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Seasonal Fluctuations of Microcirculation at Medical Students with Successful Adaptation and Desynchronosis

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***Abstract* – Chronic psychoemotional stress, high mental workload, labor noncompliance, food and many other factors that a modern student is facing every day contribute to incidence rate and increase in the number of persons with preclinical deterioration of health. The above factors may cause desynchronosis of internal biorhythms as part of the general adaptation syndrome. Today the relevance to study the adaptation of an organism does not raise any doubts. The degree of reaction of an organism on stress factors depends on adaptable mechanisms developed throughout the evolutionary process and on the individual resource of an organism. All functional systems of our body have rhythm and are subject to seasonal fluctuations. We analyzed the Doppler indicators at medical students of the North Ossetian State Medical Academy during various seasons of 2016-2018 (fall, winter, spring).**

Keywords – Doppler sonography, microcirculatory bloodstream, desynchronosis, successful adaptation, preclinical failures

I. INTRODUCTION

Rhythms are one of the most fine-tip markers of the living organism, which characterize their adaptive opportunities. The kind of work of the cardiovascular system (CVS) ensuring life support of an organism can be considered as the indicator of urgent and long-term adaptation [1, 2, 7, 8, 10–13].

II. METHODS AND MATERIALS

The paper studies Doppler indicators at 100 quite healthy medical students not playing sports in comparison with persons with desynchronosis at the age of 20.05±0.13 years (from 19 to 23 years old) during various seasons of 2016–2018 (fall, winter, spring). After receiving the informed consent all respondents were exposed to Doppler sonography, which is not invasive and widely used method of microcirculatory bloodstream assessment (ultrasonic Doppler analyzer Angiodin-PC, Bios). The general principle of operation of the device is that under the influence of the ultrasound probe the high frequency outgoing signal is transformed into the acoustic wave able, when the probe is applied to the examinee's skin, to pass to the level of the studied area. Ultrasonic gel is applied to ensure the best contact between the skin and the sensor. When contacting cells moving in blood flow (erythrocytes, leukocytes, platelets, but since the quantity of erythrocytes is 500–1000 times more than leukocytes, thrombocytes are on average 4 times less than erythrocytes, the reflection generally comes from erythrocytes) the transmitted sound wave changes and is reflected back from an erythrocyte with a different frequency of fluctuations, called a Doppler shift, which is proportional and depends on the blood flow rate in the measured vessel. The signal reflected from moving blood particles gets back to the sensor in the probe, where it is transformed into the electric signal. From this signal the useful Doppler signal is selected in the Doppler block in the range perceived by a human ear. After that it gets to the spectral analysis block and being transformed is displayed online on the screen as a blood velocity diagram. The sensor with a frequency of 16 MHz was used in the study. The perfusion of tissues (liquid exchange) and blood velocity in vessels of finger nail bed of both hands – one of objective indicators of microblood circulation in a human body were studied.

Skin is an easily available organ in clinical and experimental practice for functional diagnostics of the microcirculatory bloodstream. The distal surface of a phalanx of all fingers of right and left hands was chosen as the area for study. This area belongs to smooth skin area, which does not have any indumentum. It is rich not only in arteriolovenular anastomoses purely dependent on sympathetic innervation but also in vegetative and sensory nerve fibers. The vessels of a nail bed have small cross section and consist from capillaries and microscopic arterioles. In case of blood system disorders, these capillaries and arterioles suffer first. On the one hand, it is impossible to define the condition of macrohemodynamics only on the basis of blood circulation in a nail bed. But if the blood movement in this area is too low or too high, then it is possible to assume possible changes in the entire cardiovascular system, on the other hand, the nature of microblood flow directly reflects the condition of peripheral hemodynamics. We registered the following blood flow parameters: average (M), systolic (S) and diastolic (D) blood velocity, made real time automatic calculation of the resistivity index (Purselo rheographic index – RI) reflecting the general peripheral vascular resistance calculated by a formula (S-D)/S, pulsation index (pulsatility index – PI) reflecting resilient-elastic properties (density) of a vessel wall ((S-D)/m), Stuart index (S/D), heart rate (HR). The pulsatility

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index is more sensitive indicator than the Purselo index. These indicators shall be studied at the same time since they display different parameters of a blood flow in arterial vessels. Therefore, only their cumulative assessment will prevent incorrect interpretation of data and blood flow diagnostic failures [6].

In her study of microcirculatory bloodstream of hand skin of medical students, O.A. Gurova showed that in the morning the respondents had more plentiful perfusion while in the evening the blood flow was weakened [4]. We studied the nature of a blood flow until 3 p.m. The studied medical student was in comfortable conditions (warm, quiet, well-ventilated room) in 15-minute rest lying on a couch. Successful adaptation and CVS desynchronosis was assessed according to autorhythmometry.

Statistical processing of results was made via variation statistics considering time series coefficient of variation, by distributions of series to normality, using the package of data analysis and AtteStat in Microsoft Excel since if the distribution of sampling data differed from normal, the Mann-Whitney rank test was applied.

III. Purpose of the study

The purpose was to the self-control mechanisms of microcirculator system of a nail bed of hand fingers of hands at successfully adapted medical students not playing sports and student with desynchronosis during various seasons.

Thus, the study included the following ***research tasks***:

1. To identify seasonal features of separate links of microcirculatory bloodstream and its regulation systems at rest among healthy medical students.

2. To identify seasonal features of separate links of the microcirculatory bloodstream among medical students with desynchronosis.

IV. Results

The analysis of tissue perfusion revealed seasonal fluctuations in all explored areas of sounding of distal area of a nail bed of both hands at relatively healthy young men and women, which is explained by the decrease of the average daily temperature in winter and its sharp drops in spring and autumn. Besides, there is a need to consider active fluctuations of other meteoparameters, which also predetermine the overstress of adaptation mechanisms thus forming “allostatic stress” leading to cardiovascular functional disorder (TABLE I and II).

The analysis of Doppler sonography of healthy young men and women showed that the vascular tone (RI) and the vessel wall density (PI) of women is higher in autumn and of young men during winter and spring; women with desynchronosis have microcirculation changes – increase of pulsatility index with the vessel wall consolidation (PI) confirming the increase of resilient-elastic properties of the vessel wall in microcirculatory bloodstream vessels of a nail bed of fingers of both hands; maximum during autumn season and higher than the levels of this indicator in all studied groups. Besides, the reliable increase towards the seasonal norm is noted among women during winter ($p<0.01$), and among men with desynchronosis – during all seasons (TABLE I and II). In case of compensatory changes of hemodynamics (blood flow velocity and rheological properties of blood) it is possible to determine the adequacy of microcirculatory bloodstream and health in general, or its inadequacy in case of pathological changes. Despite the fact that the blood flow velocity in capillaries is caused by the vascular tone and influences many components of microhemodynamics. The intensity of metabolic process in capillaries is also important. Active regulation mechanisms of lumen of vessels (myogenic, endothelial and neurogenic) create cross fluctuations of a blood flow as a result of relaxation and reduction of vessels (replacing episodes of vasodilation and vasoconstriction). Respiratory and cardiac rhythms (passive factors) create longitudinal fluctuations of a blood flow expressed by periodic changes of pressure and volume of blood in a vessel, but the increase of the vessel wall density reduces the activity of all compensatory changes [3].

TABLE I. DYNAMICS OF INDICATORS OF MICROCIRCULATION OF THE NAIL BED OF HANDS AT WOMEN WITH SUCCESSFUL ADAPTATION (SA) AND WITH DESYNCHRONOSIS (D)

Indicators of microcirculation		**Autumn (n=20)**		**Winter (n=16)**		**Spring (n=13)**	
		SA	***D***	***SA***	***D***	***SA***	***D***
S - systolic velocity(cm/s)	M±m	5.51 0.08	4.88 0.06****	5.9 0.38	5.02 0.06*	6.0 0.08	5.8 0.05*
D - diastolic velocity (cm/s)	M±m	2.47 0.29	2.25 0.12	3.61 0.22	2.74 0.01****	4.14 0.21	4.2 0.14
M – average velocity (cm/s)	M±m	3.48 0.21	2.70 0.12***	4.46 0.15	3.18 0.04****	4.07 0.09	3.61 0.19*
HR – heart rate frequency	M±m	80.2 2.04	90.5 1.85***	80.11 3.18	91.7 3.1***	79.41 2.36	92.3 2.16****
Pulsatility index (cm/s) PI = (S-D)/M	M±m	0.87 0.03	0.97 0.03**	0.51 0.06	0.72 0.02***	0.45 0.04	0.45 0.11
Resistivity index RI (millimeter of mercury) = (S-D)/S	M±m	0.55 0.06	0.54 0.04	0.39 0.015	0.45 0.01***	0.31 0.02	0.28 0.03
Stuart index SD= S/D	M±m	2.23 0.28	2.17 0.07	1.63 0.17	1.8 0.16	1.86 0.13	1.38 0.15**

[a.] Reliability in relation to relatively healthy women – **** $p<0.001$; *** $p<0.01$; ** $p<0.02$; * $p<0.05$; SA – successful adaptation, D – desynchronosis.

The resistivity index (rheographic index – RI) reflecting the general peripheral vascular resistance in case of desynchronosis at young men during winter is statistically significantly higher (TABLE II), and at women, on the contrary, it is reliably low (in comparison with healthy students). The tendency towards the decrease in the index of women during spring can demonstrate the decrease of the general peripheral vascular resistance, which may be interpreted as the compensation reaction caused by the increase of endothelium-dependent vasodilation.

Analyzing the tissue perfusion in the studied locations we revealed lower seasonal values of the average velocity of a blood flow (M) at healthy women during all seasons (in comparison with seasonal values of young men); in case of desynchronosis there is statistically significant decrease of the average velocity both at young men ($p<0.001$) and women (in autumn – $p<0.01$; in winter – $p<0.001$; in spring – $p<0.05$) mainly due to reliable decrease of systolic (S) component of a blood flow whereas the diastolic velocity of a blood flow (D) statistically significantly decreased in case of desynchronosis at women during winter ($p<0.001$) and at young men during autumn ($p<0.001$). The decrease of diastolic component of blood flow velocity characterizes the increase of venous pressure in vessels of the microcirculatory bloodstream (TABLE I and II).

TABLE II. DYNAMICS OF INDICATORS OF MICROCIRCULATION OF THE NAIL BED OF HANDS AT YOUNG MEN WITH SUCCESSFUL ADAPTATION (SA) AND WITH DESYNCHRONOSES (D)

Indicators of microcirculation		**Autumn (n=19)**		**Winter (n=18)**		**Spring (n=14)**	
		SA	***D***	***SA***	***D***	***SA***	***D***
S - systolic velocity(cm/s)	M±m	6.17 0.38	5.02 0.16***	6.07 0.38	5.1 0.04**	5.34 0.13	4.9 0.16*
D - diastolic velocity (cm/s)	M±m	3.8 0.07	3.22 0.13****	2.3 0.11	2.36 0.08	2.51 0.05	2.6 0.1
M – average velocity (cm/s)	M±m	4.7 0.21	2.8 0.1****	4.8 0.29	2.9 0.14****	4.20 0.11	3.0 0.12****
HR – heart rate frequency	M±m	83.87 2.26	89.8 1.72*	70.3 1.32	82.85 3.24***	74.5 1.17	81.09 1.85***
Pulsatility index (cm/s) PI = (S-D)/M	M±m	0.5 0.02	0.64 0.06*	0.79 0.02	0.94 0.06**	0.67 0.03	0.77 0.04*
Resistivity index RI (millimeter of mercury) = (S-D)/S	M±m	0.38 0.01	0.36 0.02	0.62 0.015	0.53 0.02**	0.52 0.02	0.47 0.08
Stuart index SD= S/D	M±m	1.62 0.19	1.56 0.03	2.64 0.039	2.16 0.2**	2.12 0.06	1.88 0.09*

b. **Note 2.** Reliability in relation to relatively healthy women – **** $p<0.001$; *** $p<0.01$; ** $p<0.02$; * $p<0.05$; SA – successful adaptation, D – desynchronosis.

V. CONCLUSION

Thus, the study revealed seasonal and gender differences of microcirculation indicators. The changes of microcirculation indicators at healthy people in seasonal dynamics depend on the tendency, and in case of temporal disorder of cardiovascular system (desynchronoses) statistically significant differences are revealed. The desynchronosis deteriorates the perfusion of tissues during all seasons (tone and density of a vessel wall raises, blood flow velocity decreases), however changes at young men have more expressed than at women.

According to literature sources, the microcirculation assessment via laser doppler flowmetry when comparing microblood flow indicators of men and women show that they differ only in terms of the variation coefficient (reliably low among women) and relative blood oxygen saturation (higher among women than men). The last parameter is inversely proportional to the amount of oxygen consumed by tissues. Thus, at the initial state men are characterized by more efficient oxygen supply to tissues [9], which correlates with our data concerning healthy people during all seasons (in terms of the average velocity of a blood flow – M). Statistically significant decrease of the indicator in case of desynchronosis confirms the decrease of the adaptation resource with further development of hypoxic states against the background of system and peripheral blood flow disorder.

On the other hand, the obtained data correlate with the known provision on capillary blood circulation – “irregular fluctuations of blood flow velocity and blood pressure in different capillaries, pO_2 fluctuations in different capillaries, big differences of pO_2 in tissues show that the capillary blood circulation has no uniform nervous regulation (including, brain and, obviously, heart) and is only subject to the stochastic law of random action” [5], which may include seasonal frequency related first of all to the temperature factor.

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