11-13-year-old swimmers, these values were equal to $80.5 \pm 9.43$ min and 2.6 km ($p < 0.001$) and in 14-16-year-old swimmers were $120.7 \pm 4.23$ min and 5.2 km ($p < 0.001$). Wherein, among swimmers 9-10 years old, there were prerequisites for a decrease in overall resistance and the development of transient immune insufficiency, which was manifested by eosinophilia occurring against the background of a quiet activation reaction (Table 1) [5]. This was confirmed by the presence of frequent colds and allergic diseases. Moreover, in our opinion, one of the concomitant factors in the development of such a partial immune deficiency state was hypothermia, and the other-high intensity physical load, leading to the accumulation in the blood of a large amount of the intermediate metabolic product – lactic acid in the range of $8.4 \pm 0.15$ – $8.8 \pm 0.12$ mmol/l, ($p < 0.05$), as a result of which there were significant shifts in the acid-

base balance towards the acidic side. This served as a trigger for the activation of a number of enzymes, including proteases, which can destroy the structure of immunoglobulin molecules and reduce their level [5].

The confirmation of enhanced elimination of immunoglobulins from the blood serum was the increased ESR, which among swimmers 9–10 years old was $6.68 \pm 0.99$ mm/h, and among swimmers 11–16 years old did not exceed $3.83 \pm 1.08$ mm/h, ($p < 0.05$). For swimmers 11–16 years old, the formation of harmonious reactions of increased activation was characteristic, in which the concentration of lactic acid varied after training sessions in the range of $6.18 \pm 0.13 - 7.27 \pm 0.57$ mmol/l, ($p < 0.05$). That is, an increase in the concentration of lactic acid above 8 mmol/l after swimming training conducted with a heart rate intensity of more than 165 beats / min among swimmers 9-10 years old led to a decrease in the overall resistance of the body.

**Table 1**

**Peripheral blood parameters in swimmers of different ages**

| Parameters | 9–10 years, n=25 | 11–13 years, n=25 | 14–16 years, n=25 | $P_{1,2}$ | $P_{1,3}$ | $P_{2,3}$ |
|---|---|---|---|---|---|---|
| white blood cells ($10^9$/l) | 7.30±0.57 | 6.17±0.31 | 7.93±1.12 | P<0.05 | P>0.01 | P>0.01 |
| eosinophils (%) | 6.75±0.98 | 2.56+0.73 | 2.33±0.42 | P<0.01 | P<0.01 | P>0.01 |
| neutrophils. stick. core. (%) | 4.50±1.60 | 3.78±0.55 | 4.67±0.88 | P>0.01 | P>0.01 | P>0.01 |
| netrof. segment. core. (%) | 48.63±2.82 | 50.89±2.51 | 51.33±1.96 | P>0.01 | P>0.01 | P>0.01 |
| Lymphocytes (%) | 34.50±2.71 | 37.22±3.03 | 37.50±1.52 | P>0.01 | P>0.05 | P>0.01 |
| monocytes (%) | 5.88±0.93 | 5.78±1.00 | 4.17±0.060 | P>0.01 | P>0.05 | P>0.01 |
| ESR (mm/h) | 6.88±0.99 | 4.78±0.98 | 3.83±1.08 | P>0.01 | P<0.05 | P>0.01 |
| hemoglobin (g/l) | 128.78±3.32 | 137.37±1.95 | 137.00±2.27 | P<0.01 | P<0.05 | P>0.01 |
| hematocrit (%) | 40.75±0.96 | 40.33±0.69 | 43.00±0.02 | P>0.01 | P>0.05 | P<0.05 |

When determining the adequacy of the response of a non-specific link of the swimmers immune system to external influences, we took into account not only the quantitative characteristics of the main components of the blood immune system, but also the nature of the relationships between these components, which together determined the effectiveness of the compensatory-adaptive immune response [8, 9]. The nature and

severity of the relationships were determined using a correlation analysis between the indicators of white blood. The results of the correlation analysis are presented in Table 2.

We have shown the presence of a strong correlation between leukocytes and neutrophils (range r = 0.71–0.51), lymphocytes and neutrophils (range r = -0.79–0.68), lymphocytes and monocytes (range r =-0.85 – -0.45) among all athletes, which, especially for novice swimmers, was a favorable factor that does not allow the transition of the prerequisites of immune insufficiency in the transient type to immune insufficiency with a pathological symptom complex [9].

**Table 2**

**Correlations links between peripheral blood parameters in swimmers of different ages**

| Correlation pairs | 9–10 years | 15–16 years |
|---|---|---|
| White blood cells-lymphocytes | +0.38 | -0.32 |
| White blood cells-neutrophils rod-shaped | +0.71** | +0.51* |
| White blood cells-segmented neutrophils | -0.28 | +0.22 |
| White blood cells-eosinophils | -0.98 ** | +0.01 |
| Lymphocytes-monocytes | -0.85** | -0.45* |
| Lymphocytes-neutrophils | -0.79** | -0.68** |
| Neutrophils-eosinophils | +0.35 | -0.31 |
| Hemoglobin-white blood cells | -0.56** | -0.28 |

Note: * – correlation significant on the 0.05 level,
** – correlation significant on the 0.01 level;

So, it can be concluded that in young swimmers of 9–10 years old, when performing swimming loads, a more pronounced acidotic state of the blood was recorded due to a significant accumulation of lactic acid in the blood compared to adolescent and youth swimmers. Obviously, the development of metabolic acidosis is a provoking factor in the formation of immunodeficiency states, especially in the inferiority phase of nonspecific adaptive reactions. It is known that the enhanced elimination of immunoglobulins from the blood serum is accompanied by their fixation with numerous receptors of blood cells, including erythrocytes [10]. This leads to a change in the electric charge of the last and promotes bonding and faster settling. We showed that the ESR index in swimmers 9-10 years old was significantly higher compared to older age groups ($p < 0.05$). Also noteworthy is a significant decrease in lactic acid and the number of eosinophils in the peripheral blood of adolescent and young swimmers, who have registered harmonious nonspecific adaptive reactions. Moreover, the formation of a harmonious adaptive reaction of the body in response to the influence of an external factor is determined by the variety of interactions of various components of the functional system responsible for the implementation of the adaptive effect. Depending on the level of functional requirements imposed on the structural components of the system, the most rational algorithm for quantitative and qualitative relationships between the components of the system is

selected. The presence of a strong correlation between leukocytes and neutrophils, lymphocytes and neutrophils, lymphocytes and monocytes, which we found in young swimmers in the age range from 11 to 16 years, seems to be a prerequisite for ensuring effective nonspecific adaptation to the factors of swimming loads. The conducted studies confirm our assumptions that the main factor influencing the decrease in the general resistance of the body of children 9–10 years old engaged in sports swimming is high-intensity physical activity, which causes the prerequisites for metabolic acidosis. In this case, it is necessary to focus on childhood, in which adaptive reactions, exactly, their effectiveness, are determined by age-related features and imperfect mechanisms for regulating the vegetative functions of the body, increased vegetative reactivity of the sympathetic, and as a result, the excess of the adaptive metabolic link.

In connection with the last, it is recommended to control the intensity of swimming loads for young swimmers aged 9–10 years, and not to allow it to exceed the heart rate above 165 beats/min. Applied to young swimmers over 10 years old, similar in intensity to swimming physical activities, increase the overall resistance of their body.

## CONCLUSIONS

1. Swimming physical activity with a heart rate intensity of more than 165 beats / min contributes to the increase in lactic acid production over 8 mmol/l in swimmers 9–10 years old, forms the prerequisites for fatigue, against which there is a decrease in overall resistance and the development of transient immune deficiency. A similar intensity of swimming loads among swimmers 11–16 years old contributes to an increase in overall immunological resistance.
2. The presence of a strong correlation between leukocytes and neutrophils ($r = 0.71$; $r = 0.51$), lymphocytes and neutrophils ($r = -0.79$; $r = -0.68$), lymphocytes and monocytes ($r = -0.85$; $r = -0.45$), established in the range of 11-16 years, is a prerequisite for ensuring effective nonspecific adaptation to swimming load factors.
3. The revealed age-specific features of non-specific immunological resistance among swimmers with different metabolic factors of fatigue in conditions of swimming loads allow us to reasonably recommend the amount of external influence during swimming classes to increase the overall resistance of the body.

## References

1. Tolstoy O. A. *Immune system dysfunction and its correction under intense physical exertion* (diss cand med sci St-Petersburg: Military Medical Academy S. M. Kirov) p. 153. (2022)
2. Mikhailov K. K. and Ivanov V. G. Factors determining the need for the use of physical exercise for the prevention of coronavirus infections, *J. Scientific notes of the P. F. Lesgaft University.,* **5 (183),** 276 (2020).
3. Petrushkina N. A. Immunology of sports (literature review), *Scientific and Sports Bulletin of the Urals and Siberia.,* **3 (23)**, 21 (2019).
4. Badtieva V. A. , Sharykin A. S. and Zelenkova I. E. Sports medicine and the sports community in the context of the coronavirus epidemic, *J. Consilium Medicum.,* **22 (5)**, 28 (2020)
5. Pogodina S. V. , Pogrebnoy A. I. and Yuferev V. S. *Functional parameters of adaptation systems in swimmers of different ages,* 177 p. (Krasnodar: KSUFKST, 2018).

6. Garkavi L. Kh., Kvakina E. B. and Ukolova M. A. *Adaptive reactions and resistance of the organism,* 223 p. (Rostov-on-Don: Rostov University Press, 1990).
7. Garkavi L. Kh., Kvakina E. B. and Kuzmenko T. S. Signal indicators of antistress adaptive reactions and stress in children, *J. Pediatrics.,* **5**, 107 (1996).
8. Lebedev K. A. and Ponyakina I. D. *Immune insufficiency (detection and treatment),* 442 p. (Moscow: Meditsinskaya kniga, N-Novgorod: Publishing House of NGMA, 2003).
9. Mikhailenko A. A. and Fedotova T. A. The role of correlation relationships in the assessment of the functional capabilities of the immune system, *J. Immunologiya.,* **2**, 59 (2000).
10. Suzdalsky R. S. and Levando V. A. New approaches to understanding sports stress immunodeficiency *J. Theory and practice of physical culture.,* **1**, 68 (2003).

**Епишкин И. В. Возрастные особенности неспецифической иммунологической резистентности организма юных пловцов при разных метаболических факторах утомления / И. В. Епишкин //** Ученые записки Крымского федерального университета им. В. И. Вернадского. Биология, химия. – 2022. – Т. 8 (74), №2. – С. 49–55.

В статье показаны результаты исследования возрастных особенностей неспецифической иммунологической резистентности, формирующейся у пловцов в ответ на метаболические факторы утомления при плавательных физических нагрузках. Исследования проведены на пловцах 9-10, 11-13, 14-16 лет с применением гематологического, биохимического, пульсометрического и статистического методов. Результаты показали, что при равной суммарной пульсовой стоимости плавательных физически нагрузок у пловцов 9-10, 11-13 и 14-16 лет определены различия в продукции молочной кислоты после тренировочных занятий и ответах неспецифического звена иммунной системы крови. В группе 9-10 лет установлено снижение неспецифической резистентности в ответ на плавательные нагрузки суммарная интенсивность, которых находилась в диапазоне ЧСС 165-166 уд/мин. В периферической крови детей 9-10 лет определено содержание молочной кислоты свыше 8 мМоль/л, повышение концентрации эозинофилов и СОЭ до предела порога нормы. Аналогичная интенсивность плавательных нагрузок у пловцов 11-16 лет способствовала повышению общей иммунологической резистентности и формированию неспецифических адаптационных реакций на уровне повышенной активации. При этом обязательным условием формирования гармоничных неспецифических реакций в организме 11-16 летних пловцов явилось наличие стойкой корреляции между лейкоцитами и нейтрофилами, лимфоцитами и нейтрофилами, лимфоцитами и моноцитами. Выявленные возрастные особенности неспецифической резистентности пловцов позволяют рекомендовать величину внешнего воздействия при занятиях плаванием для повышения общей сопротивляемости организма.

***Ключевые слова:*** возрастные особенности, неспецифическая резистентность системы крови, плавательные нагрузки, молочая кислота, юные пловцы.