http://dx.doi.org/10.35630/2199-885X/2021/11/6.6

CHARACTERISTICS OF THE INTERACTION BETWEEN LOW-INTENSITY LASER RADIATION AND ERYTHROCYTES

Received 20 September 2021;
Received in revised form 19 October 2021;
Accepted 21 October 2021

Marina Ivashchenko[1], Andrey Belov[1], Anna Deryugina[2], Vladimir Petrov[1], Tatyana Solovyova[3], Andrew Martusevich[1,2]

[1] Nizhny Novgorod State Agricultural Academy, Nizhny Novgorod;
[2] N.I. Lobachevsky State University of Nizhny Novgorod, Nizhny Novgorod;
[3] Privolzhsky Research Medical University, Nizhny Novgorod, Russia

cryst-mart@yandex.ru

ABSTRACT — The results of the effect of low-intensity laser radiation on lipid peroxidation and the sorption capacity of erythrocyte membranes under stress are presented. The membrane-stabilizing effect of low-intensity laser radiation and a decrease in the rate of free radical processes are noted, which indicates the prospects of using laser radiation as an activator of the body's natural antioxidant systems. An increase in the sorption capacity of erythrocyte membranes proves the advisability of using low-intensity laser radiation to increase the adaptive capacity and to protect the body from stress.

KEYWORDS — low-intensity laser radiation, stress, lipid peroxidation, sorption capacity of erythrocyte membranes, adaptation.

INTRODUCTION

Currently, the problem of the impact of stress on the body is becoming more relevant. A promising approach to solving this issue may be the use of low-intensity laser radiation (LLLT). The available experimental studies indicate that the LLLT effect is based on a complex nonspecific effect on the body, when local changes cause a change in the functioning of bio systems due to the formation of a protective-adaptive reaction. Despite this, the introduction of LLLT into clinical practice is mainly empirical; there is practically no experimental justification for the use of laser light [2, 3, 5].

The blood system, being one of the main homeostatic systems of the body, plays an important role in the formation of adequate compensatory-adaptive reactions under stress. As a marker of adaptive reactions, erythrocytes are used, structural rearrangements, which are an integral reflection of the reaction of cells at the level of the whole organism [1, 7].

These circumstances determined the purpose of the study – to estimate the effect of low-intensity laser radiation on the functional characteristics of erythrocyte membranes under stress.

MATERIAL AND METHODS

4 groups of animals were formed. Animals of the first group served as control (intact), animals of the second group exposed to LLLT, animals of the third group exposed to technological stress, and animals of the fourth group exposed to LLLT for 5 minutes in the area of the withers against the background of stress. A laser therapeutic complex - an autonomous laser shower "MarsIK" (NPO "Petrolaser", St. Petersburg) with a radiation wavelength of 890 nm was used as a radiation source.

The sorption capacity of erythrocyte membranes (RBC) evaluated by the intensity of sorption of erythrocyte membranes of methylene blue [6], the functional state of erythrocytes was judged by the accumulation of malondialdehyde (MDA), the content of which was assessed by the method of M.S. Goncharenko and A.M. Latypova [4]. Blood sampling performed 7, 14, and 30 days after the start of the experiment.

Experiments with animals wereprovided in accordance with the rules of the European Convention ET/S 129, 1986 and Directives 86/609 EEC.

Statistical processing carried out using the BIOSTAT and Microsoft Excel software package. To assess the significance of differences between the groups, Student's t-test was used ($p < 0.05$).

RESULTS

Because of the study, it found that the intensity of lipid peroxidation processes under stress undergoes significant changes over a long period. A significant increase in the concentration of MDA in erythrocytes noted by the 7th day; by the 14th day, the tendency towards an increase in the MDA level remained.

The effect of LLLT on stressed animals by day 7 determined the preservation of an increased level of MDA in erythrocytes, revealed during stress. 14 days after exposure, the level of MDA in erythrocytes was lower relative to the group of animals that underwent stress and approached the value of intact animals. 30

days after stress in all groups, the MDA content restored to the level of intact values.

The data obtained are shown in table 1.

To assess the state of erythrocyte membranes, the sorption capacity of erythrocytes studied using methylene blue. Analysis of the sorption capacity of erythrocytes provides information on changes in the barrier properties of the plasma membrane. The decrease in the sorption capacity interpreted from the standpoint of the energy deficit in erythrocytes. An increase in the sorption capacity of erythrocytes considered an indicator of membrane damage and cellular disorganization [5].

As shown by the studies presented in table 2, under stress on the 7th day, an increase in the sorption capacity of erythrocytes observed. On the 14th day after stress, the value of the sorption capacity of erythrocyte membranes decreased relative to the values of the control group.

The impact of LLLT against the background of stress promoted an increase in the sorption capacity of erythrocytes by the seventh day. By the 14th day, the sorption capacity of erythrocyte membranes approached that of the control group.

Thus, the effect of stress is manifested by an increase in the processes of free radical oxidation and, accordingly, changes in the lipid spectrum of the erythrocyte membrane. This leads to some loss of peripheral low molecular weight membrane proteins and a relative increase for glycoproteins, which, apparently, increases the sorption capacity of erythrocytes. When a certain critical level of the protein-lipid ratio in the erythrocyte membrane reached, there is already a loss of integral proteins, which leads to a decrease in the sorption capacity of erythrocytes [8].

CONCLUSION

The use of LLLT reduces the content of LPO products, normalizes the sorption capacity of erythrocyte membranes. The LLLT effect is based on its ability to stimulate various processes of protection, adaptation, and compensation. The electromagnetic nature of LLLT suggests the possibility of its interaction with a variety of regulatory mechanisms in living systems. The most important regulatory system of the body is the system of free radical processes, which is associated with many biological phenomena, including the mechanisms of regulation of membrane permeability [9].

Thus, the experimental data give reason to believe that the use of LLLT under stress is justified.

Table 1. *Malonicdialdehyde content (nmol / ml) in erythrocytesunder stress and exposure to low-intensity laser radiation*

Group of animals	7 day	14 day	30 day
Control (intact animals)	1.72±0.23	1.91±0.31	1.85±0.26
Technological stress	2.74±0.29*	2.29±0.25*	1.92±0.31
Control + LLLT	1.78±0.26	1.85±0.42	1.91±0.23
Stress + LLLT	2.61±0.35*	2.12±0.37	1.87±0.29

Note: ** — p <0.05 relative to the control group*

Table 2. *Sorption capacity of blood erythrocytes under stress and exposure to low-intensity laser radiation, %*

Group of animals	7 days	14 days	30 days
Control (intact animals)	36.2±1.8	39.7±1.5	38.5±1.4
Technological stress	62.4±1.5*	54.4±1.5*	40.3±1.2
Control + LLLT	32.7±1.4	36.1±1.8	36.2±1.3
Stress + LLLT	52.6±1.9*	42.3±1.4*	34.7±1.9

Note: ** — p <0.05 relative to the control group*

Funding

This work was financially supported by the Russian Foundation for Basic Research, project No 19-316-90066.

REFERENCES

1. **Alves A.C., Vieira R.D., Leal-Junior E.C., Dos Santos S.A., Ligeiro A.P., Albertini R., Junior J.A., de Carvalho P.D.** Effect of low-level laser therapy on the expression of inflammatory mediators and on neutrophils and macrophages in acute joint inflammation // Arthritis Res. Ther. – 2013. – No 15. – P. 116. doi: 10.1186/ar4296.
2. **Deryugina A.V., Ivashchenko M.N., Samodelkin A.G., Ignatiev P.S., Balalaeva I.V.** Low-level laser therapy as a modifier of erythrocytes morphokinetic parameters in hyperadrenalinemia. Lasers in Medical Science. – 2019. – No 34 (8). – P. 1603–1612. doi: 10.1007/s10103-019-02755-y.
3. **Deryugina A.V., Ivashchenko M.N., Ignatiev P.S., Metelin V.B., Talamanova M.N., Belov A.A., Petrov V.A.** Morphofunctional indices of cattle erythrocytes under stress and its correction with low-intensity laser radiation // Bulletin of Russian agricultural science. – 2021. – No 1. – P. 67–71. doi: 10.30850/vrsn/2021/1/67-71.
4. **Goncharenko M.S., Latipova A.M.** Method for assessing lipidperoxidation // Laboratornoedelo. – 1985. – No 1. – P. 60-61.
5. **Kopytova T.V.** Study of the sorption capacity of erythrocyte membranes to assess the nature of endogenous intoxication in dermatoses // Clinical laboratory diagnostics. – 2006. – No 1. – P. 18–19.
6. **Kujawa J., Pasternak K., Zavodnik I., Irzmański R., Wróbel D., Bryszewska M.** The effect of near-infrared

MLS laser radiation on cell membrane structure and radical generation // Lasers in Medical Science. – 2014. – No 29. – P.1663–1668.

7. **Martusevich A.K., Martusevich A.A., Derygina A.V., Peretyagin S.P.** Electrophoretic assessment of the state of erythrocyte membranes under the action of reactive oxygen species and nitric oxide // Biomedicine. – 2019. – No 1. – P. 102–112.

8. **Mukhomedzyanova S.V., PivovarovYu.I., Bogdanova O.V., Dmitrieva L.A., Shulunov A.A.** Lipids of biological membranes in norm and pathology (literature review) // ActaBiomedicaScientifica (East Siberian Biomedical Journal). – 2017. – Vol.2, No 5–1 (117). – P. 43–49. doi: 10.12737/article _59e8bcd3d6fcb1.49315019.

9. **Srubilin D.V., Gadelshina G.F., Enikeev D.A., Sultanov E.F.** The effect of low-intensity laser radiation on the energy metabolism of red blood cells in rats with chronic dichloroethane intoxication // Modern problems of science and education. – 2020. – No 1. – P. 63. doi: 10.17513/spno. 29507.