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INDICATORS OF THE CARDIOVASCULAR SYSTEM IN THE CAUCASIAN RESIDENTS OF MAGADAN REGION DEPENDING ON THE TERM OF RESIDING UNDER CONDITIONS OF RUSSIA' NORTHEAST

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ABSTRACT

The climatic conditions of the North have been forcing the human body to use additional social and biological means of protection against the adverse effects of environmental factors. It should be noted that, first of all, the cardiorespiratory system undergoes the influence of these abiotic factors. In this regard, the purpose of the research was to study and identify the characteristics of the cardiovascular system in young male residents of Magadan Region who differ in terms of residence in the northeast of Russia. 1632 young male subjects aged 17 to 21 and permanently residing in the city of Magadan, were examined in 2005–2017 using standard methods for determining cardiovascular parameters. Depending on the length of residing in the region all the subjects were divided into 4 groups. They represented three generations as well as migrant Caucasians who were not born in Magadan Region but came there from the central regions of the country. Residents of the northeast of Russia with short periods of residence in the North demonstrated a state of stress in the cardiovascular system manifested by an increase in systolic pressure, total peripheral vascular resistance, heart rate, and a decrease in the blood stroke volume. At the same time, the representatives of the 3rd generation had better functioning of the system. They were significantly lower in blood pressure (both systolic and diastolic) and the heart rate. In addition, the subjects of this group had minimal cardiac output, which indicated a more economical functioning of the cardiovascular system in the conditions of the northeast of Russia.

Keywords: cardiovascular system, generations of residence in the North, adaptive changes

The territory of Magadan Region that is located in the northeast of Russia (59.33 northern latitude) belongs to the subarctic region (55-66.5 north latitude) according to modern concepts of circumpolar regions [20]. Circumpolar regions create a unique set of negative environmental factors affecting humans, including prolonged and severe cold stress with negative monthly temperatures, which in some regions may drop to -40C° [20]. Living in the conditions of the northeast of Russia can be considered as life with additional functional tension. So the climatic characteristics of the North are defined by researchers as uncomfortable, severe [1], and even extreme [12] as they make significant demands to the human body, forcing it to use additional social and biological means of protection against unfavorable environmental factors [18].

The physiological mechanisms of adaptation changes in the cardiovascular system under northern conditions have been studied fairly well and are presented in numerous works [3, 4, 7, 19]. The results of such studies are aimed at creating the conditions for maintaining health and increasing the life expectancy of people living and working in the arctic and subarctic climatic zones under unfavorable natural conditions [4]. At the same time, much less attention is paid to the study of adaptive rearrangements in the activity of the cardiovascular system in different periods of residence under the northern conditions.

The circulatory system serves as a marker of the nature of the adaptation processes in the body and is one of the first to reflect a state of stress, exhaustion, and pathology [10]. Acute exposure to cold is associated with a decrease in peripheral blood flow and an increase in metabolic heat production to maintain body temperature. The vasomotor response of the cardiovascular system is mediated by sympathetic activation directed toward peripheral vasoconstriction which results in the body heat loss decrease at the expense of a decrease in peripheral blood flow [16]. This is a necessary term for the functioning of the cardiovascular system since peripheral cold stress due to sympathetically controlled vasoconstriction increases arterial pressure by increasing the peripheral resistance [17]. Of note that chronic vasoconstriction leads to the development of hypertension [15]. At the end of the 20th and beginning of the 21st centuries, the identification and study of the mechanisms of the development of early stages of hypertension, called "near-disease" or "prehypertension" became of special relevance. This condition is more often demonstrated by young men [14; 22]. According to the authors, one of the prenosological conditions is the so-called "high normal pressure" of 130-139 / 85-89 mm Hg [23].

Based on the above, the **purpose** of this work was to study the cardiovascular system in young residents of Magadan region differing in terms of residence in Russia' northeast.

Materials and methods. By random sampling, 1,632 young men aged 17 to 21, permanent residents of the Magadan Region, were examined. Depending on the term of residence in the territory of Magadan Region all the examinees were divided into 4 groups. The I group (n = 62) included migrant-Caucasians moved here from the central regions of the country and characterized by a short period of residence in the North (average 7.1 ± 1.3 years). We designated this group as the "zero generation". The II group included those born in Magadan Region in the 1st generation from among Caucasians but whose parents were migrants (n = 924). The III group included young people born

in the region in the second generation (n = 580) whose parents were born in the territory of Magadan region in the 1st generation. And the IV group are the subjects with the longest term of residence in Magadan region, which are representatives of the population that is just starting to form (due to the "relative youth" of our region). They are young males of the third generation (n = 66) whose parents belong to the representatives of the 2nd generation. All studies were conducted between 2005 and 2017.

Characteristics of the cardiovascular system were determined using an automatic blood pressure tester Nessei DS-1862 (Japan). The systolic (BP_S, mmHg) and diastolic (BP_D, mmHg) values of arterial pressure were measured at rest as well as the heart rate (HR, bpm). In addition, the Starr stroke volume (SV, mL), cardiac output (CO, L/min) and the total peripheral vascular resistance (TPVR, dyne^2 s cm^{-5}) were calculated [11].

Results and discussion. The parameters of the cardiovascular system in young men with different degrees of adaptation to the conditions of Russia's northeast are presented in the table. Our study has found the young male subjects of the 0th generation to be very close to the upper limit of the normal systolic blood pressure. These values reflected high normal blood pressure [21] and significantly exceeded the indices typical for residents of the central part of the country and the European North [2, 9, 13]. We have concluded before that, modern young male Caucasians of Magadan region are oriented towards hypertensive values in their blood pressure [6]. The reaction of the cardiovascular system in individuals with the shortest period of adaptation to the conditions of the northeast of Russia was due to the increased systolic blood pressure. We assumed the latter to be a compensatory mechanism under the action of low ambient temperatures. It should be noted that the young male residents among the representatives of the third generation characterized by the longest period of residence in the Northern conditions demonstrated the lowest indices of the arterial pressure against the backdrop of the lowest values of the total peripheral resistance of the vessels.

Statistically higher heart rate indices were observed in groups of young men of the 0th, 1st, and 2nd generation, relative to their age mates from among the representatives of the 3rd generation. It is known that a faster heart rate is potentially unfavorable for the optimal circulatory state, in particular, due to the shortening of the period of the diastolic phase and the increased tension with respect to the cardiac output (CO) which is metabolically much more expensive for the body, requires a significant increase in oxygen intake [5], and indirectly may indicate a reduced effectiveness in the work of the cardiovascular system. Cardiac output is an extremely important variable in the cardiovascular system which is constantly regulated so that the this system can satisfy the gas transporting needs of the organism at particular time, and the higher the potential energy expenditure of the organism, the more pronounced the proportional increase in CO. From this position, the lower values of this indicator in the group of young men, the representatives of the third generation who are most adapted to the abiotic factors of the North, have become clear, which is consistent with the principle of economizing the energy functions of the organism in conditions of extreme climatic characteristics. In the series from the 0th generation to the 3rd generation, a significant dynamics of the increase in the blood stroke volume was noted, which reflects the effective provision of the blood cardiac output circulation due to the high value of the stroke volume against the significantly lower values of heart rate in the young male subjects of the 3rd generation.

Conclusion. The analysis has shown, that Russia' northeast subjects with short periods of residence in the North have been experiencing the state of stress in the cardiovascular system manifested by an increase in systolic pressure, total peripheral vascular resistance, heart rate, and a decrease in the blood stroke volume. At the same time, the representatives of the 3rd generation have demonstrated more optimal parameters in the work of the system, which is seen in significantly lower values of the arterial pressure (both systolic and diastolic), and the heart rate. In addition, the subjects of this group have had minimal blood cardiac output, which indicates a more economical functioning of the cardiovascular system under Russia' northeast conditions and characterizes the strategic orientation of adaptive rearrangements associated with the body functional systems' energy minimization under the cold factor, which is well shown in animal studies [8]. In this regard, the direction of changes in the circulatory system has become reasonable. The tension of the system functioning in migrants proved to be significantly higher than that of representatives of the 1st and the subsequent generations. At the same time, the vector of functional physiological rearrangements among migrants and different generations of the north born Caucasians allows us to state that in the current conditions, a new population is forming in the northeast of Russia which we have designated as rooted individuals.

References

1. Agadzhanjan N.A. Ermakova N.V. Jekologicheskij portret cheloveka na Severe [Ecological portrait of a man in the North]. Moscow: KRUK, 1997, 212 p. http://www.biblus.ru/Default.aspx?book=876a1i1i1

2. Buduk-ool L.K. Ajzman R.I. Sravnitel'naja dinamika kardiorespiratornoj sistemy studentov Juzhno-Ural'skogo regiona [Comparative dynamics of the cardiorespiratory system of students of the South Ural region]. Rossijskij mediko-biologicheskij vestnik im. I.P. Pavlova [I.P. Pavlov Russian Medical and Biological Bulletin]. 2008, № 4, pp. 28-33. https://elibrary.ru/item.asp?id=12229750

3. Djomin D.B. Klimatojekologicheskie uslovija severnyh territorij i ih vlijanie na serdechno-

Cardiovascular system indices in subjects with different rates of adaptation to the conditions of the northeast of Russia (M ± m)

Parameter	Examined subjects				Significance of differences among examined groups					
	0th generation (1). n = 56	1st generation (2) n = 924	2nd generation (3) n = 580	3rd generation n = 66	I–II	II–III	III–IV	I–III	I–IV	II–IV
BPS. mmHg	129.7±0.6	128.0±0.4	128.0±0.4	127.8± 0.8	p=0.18	p=1.00	p=0.94	p=0.18	p<0.05	p=0.86
BPD. mmHg	77.1±1.0	76.0±0.3	75.0±0.3	71.8 1.2	p=0.29	p<0.05	p<0.001	p<0.05	p<0.001	p<0.001
HR. bpm	78.2±1.1	79.6±0.4	79.0±0.5	71.8 1.6	p=0.61	p=0.34	p<0.001	p=0.32	p<0.001	p<0.001
SV. mL	69.8±1.3	70.4±0.3	71.1±0.3	75.1 1.0	p=0.48	p=0.09	p<0.001	p=0.19	p<0.001	p<0.001
CO. L/min	5594.5±92.5	5575.2±34.3	5510.6±43.8	5362.3±96.6	p=0.82	p=0.24	p=0.26	p=0.39	p<0.05	p<0.05
TPVR. dyn2 s cm-5	1579.6±46.1	1532.9±12.5	1467.4±14.8	1434.1±31.1	p=0.32	p<0.05	p=0.33	p<0.05	p<0.05	p<0.05

sosudistuju i nervnuju sistemy cheloveka [Climatological conditions of the northern territories and their influence on human cardiovascular and nervous systems]. Vestnik Ural'skoj medicinskoj akademicheskoj nauki [Bulletin of the Ural Medical Academic Science]. 2014, № 2, pp. 20-25. https://elibrary.ru/item.asp?id=21615143

4. Evdokimov V.G. Rogachevskaja O.V. Varlamova N.G. Modulirujushhee vlijanie faktorov Severa na kardiorespiratornuju sistemu cheloveka v ontogeneze [Modulating influence of factors of the North on cardiorespiratory system of the person in ontogenesis]. Ekaterinburg: UrO RAN, 2007, 257 p. https://elibrary.ru/item.asp?id=19494959

5. Moshhich P.S. Sidel'nikov V.M. Krivchenja D.Ju. [i dr.] Kardiologija detskogo vozrasta [Cardiology of childhood]. Kiev: Zdorov'ja, 1986, 400 p. https://search.rsl.ru/ru/record/01001336282

6. Maksimov A.L. Suhanova I.V. Vdovenko S.I. Funkcional'nye osobennosti organizma junoshej i devushek, zhitelej razlichnyh klimatogeograficheskih zon Magadanskoj oblasti [Functional profiles of the organism of young men and women residing in different climatic geographic areas of Magadan Region]. Rossijskij fiziologicheskij zhurnal im. I.M. Sechenova [I. M. Sechenov Russian Journal of Physiology]. 2012, V. 98, №. 1, pp. 48-56. https://elibrary.ru/item.asp?id=17697768

7. Semjonova E.I. Krivoshapkina Z.N. Olesova L.D. [i dr.] Ocenka pokazatelej gemodinamiki u zhitelej arkticheskoj zony s pozicii «Zolotogo sechenija» [Assessment of hemodynamics in residents of the Arctic zone from the position of the "Golden Section"]. Yakut Medical Journal, 2018, № 2, pp. 22-25. https://doi.org/10.25789/YMJ.2018.62.07

8. Pastuhov Ju.F. Maksimov A.L. Haskin V.V. Adaptacija k holodu i uslovijam Subarktiki: problemy termofiziologii [Adaptation to the cold and conditions of the Subarctic: problems of thermophysiology]. Magadan: SVNC DVO RAN, 2003, V. 1, 373 p. https://elibrary.ru/item.asp?id=19488956

9. Pushkina V.N. Gribanov A.V. Sezonnye izmenenija vzaimootnoshenij pokazatelej kardiorespiratornoj sistemy u junoshej v uslovijah cirkumpoljarnogo regiona [Season-related changes in the relations between cardiorespiratory parameters in young men in the circumpolar region]. Jekologija cheloveka, 2012, №. 9, pp. 26-31. https://elibrary.ru/item.asp?id=17930062

10. Rappoport, Zh. Zh. Adaptacija rebjonka na Severe [Child's Adaptation in the North]. Leningrad: Medicina, 1979, 192 p. https://search.rsl.ru/ru/record/01007819008

11. Jur'ev V.V. Simahodskij A.S. Voronovich N.N. [i dr.] Rost i razvitie rebenka [Growth and development of the child]. Moscow-SPb: Piter, 2003, 272 p. http://bookre.org/reader?file=1477715

12. Chashhin V.P. Gudkov A.B. Popova O.N. [i dr.] Harakteristika osnovnyh faktorov riska narushenij zdorov'ja naselenija, prozhivajushhego na territorijah aktivnogo prirodopol'zovanija v Arktike [Characteristics of the main risk factors of health disorders of the population living in the territories of active nature management in the Arctic]. Jekologija cheloveka, 2014, № 1, pp. 3-12. https://elibrary.ru/item.asp?id=21309456

13. Gapon L.I. Shurkevich N.P. Vetoshkin S.A. [i dr.] Hronobiologicheskaja harakteristika ritmov arterial'nogo davlenija u bol'nyh arterial'noj gipertoniej: desinhronoz kak faktor formirovanija bolezni v uslovijah vahty na Krajnem Severe [Chronobiological characteristics of the rhythms of arterial pressure in patients with arterial hypertension: desynchronosis as a factor of disease formation in conditions of shift work in the Far North]. Kardiologija, 2011, №. 3, pp. 54-60. http://www.medalmanac.ru/ru/old/archive/year2011/number_16/cardiology/2247

14. Carrington M. Prehypertension causes a mounting problem of harmful cardiovascular disease risk in young adults. J. Hypertension, 2009, V. 2, pp. 214-215. https://doi.org/10.1097/hjh.0b013e328325d1a0

15. Kaplan N.M. Stress, the sympathetic nervous system and hypertension. J. Human Stress, 1978, v.4, pp. 29-34. https://doi.org/10.1080/0097840x.1978.9934993

16. Milan F.A. Elsner R.W. Kaare R.Thermal and metabolic responses of men in the Antarctic to standard cold test. J. Appl Physiol, 1961, v.16, pp. 401-404. https://doi.org/10.1152/jappl.1961.16.3.401

17. Pickering T.G. Gerin W. Cardiovascular reactivity in the laboratory and the role of behavioral factors in hypertension: a critical review. Ann. Behav. Med, 1990, v.12, pp. 3-16. https://doi.org/10.1207/s15324796abm1201_1

18. Risikko T. Makinen T. Hassi I. Assessment and management of cold risks in construction industry. Barents, 2001, v.4, №1, pp. 18-20. http://medtsu.tula.ru/mng/tpvm2015.pdf

19. Harinath K. Malhotra A.S. Karan P. [et al.] Sawhney Autonomic Nervous System and Adrenal Response to Cold in Man at Antarctica. Wilderness & Environmental Medicine, 2005, v.16, № 2, pp.81-91. https://doi.org/10.1580/pr30-04.1

20. Snodgrass J.J. Health of Indigenous Circumpolar Populations. Annual Review of Anthropology, 2013, v.42, I.1, 21 Oct, pp.69-87. https://doi.org/10.1146/annurev-anthro-092412-155517

21. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 Report-Correction. JAMA, 2003, v. 290, pp. 192-197. https://doi.org/10.1001/jama.290.2.197

22. Toprak A. Wang H. Chen W. [et al.] Prehypertension and black_ white contrasts in cardiovascular risk in young adults: Bogalusa Heart Study. J. Hypertension, 2009, v.2, pp. 243-250. https://doi.org/10.1097/hjh.0b013e32831aeee3

23. Vasan R.S. Larson M.G. Leip E.P. [et al.] Assessment of frequency of progression to hypertension in non-hypertensive participants in the Framingham Heart Study: a cohort study. Lancet, 2001, v. 358, pp. 1682-1686. https://doi.org/10.1016/s0140-6736(01)06710-1

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