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Effect of Hypobaria on Cardiorespiratory Parameters in Students

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***Abstract* – The paper presents the comparative analysis of hemodynamic parameters in students of 1–5 years of study living in the plain, low altitude and mid altitude zones. The survey was performed in the Laboratory of Human Physiology, Biology and Chemistry Faculty, Chechen State University. 284 male and female students volunteered for the experiment. Different patterns of adaptation to the mountain climate were established experimentally. Increased average values of the heart rate (higher than the standard values) were found for female students, especially among residents of the low altitude and mid altitude zones. Tachycardia in female students indicates that heart and blood vessels are experiencing strain caused by excitation of the sympathetic division of the autonomic nervous system. Subsequently, tachycardia led to increased minute blood volume.**

Keywords* – *hemodynamic parameters, climate and geographical zones, students, gender features.

I. INTRODUCTION

A large number of well-known physiological mechanisms help living creatures adapt to adverse environmental conditions.

Physiological adaptation implies reactions initiated to adapt the organism to changing environmental conditions. Through adaptation, the internal composition of body fluids, that is homeostasis, is maintained stable [3, 10].

The analysis of the health status of male and female students living in the plain, low altitude and mid altitude zones indicates that a significant number of the students examined experience chronic stress.

In previous publications, we have already addressed the issue of hypobaria (decreased barometric pressure), since the Chechen Republic is physically and geographically the region of amazing contrasts of nature. A large variety of subtypes of mountainous reliefs can be found in a relatively small area: high altitude, plain, low altitude and mid altitude zones [1, 9].

Hypobaria activates the reserve capabilities of heart and blood vessels, and evaluation of these capabilities is of current relevance.

To this end, we studied cardiac and vascular activity in students, who live in different physiographic zones.

II. METHODS AND MATERIALS

The automatic Omron MX3 Plus tonometer was used to study hemodynamic parameters. The studied values were calculated by an analytical method using formulas.

A total of 284 persons were examined (233 females and 51 males), of which:

1. Full-time and part-time students of 1–5 years of study from the Biology and Chemistry Faculty, majoring in Biology, specialization in Physiology, Microbiology and General Biology;

2. Students of the Agrotechnological Institute, majoring in Veterinary;

3. Schoolchildren of Gymnasium 12, Grozny.

Male and female students were divided into 3 groups according to the physiographic area of residence.

The following parameters were studied: heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP), minute blood volume (MBV), respiratory rate (RR).

Statistical data processing was carried out using the software Excel 2016.

III. RESULTS

The comparative analysis of the main parameters of cardiohemodynamics in students (Table 1) showed that the climate and geographical features of the region of residence have a diverse effect on the body [2].

We noted wave-like changes in blood pressure during heart systole. In residents of the low altitude zone, SBP was low, and in females living in the mid altitude zone, it was the highest in comparison with that in the females from the plain zone, but not beyond the limits of standard values. Data from other studies confirm that lower blood pressure is characteristic of young girls [5]. The ideal is the pressure level with the lower value of 80 mm Hg and the upper one equal to120 mm Hg (Fig. 1).

The level of blood pressure during systole in male students of all three groups exceeded standard values to a greater extent compared to female students, especially among residents of the mid altitude zone.

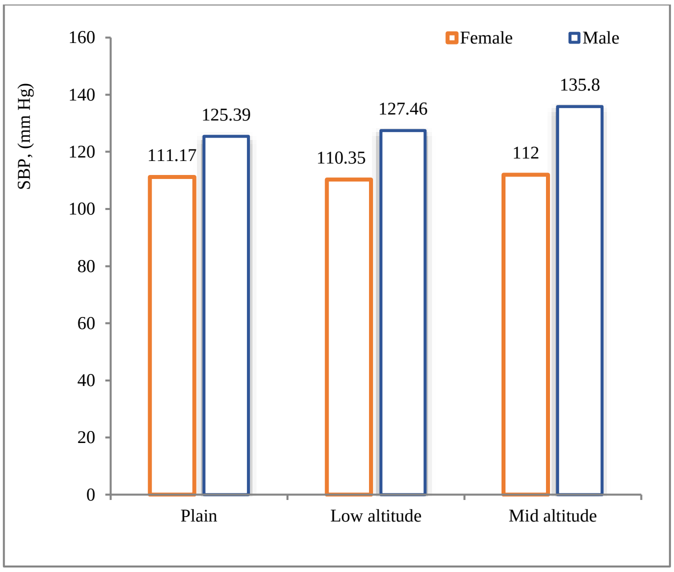

Fig. 1. Dynamic nature of SBP in students of different sex living in the plain, low altitude and mid altitude zones

In addition, we noted a significant increase ($P < 0.05$) in SBP in male students (Group 3), who live in the mid altitude zone. The data obtained are statistically significant.

The scientists consider that an increase in the pressure level at the altitude is mainly due to increased activity of the sympathetic nervous system associated with lack of oxygen. As a result, peripheral blood vessels become compressed, which increases cardiac activity [7].

DBP was observed to decrease in female students of all groups, to a greater extent in residents of the low altitude zone by 2.3% compared to those living in the low altitude zone. The changes obtained are not statistically significant.

At the same time, DBP in male students exhibits a wave curve, which tends to increase in students of Group 3, but the changes are insignificant and do not exceed the average statistical standard values. DBP in healthy people is not supposed to exceed 65±10 mm Hg. The data obtained are not statistically significant (Fig. 2).

DBP parameters depend on peripheral resistance. The greater the resistance of the artery walls, the higher the heart rate. Also, the lower the elastic resistance of the walls of large arteries, the higher the diastolic pressure. In our case, this statement is applicable to male students only. Female students living in the low and mid altitude zones showed an inverse pattern associated with decreased diastolic pressure.

We also calculated HR, as it is an important parameter of the state of both the cardiovascular system and the blood and respiratory systems.

The HR stability at rest indicates normal functioning of these systems.

The scientists state sex differences in the HR regulation: statistically, HR in females is higher than that in males [8].

Increased HR was found to be more frequent in female students living in the low altitude and mid altitude zones (by 3.5 and 4.4 %, respectively) compared to female residents of the plain zone. The changes observed are statistically significant ($P < 0.05$).

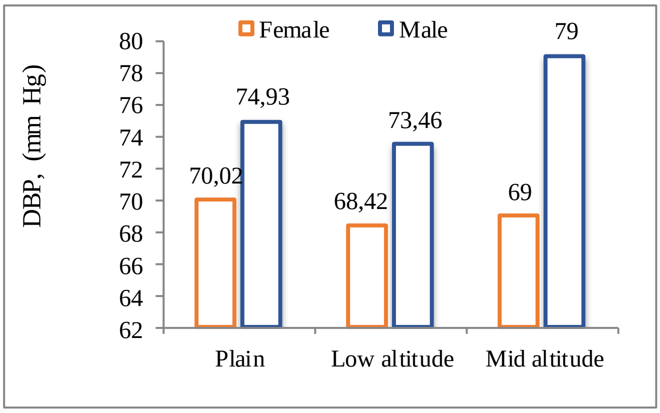

Fig. 2. Dynamic nature of DBP in students of different sex–living in the plain, low altitude and mid altitude zones

Tachycardia in females indicates the cardiovascular system strain associated with excitation of the sympathetic division of the autonomic nervous system.

Male residents of the low and mid altitude zones exhibited a decrease in arterial pulse compared to male residents of the low altitude zone. The data are statistically insignificant. Standard HR values of a healthy person aged 16 to 62 years are 68–72 bpm. According to this, HR parameters in all the students examined exceeded the physiological norm (especially in male students).

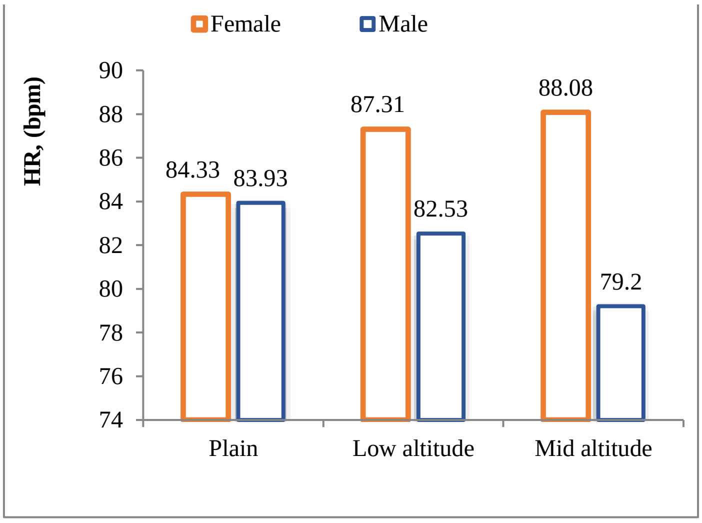

Fig. 3. Dynamic nature of HR in students of different sex living in the plain, low altitude and mid altitude zones

The HR parameters in male students showed a clear tendency towards a decrease in HR in students of Groups 2 and 3. Thus, we can conclude that the cardiovascular system of residents of the low and mid altitude zones is more adapted to changing conditions of the mountain climate (Fig. 3).

As it is known from literature sources, slow HR is characteristic of residents of the high altitude zone, which is due to low atmospheric pressure and ultraviolet radiation. The experimental data obtained show that hemodynamic parameters are closely related to the vegetative nervous system (VNS) and central nervous system (CNS), which are also interrelated [6, 11].

Heart rate and the level of blood pulse pressure during hypoxia are regulated by the VNS, which contributes to normal blood circulation [13].

Decreased HR leads to decreased MBV, which is characteristic of male residents (Group 2) of the low altitude zone.

Decreased MBV was also recorded in the group of female students living in the low altitude zone.

Regardless of sex, residents of the mid altitude zone (Group 3) showed a persistent increase in MBV.

It is known that increased systolic pressure causes an increase in MBV, which was observed in both male and female students of Group 3. An increase in MBV leads to an increase in blood supply due to blood redistribution [14].

As is known, the cerebral cortex is most sensitive to hypoxia (Fig. 4).

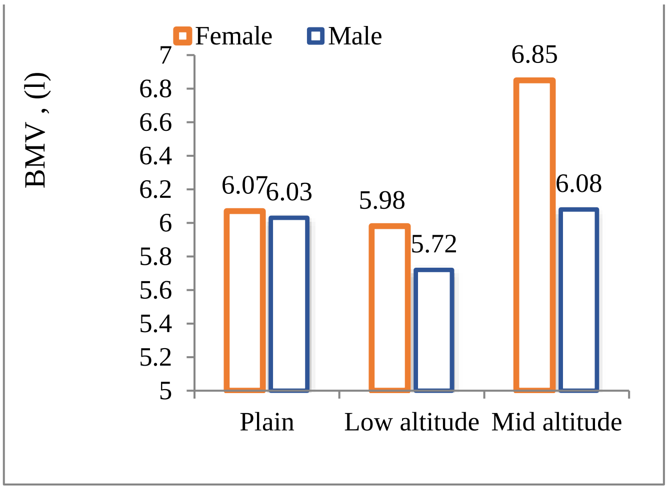

Fig. 4. Dynamic nature of MBV in students of different sex living in the plain, low altitude and mid altitude zones

RR in students of different groups was maintained within the average statistical norm (Fig. 5).

Residents of the mountains exhibit a much higher ventilation capacity of the lung tissue than those living in the low altitude zone. High altitude adaptation usually enhances respiratory function. This is due to the fact that oxygen dependence of the organism increases in the conditions of hypoxic hypoxia [4].

In our case, the highest RR was observed in students of Group 3 living in the mid altitude zone. The data obtained are statistically significant (P <0.02; P <0.001).

According to the literature data, increased RR is associated with reduced hypoxic resistance [12].

The study results are presented in Table 1.

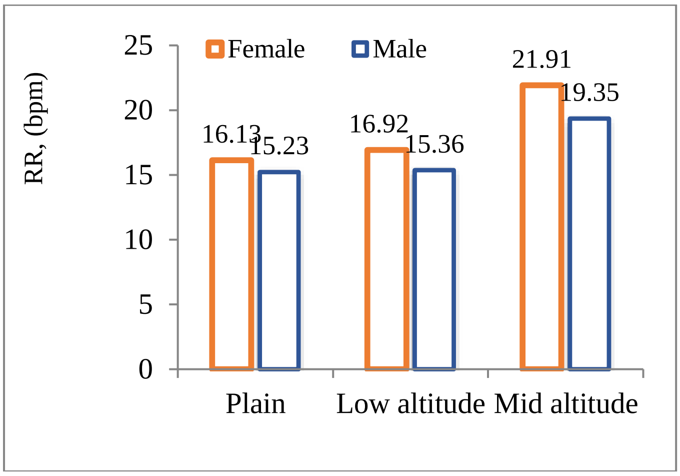

Fig. 5. Dynamic nature of RR in students of different sex living in the plain, low altitude and mid altitude zones

IV. Conclusion

1. When comparing the study results, we concluded that female residents of the low altitude zone showed decreased SBP, whereas those living in the mid altitude zone had higher SBP.

2. BP indicators in male students were significantly higher than those in female students in all the groups studied. In addition, we recorded a significant increase in SPB in residents of the mid altitude zone.

3. Male students exhibited mainly wave-like DBP, which tended to increase in students of Group 3, but the changes were insignificant and maintained within standard values.

4. Female residents of the low altitude and mid altitude zones showed an inverse pattern associated with a decrease in DBP.

5. HR was observed to increase more frequently in female residents of the low altitude and mid altitude zones (by 3.5% and 4.4%, respectively) compared to those living in the plain zone.

6. HR had a clear tendency to decrease in students of Groups 2 and 3.

7. All residents of the low altitude zone exhibited decreased MBV.

8. The lowest HR was recorded in residents of the plain zone, and the highest one was observed in those living in the mid altitude zone.

TABLE I. COMPARISON OF THE HEMODYNAMIC PARAMETERS OBTAINED FOR THREE GROUPS OF STUDENTS LIVING IN DIFFERENT CLIMATE AND GEOGRAPHICAL ZONES

Indicators	Sex	Group					
		1		2		3	
		Plain		*Low altitude*		*Mid altitude*	
		F (n=134)	*M (n=34)*	*F (n=87)*	*M (n=13)*	*F (n=12)*	*M (n=5)*
SBP, mm Hg	F	111.17±11.986		110.35±11.424		112.00±12.449	
	M	125.39±10.550		127.46±11.185		135.80±7.120*	
DBP, mm Hg	F	70.02±9.005		68.42±10.273		69.00±70.500	
	M	74.93±9.931		73.46±6.995		79.00±17.088	
HR, bpm	F	84.33±11.533		87.31±10.855*		88.08±8.479*	
	M	83.93±14.195		82.53±11.841		79.20±8.339	
BMV, l	F	6.07±1.381		5.98±1.228		6.85±8.114	
	M	6.03±1.121		5.72±1.120		6.08±8.114	
BR, bpm	F	16.13±5.234		16.92±5.512		21.91±6.631***	
	M	15.23±4.135		15.36±4.648		19.35±5.734**	

Statistical significance of cardiorespiratory indicators in 3 groups of students: * – P<0,05; ** – P<0,02; *** – P<0,001

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