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FEATURES OF BLOOD'S MICROCIRCULATION AT PHYSICAL LOADS

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This research deals with the study of blood microcirculation peculiarities.

Materials and methods. 72 students of Bogdan Khmelnytsky Melitopol State Pedagogical University, aged 18–19, were examined. The experimental research consisted of the study of blood microcirculation functional state by means of Laser Doppler flowmetry (LDF) method. It helped to evaluate the state of tissue blood-circulation and to detect individual-typological peculiarities of blood microcirculation under the influence of physical activity (before and after exercise).

Results. Three types of blood microcirculation were identified by using LDF-metry. The normoemic type of blood microcirculation, characterized by the superposition of oscillatory rhythms and reflected the balance of the mechanisms of regulation of microcirculation. The hyperemic type, characterized by a «monotonous» LDF-gram with a high parameter of microcirculation, which reflects the relative predominance of metabolic mechanisms in the regulation of microcirculation. The hypoemic type, characterized by a «monotonous» LDF-gram with a low parameter of the microcirculation parameter, which reflects the decrease of vasomotor mechanisms in the regulation of microcirculation. According to the LDF-metric data, the examined students under intensive physical activity have a significant increase in microcirculatory status: by 6 % of the microcirculation parameter, by 28 % of the mean square deviation and by 45 % of the initial value of the coefficient of variation.

Conclusions. This dynamics of microcirculation shows that under the influence of physical exertion, a person creates significant functional reserves for the redistribution of blood flow and for more perfect intraorgan capillary blood flow. It was found, that in the process of physical activity, morpho-functional rearrangements of the human cardiovascular system occur. This reaction is formed by several components of blood microcirculation: blood flow in the transport direction, regulating blood supply in accordance with the needs of tissues and the exchange component of the histochemical barrier

Keywords: blood microcirculation, Laser Doppler flowmetry (LDF), physical activity

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1. Introduction

As a result of numerous studies of last decades [1, 2] it becomes gradually clear that just peripheral blood circulation provides a base of normal vital activity of separate organs and systems – full-value functioning of their cellular elements.

Talking about the topicality of studying the microvascular system, it is necessary to take into account such important aspect of this problem as reactivity of different systems of blood microcirculation. There are not enough works in this direction to form a satisfactory idea about the dynamics of the blood microcirculation status in a human with different functional conditions of the organism in normal and pathologic conditions. At the same time new researches [3, 4] allow to judge about the microvascular system as about a link of the cardiovascular one that important events take place in at organism's adaptation to different influences.

2. Literary review

Researches, dealing with the status of microcirculation ways at muscular activity and directed physical loads gains special interest [5, 6]. Thus, it is known, that physical loads essentially influence all sections of the cardiovascular system, the one of haemodynamic and the status of the human vascular channel.

Microcirculation determines the effective adaptation of the organism to physical loads realization, provides transport of respiratory gases, oxidation sub-

strates, regulatory molecules and immune complexes [7]. At adaptation to muscular loads the blood flow redistribution takes place at the level of organ haemodynamic with its typical intensification in working muscles. At that the blood flow essentially decreases in organs of the digestive system, and, it is stated, that it practically doesn't change in the skin [4, 7]. At the same time intensive physical load realization, involving rather large muscular groups results in the body temperature increase that, it its turn, needs the thermoregulatory increase of skin microcirculation [4, 8]. It may be assumed, that the increase of microcirculatory perfusion in the skin takes place proportionally to the load intensity, so changing mechanisms of microcirculation are typical for mobilizing the adaptive organism potential at muscular activity in whole.

Studying the problem of microcirculation is of indisputable interest, because it allows to disclose such delicate mechanisms that are in the base of organism reactions, adaptive to physical loads.

That is why, taking into account the aforesaid, it is an urgent question of biological researches to study blood microcirculation changes in the skin at physical loads of different intensity.

3. Research aim and tasks

The research aim is to reveal individual-typological features of blood microcirculation in a human at physical loads.

The following tasks were set for attaining this aim:

1. To reveal main types of LDF-grams and rhythmic components of oscillations of the tissue blood flow in the studied students, using the LDF method.

2. To trace the change of blood microcirculation indices at physical loads in adolescents.

4. Research materials and methods

The condition of blood microcirculation was studied using Laser Doppler flowmetry (LDF). LDF method is based on noninvasive optic revelation of tissues by the monochromatic signal and analysis of its frequency spectrum, reflected from movable erythrocytes [9, 10]. The high-informative computer laser Doppler flow-meter LAKK-0.1 was used at the study.

72 practically healthy students-volunteers, boys and girls of 18–19 years old, who reside permanently in the Southern East of Ukraine, participated in the study. The studied persons were not distributed by gender, and at their distribution by age, no essential difference in blood microcirculation indices was observed. The indices were registered at the seating position on the palm surface of the distal phalanx of the fourth finger during four minutes. All records of LDF-grams were made in the first half of the day, from 8 to 13 according to methodical recommendations: “Method of Laser Doppler flowmetry” [10]. At the study, modern requirements of bioethics were taken into account: Helsinki declaration of the World medical association (last version of 2008), Declaration on policy of pa-

tient’s rights protection in Europe (1994), Convention on human’s rights and dignity protection at using biology and medicine achievements (Council of Europe, 1996), Cartagena protocol on biosafety (2000), European charter of patients’ rights (2002), Constitution of the European union (2004), General declaration on bioethics and human rights (UNESKO, 2005), Resolutions of the First national congress on bioethics (Kiev, 2001) and correspondent Laws of Ukraine.

One of most available noninvasive methods for estimating reactivity of the blood microcirculation system is a test with a dosed physical load. A studied person is asked to squat 30 times rather slowly. Microcirculation parameters are usually recorded before a test with the physical load and immediately after it. The functional reserve and reactivity of the microcirculation system are estimated by the blood flow intensity comparing with its initial level.

The statistical processing of the research results was conducted by the standard software product Microsoft Excel and Biostat 5.0. The mean arithmetic value (M), mean error (m) and mean square deviation (σ) were calculated for each studied parameter.

5. Research results

Three types of LDF-grams were revealed in students-volunteers, boys and girls of 18–19 years old that correspond to different types of blood microcirculation system (by Kozlov V. I.) (Fig. 1) [8].

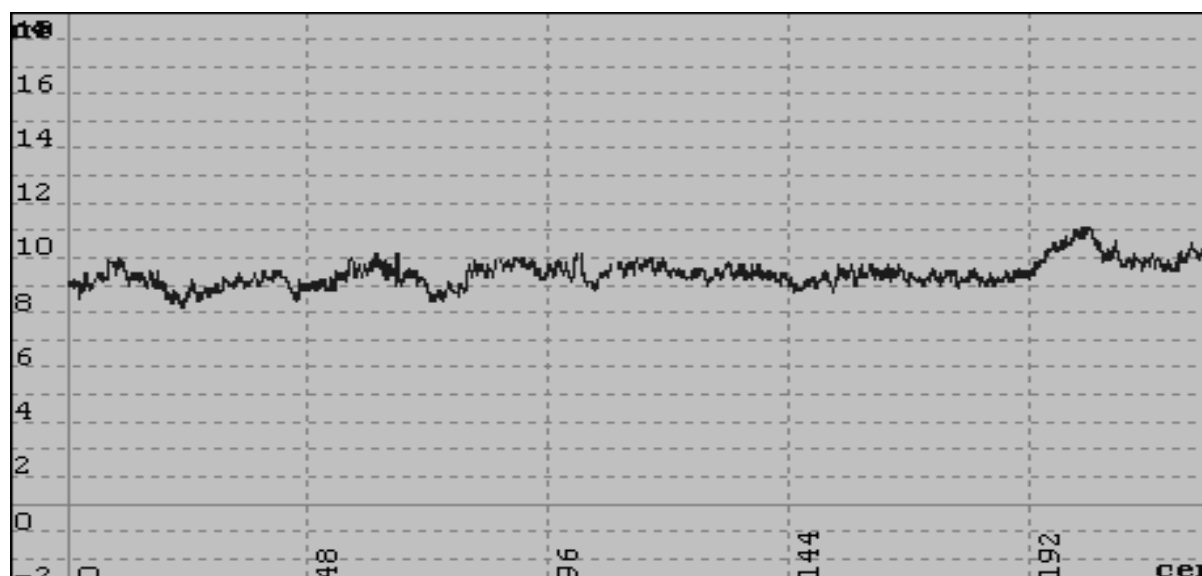


Fig. 1. Typical LDF-gram of 19 years old student

The first type it is an “aperiodic” LDF-gram: it is characterized with irregular oscillations of the blood flow with the rather high amplitude and expressed vasomotor waves. This type of LDF-gram corresponded to the normoemic type of blood microcirculation, inherent to the balanced condition of mechanisms of sympathetic and parasympathetic regulation of tissue blood flow oscillations.

The other type is a “monotonous” LDF-gram, characterized by the high amplitude of the microcirculation parameter. This type corresponded to the hyperemic type of blood microcirculation, observed at the blood in-

flow increase and connected with a certain dilatation of microvessels, conditioned by weakening sympathetic effects in regulation of the tissue blood flow.

The third type is a “monotonous” LDF-gram with the low microcirculation parameter: corresponded to the hypoemic microcirculation type, characterized by the increased blood inflow to the microcirculatory channel and increased tone of microvessels, appeared as a result of increased neurogenic effects.

At the research it has been established, that at rest the microcirculation parameter (MP) was in average 18.6 ± 6.68 perf un. in the system of blood micro-

circulation in 18–19 aged students. After the dosed physical load (30 times slow squatting) the blood microcirculation parameter increased by 6 % ($p < 0.05$) and was 19.8 ± 6.83 perf.un. The microcirculation parameter increase after the physical load is explained by the improved speed of the blood microcirculation process and vasomotor activation of vessels.

Another important characteristic of LDF-gram was mean square deviation (MSD), characterizing the value of blood flow oscillations in tissues that is the functional changeability of the microcirculation system. MSD index in students before the load was 1.8 ± 0.85 perf. un., and after its essential increase to 2.5 ± 0.91 perf. un. that is by 28 % was observed ($p < 0,05$). This parameter increase is explained by the fact that mechanisms of tissue blood flow regulation function better after loads. Loads in the process of or-

ganism's adaptation provide participation of an additional number of reserve capillaries that is reflected on microvessels' regulation variability. Several authors [6, 7] explain the functional changeability of the microcirculation system at physical loads by peculiarities of hypothalamic regulation of the cardiovascular system.

The research results indicate that a physical load causes the essential increase of the variation coefficient index (Δf). Before the load Δf in the studied students was 7.2 ± 2.83 , and after it, it essentially increased by 45 % ($p < 0.05$) and equaled 13.2 ± 5.53 . Thus, it has been revealed, that at physical loads, sympathetic influences on blood microcirculation become dominant.

The dynamics of microcirculation indices at physical loads differed in the studied students with different types of blood microcirculation (Table 1).

Table 1

Blood microcirculation indices at rest and at physical loads in students with different types of blood microcirculation ($M \pm m$)

blood microcirculation types	MP _{in} , perf.un.	MP _{phys.} , perf. un.	MSD _{in} , perf. un.	MSD _{phys.} , perf. un.	Δf in., %	Δf phys., %
Normoemic type (I type of LDF-grams)	15.41 ± 3.46	18.87 ± 0.4	1.83 ± 0.99	3.21 ± 1.11	10.57 ± 8.41	16.88 ± 4.11
Hyperemic type (II type of LDF-gram)	26.62 ± 4.71	30.47 ± 0.48	1.41 ± 0.99	2.23 ± 1.63	6.77 ± 5.11	11.97 ± 2.41
Hypoemic type (III type of LDF-gram)	4.9 ± 0.83	7.82 ± 0.29	1.27 ± 0.52	2.11 ± 0.85	4.41 ± 17.68	10.59 ± 1.22

Note: MP_{in} – initial value of the blood microcirculation parameter; $MP_{phys.}$ – value of the blood microcirculation parameter after the physical load; MSD_{in} – initial value of mean square deviation, $MSD_{phys.}$ – value of mean square deviation after the physical load; Δf_{in} – initial value of the variation coefficient, $\Delta f_{phys.}$ – variation coefficient after the physical load

Most changes after the physical load are observed in the condition of amplitude-frequency spectrum (AFS) of LDF-grams. In students of 18-19 years old the physical load results in strengthening the amplitude of low-frequency VLF and LF-oscillations: by 22 % and 24 % respectively. Thus, the average amplitude of VLF-oscillations before the load was 4.28 ± 1.71 perf.un., after the load – 5.48 ± 1.52 perf.un., and the average amplitude of LF-oscillations before the load was 3.13 ± 1.09 perf.un., after the load – 4.10 ± 1.78 perf.un.

The amplitude of high-frequency HF and CF-oscillations also increased by 33 % and 29 % respectively. Thus, the average amplitude of HF-oscillations before the load was 1.03 ± 0.34 perf.un., after the load – 1.53 ± 0.48 perf.un., and the one of CF-oscillations before the load was 0.37 ± 0.15 perf.un., after the load – 0.52 ± 0.14 perf.un.

Such dynamics of parameters testifies to the intensification of active vasomotor and passive respiratory and pulse oscillations of the blood flow.

6. Research results discussion

The studied persons demonstrate the essential increase of blood microcirculation parameters at the physical loads: microcirculation parameter by 6 %, mean square deviation parameter by 28 % and the variation coefficient value by 45 %, comparing to the initial one. This dynamics of blood microcirculation parameters indicate that under the influence of physical loads, essential

functional reserves form in a human for the blood current redistribution and for more perfect intraorgan capillary blood flow. A certain reaction forms by several components of microcirculation: blood flow in the transport direction, regulating blood supply according to tissue needs and exchange component of the histochemical barrier.

Such regularities of changes of the microcirculatory channel allow to assume that physical loads cause not only the development of the “sports heart”, but also of the “sports cardiovascular system” [6, 7], manifesting itself most brightly as typological features of microvessels' reaction.

Research limitation. It must be noted, that despite the wide spread of researches on the human cardiovascular system [2, 8] in clinical practice and especially at studying the microcirculatory channel of persons with different pathology, there is the urgent deficit and limitation of the research at characterizing normative parameters of blood microcirculation in healthy people, especially taking into account age-gender differences of the organism, at different functional tests and for making statistics of blood microcirculation changes in persons, continuously practicing intensive kinds of sport.

Further research prospects. The obtained data as to revelation of the functional status of the blood microcirculation system in the organism of adolescent persons at physical loads give prospects of further deepened study of results of intensive physical training, functional disorders and pathological processes.

7. Conclusions

1. The three blood microcirculation types have been revealed in adolescents by LDF-metry: normoemic, characterized with the superposition of oscillation rhythms and reflects balanced mechanisms of blood microcirculation regulation; hyperemic type, characterized with a “monotonous” LDF-gram with the high microcirculation index that reflects the relative predominance of metabolic mechanisms in blood microcirculation regulation; hypoemic type, characterized with a monotonous LDF-gram with the low microcirculation index, reflecting the vasomotor reactions decrease in blood microcirculation regulation. The monotonous high-amplitude LDF-gram of type II (48 %), determined as the hyperemic type of blood microcirculation, was registered in most studied students.

2. According to the data of LDF-metry, the essential increase of blood microcirculation parameters at the intensive physical loads is observed: microcirculation parameter by 6 %, mean square deviation parameter by 28 % and the variation coefficient value by 45 %, comparing to the initial one.

This dynamics of blood microcirculation parameters indicate that under the influence of physical loads, essential functional reserves form in a human for the blood current redistribution and for more perfect intraorgan capillary blood flow.

Conflict of interests

The authors declare that they have no conflicts of interest.

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