MEDICAL AND BIOLOGICAL ASPECTS RELATED TO ASSESSMENT OF IMPACTS EXERTED BY RISK FACTORS

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ASSESSING TENSION COEFFICIENT OF BODY ADAPTATION RESERVES UNDER CHRONIC EXPOSURE TO FACTORS EXISTING IN POLAR REGIONS

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When northern territories are divided into different zones, it is conventionally done as per a geographic approach. However, according to some researchers, the issue is to be considered within a more complex approach. Experts at «Arktika» Scientific Research Center of the RAS Far East Division suggested a procedure for determining a degree of environment discomfort; the procedure included assessing several factors: natural and climatic, economic-geographic, socioeconomic ones and factors related to the environment on a territory being suitable for living.

Our research goal was to assess tension coefficients of basic physiological systems and functional state of young people living in the North, in different Far East regions.

We applied random sampling and examined 1,632 young males aged from 17 to 21 who permanently resided in Magadan region. Similar groups made up of Caucasian young males were examined in Susuman settlement (n = 88) and Anadyr in Chukotka Autonomous Area (n = 65). We analyzed basic functional parameters of the cardiovascular system, microcirculation, external breath functioning, gas analysis, biochemical and microelement profile of a body.

Comparative analysis of all the obtained data reveal that Magadan city territory which is considered to belong to Zapolyarye (extreme climatic conditions) is no less uncomfortable, and in some relation even more uncomfortable, as per medical and biological parameters than subarctic territories in Magadan region (Susuman) or arctic zone (Anadyr, Chukotka) as it is shown by calculated discomfort coefficient. Accordingly, aggregated discomfort coefficients amounted to 3.21 arbitrary units in Magadan; 3.42 arbitrary units, in Susuman; 2.90 arbitrary units; in Anadyr (Chukotka); 0.46 arbitrary units, in Central Russia.

Given all the above stated, we believe that Magadan region territory can be considered a territory with a high discomfort degree.

Key words: *young males living in north-eastern Russia, functional reserves, adaptation, cardiovascular system, external breath, gas analysis, microelements.*

Ecological-climatic conditions in the arctic zones produce specific effects on functional systems in a human body as they require considerable efforts aimed at preserving its internal environment. Special attention should be paid to external breath as being the first system in a body exposed to negative impacts exerted by cold air as well as to possible changes in metabolism in people who have been residing under extreme climatic conditions for a long time. The cardiovascular system is among the most significant ones that reflect how well a person is adapted to extreme conditions in the arctic zones.

The cardiovascular system is a complicated transport structure and its main function is supplying metabolizing tissues with oxygen. Microcirculation is aimed at providing oxygen delivery in accordance with metabolic demands of an overall body; perfusion pressure is a key element in the microcirculatory system [1]. Functional properties of microcirculation primarily depend on its angioarchitecture (vessels morphology and location). Microcirculation undergoes constant dynamic structural adaptation (remodeling) that is controlled by hemodynamic and metabolic stimuli [2]. Func-

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tional state of the capillary lumen and lability of microcirculation dynamic properties create conditions that are necessary for circulation being able to adapt to external loads [3].

People's live activities are closely interconnected with chemical structure of the environment and contents of various macro- and microelements in it; these elements participate in formation of several most significant adaptive mechanisms in a human body [4]. Assessment of chemical elements metabolism that occurs in a body allows making precise judgments on how efficient its morphologic systems are and on risks of various pathologic states. It gives an opportunity to use such assessment as a pre-nosologic diagnostic tool [5].

Here it is necessary to take into account the fact that environmental factors can exert different impacts, starting from moderate cold pressure to extreme combined influence on a whole body. Specific climate in the arctic zones undoubtedly makes adaptation «much more expensive» and not all people can adapt successfully [6]. Northern-Eastern regions in Russia are vast territories that differ significantly in terms of ecological and climatic conditions as well as effects produced by abiotic factors on people. Magadan region (MR) can be divided into several subzones that are significantly different from each other; there is a coastal subzone (Magadan city) which is cyclonal, with constant winds and relatively high temperature during cold season (-15 ^{o}C); and then there is a continental subzone (Susuman city) where there are practically no winds but there are extreme temperatures, both in summer (+36 ^{o}C) and in winter (-53 ^{o}C) and relatively low humidity [7]. We should also mention a coastal subzone in the Chukotka Autonomous Area (Anadyr) that belongs to the subarctic climatic zone [8, 9]. These unfavorable conditions make people use additional protection from influence exerted by environmental factors [10].

Starting from the 2nd half of the last century, there has been a permanent trend in the North-Eastern Russia, namely, creation of a permanent population consisting of people born in other parts of the country and belonging to eastern Slavs ethnic group. The existing demographic situation in Magadan region is predetermined by two phenomena; the first one is persisting decrease in population (by 6.04 % from 2014 to 2019); the second one is creation of permanent population that is a positive demographic factor necessary for industrial development of the region.

Young people aged 17−23 who don't have any diagnosed chronic diseases, with already stabilized sexual development and their health being «conditionally good» are the most interesting for researchers as a model for assessing influence exerted by a set of natural and social factors on population living in northern regions.

Therefore, **our research goal** was to assess tension coefficients for basic physiological systems responsible for the overall functional state among young people living in different Far East regions in the country.

Data and methods. We examined 1,632 young males aged 17−21 who were selected via random sampling; they all permanently resided in Magadan region. The same group of young male Caucasians was examined in Susuman (n = 88) and Anadyr in the Chukotka Autonomous Area (n = 65).

External breath functional parameters (EBFP) were registered in an open system built according to «volume – flow» principle with «Diamant-S» KM-AP-01 computer spiroanalyzer (Russia). Due values were calculated in accordance with the conventional standards for spirography samples assessment accepted in the Russian Federation [11]. We applied several parameters to assess tension intensity in the respiratory system; they were instantaneous volume velocity 25 % or IVV25 %, a velocity occurring at a point 25 % from FVC; IVV59 %, at a point 50 % from FVC; and IVV75 %, at a point 75 % from FVC;. The parameters were compared with due values with «Diamant-S» KM-AP-01 computer spiroanalyzer (Saint Petersburg, Russia).

To assess tension in gas exchange parameters in young males being in a rest state, we applied MedGraphics VO2000 metabolic system (the USA); the device operates according to «indirect calorimetry» procedure [12]. We determined energy expenses in a rest state per day (REE, kcal/day) and compared with a due value (REE/Ped, %).

Tension in the cardiovascular system functioning was assessed basing on its parameters via measuring systolic (SBP, mm Hg) and diastolic (DBP, mm Hg) blood pressure with Nessei DS–1862 automatic tonometer (Japan) as well as on examining capillary structure and microcirculation in skin swelling near the nail bed with «Capillaroskan-1» computer capillaroscope («New Energy Technologies» LLC, Skolkovo, Moscow). The device was equipped with an optic probe with x200-400 magnification. All the tests were performed on sitting participants under comfortable temperature that varied from 22 to 25; all participants had their arms used for measuring located at the same level as their hearts [13]. Morphologic properties were calculated with software installed on the devices. We analyzed several morphofucntional parameters of microcirculatory vessels, namely arterial section diameter (μm), venous section diameter (μm), capillary length (μm), and deformation coefficient (arbitrary units).

Tension in the biochemical profile was assessed via determining dextrose contents (mmol/g) in capillary blood taken on an empty stomach in the morning 10–12 hours after the last meal; the test was performed with Cardio-Chek PA potable biochemical express-analyzer (The USA).

A promising trend in up-to-date medicine is examining an elemental "profile" of people living in specific biogeochemical regions in order to develop and implement activities aimed at eliminating detected disorders in microelement balance [14]. Changes in elemental state that are short-term regarding exposure to them but significant in terms of deviations from normal elemental state can be estimated with microelements concentrations in liquid media in a human body. Solid tissues (hair, nails, or bones) can be used to estimate elemental state that exists over a long-term period (weeks, months, or years); they are also applicable in clinical and hygienic pre-nosologic diagnostics, including assessment and monitoring performed at population level.

We estimated excess or deficient concentrations of chemical elements in a body via examining concentrations of the following micro- and macro-elements: Ca, Mg, Cr, I, Mn, Co, Se, Zn, Cu, Fe, K; the concentrations were estimated in hair taken from the occipital region with ICP-MS on NexION 300 ICP-MS device (Perkin Elmer, Shelton, CT, USA) at a laboratory of «Micronutrients» LLC (Moscow).

Data were statistically processed with Microsoft Excel standard software, StatSoft Statistica 6.0, Statistica 7.0, and IBM SPSS Statistica 21 applied software. We calculated mean values (M), error of the mean (±m), and median (Me). Distribution of measured variables was tested in order to determine whether it was normal basing on Shapiro-Wilk test. Significance of discrepancies was estimated as per non-parametric Mann-Whitney test for samplings with abnormal distribution. All deviation parameters were reduced to uniformity in order to make comparisons more comfortable and were measured in % of the physiological standard or conventional reference values. Then, coefficients showing «adaptation costs» were calculated as per a total share of deviations for each functional system separately and for the regions as a whole.

To make comparisons, we included literature data on several central regions in the country (Moscow, Yaroslavl, Vladimir, Tambov regions as well as Kazan and Groznyy cities) into our calculation [15–20].

All the examinations were performed in conformity with the principles stated in Helsinki Declaration and the Federal Law «On the basics of citizens health protection in the RF» issued on November 21, 2011 No. 323[1], and the Federal Law «On personal data» issued on July 27, 2006 No. 152[2]. Before being included into the research, all participants voluntarily gave their written informative consent.

[1] On the basic of citizens' health protection in the RF: the Federal Law issued on November 21, 2011 No. 323. *KonsultantPlus*. Available at: http://www.consultant.ru/document/cons_doc_LAW_121895/ (09.01.2020) (in Russian).

[2] On personal data: the Federal Law issued on July 27, 2006 No. 152. *KonsultantPlus*. Available at: http://www.consultant.ru/document/cons_doc_LAW_61801/ (09.01.2020) (in Russian).

Results and discussion. To examine tensions in cardiovascular system functioning basing on blood pressure, all participants were divided into 4 groups according to recommendations given by the European Society of Cardiologists (ESC) 2018 [21]. Having distributed young males from Magadan as per their blood pressure, we revealed that 19 % had optimal blood pressure; 30 %, normal; 27 %, high normal blood pressure (pre-hypertension); and 24 % had stage 1 arterial hypertension. 21 % of young males from Susuman had optimal blood pressure; 42 %, normal; 21 %, high normal blood pressure (pre-hypertension); and 16 % had stage 1 arterial hypertension. Optimal and normal blood pressure was detected in 29 % examined young males from Anadyr; 34 % had high normal blood pressure (pre-hypertension); and 8 % had signs of stage 1 arterial hypertension. Frequency of young males with high normal blood pressure and stage 1 arterial hypertension was taken as tension in cardiovascular system functioning; it amounted to 51 % among young males from Magadan; 37 %, from Susuman; and 42 %, from Anadyr. Figure 1 shows the results.

We assessed tension in capillary structure and microcirculation via comparing the obtained results with standard values given in the following works [13, 22]; standard ranges taken from them are as follows: arterial section diameter should be from 7 to 17 μm (11.91 ± 1.87 μm on average); venous section diameter, from 11 to 20.6 μm (15 ± 2.42 μm on average); capillary length, from 92 to 295 μm (240 ± 38.3 μm on average).

Arterial section diameter amounted to 8.4 ± 0.1 μm in examined young males from Magadan and it was 29 % lower than the standard value mentioned above. Venous section diameter was equal to 12.1 ± 0.20 μm and it was 19 % lower than the standard, but capillary length was 310.0 ± 5.3 μm or 30 %, higher than the standard and it was accompanied with deformation coefficient amounting to 35.0 ± 0.9 arbitrary unties. A sum of these deviations from standards values amounted to 113 % without taking negative or positive sign into account; we considered it as tension in the microcirculation system.

Young males from Susuman had the following average microcirculation parameters: artery section diameter being equal to 8.1 ± 0.1 μm (by 32 % lower than the standard value); venous section diameter, 11.8 ± 0.2 μm (by 21 % lower); capillary length, 325.7 ± 5.6 μm (by 35 % higher than the standard value); deformation coefficient, 35.0 ± 0.9 arbitrary units. A total sum of deviations in morphofucntional vessels parameters amounted to 123 % for young males from Susuman. The same sum for young males from Anadyr also amounted to 123 %; it resulted from artery section diameter being by 21 % lower than the standards value (9.33 ± 0.3 μm); venous section diameter, by 5 % lower (17.3 ± 0.4 μm); capillary length being by 65 % longer (398.0 ± 14.3 μm), and deformation coefficient being equal to 32.5 ± 0.1 arbitrary units.

Figure 2 shows tension of body functional reserves regarding gas analysis parameters, external breath function, and biochemical profile in people living in different regions located in the Far East Federal District. Thus, tension in the external breath system becomes apparent via volume-velocity lung properties exceeding the due values; these parameters allows estimating patency of upper (IVV25, %), middle (IVV50, %), and lower bronchial tubes (IVV75, %). Having analyzed these properties, we revealed that young males from Magadan, Susuman, and Anadyr tended to have their IVV25 by 9 %, 4 %, and 8 % higher than the due values accordingly; IVV50, by 13 %, 11 %, 6 %; and IVV70, by 31 %, 50 %, and 14 %. A sum of deviations in IVV25, IVV50, and IVV75 from due values amounted to 53 % for young males from Magadan; 65 %, young males from Susuman; and 28 %, young males from Anadyr. Detected increase in REE/Ped % that amounted to 17 % against the due value for young males in Magadan, 31 % for young males from Sususman, and 15 % for young males from Anadyr was thought to be tension in the basic metabolism.

29 % young males from Magadan had their hyperglycemia higher than the standard value (5.6 mmol/l); the same was true for 48 % young males from Susuamn, and 57 % young males from Anadyr; we considered it to be apparent tension in biochemical profiles of the examined young males from different regions.

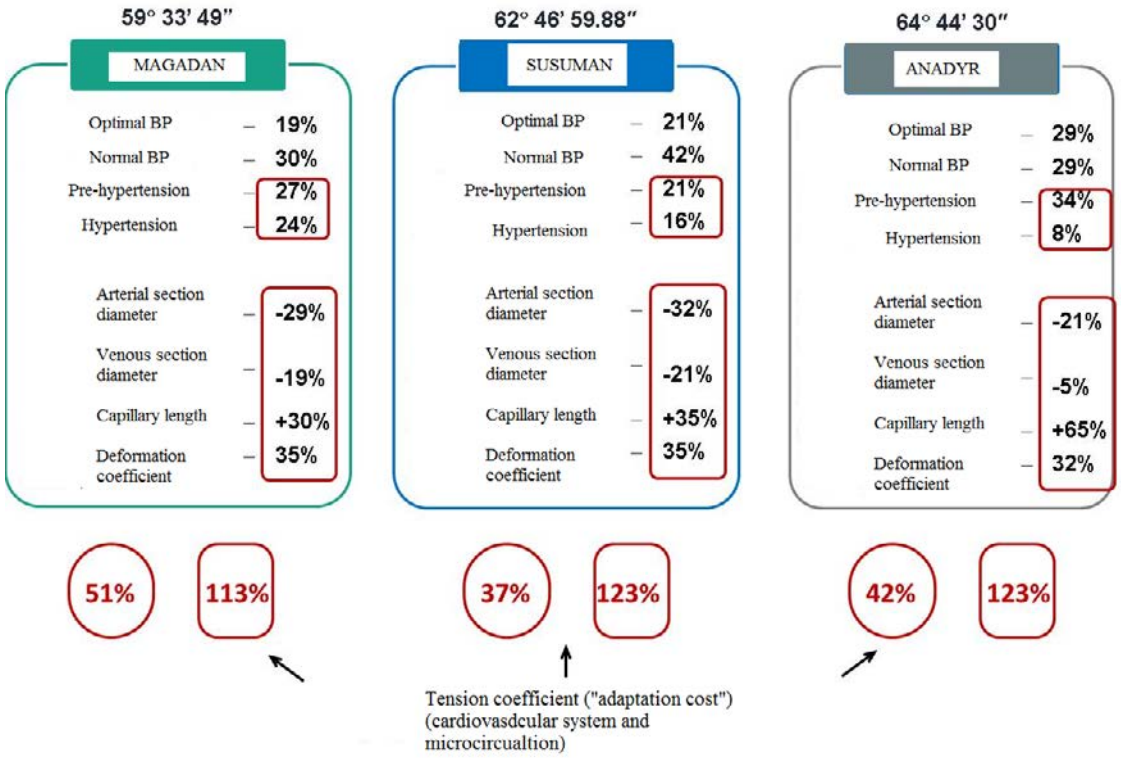

Figure 1. Tension in the cardiovascular system and microcirculation in young males from different regions in the Far East

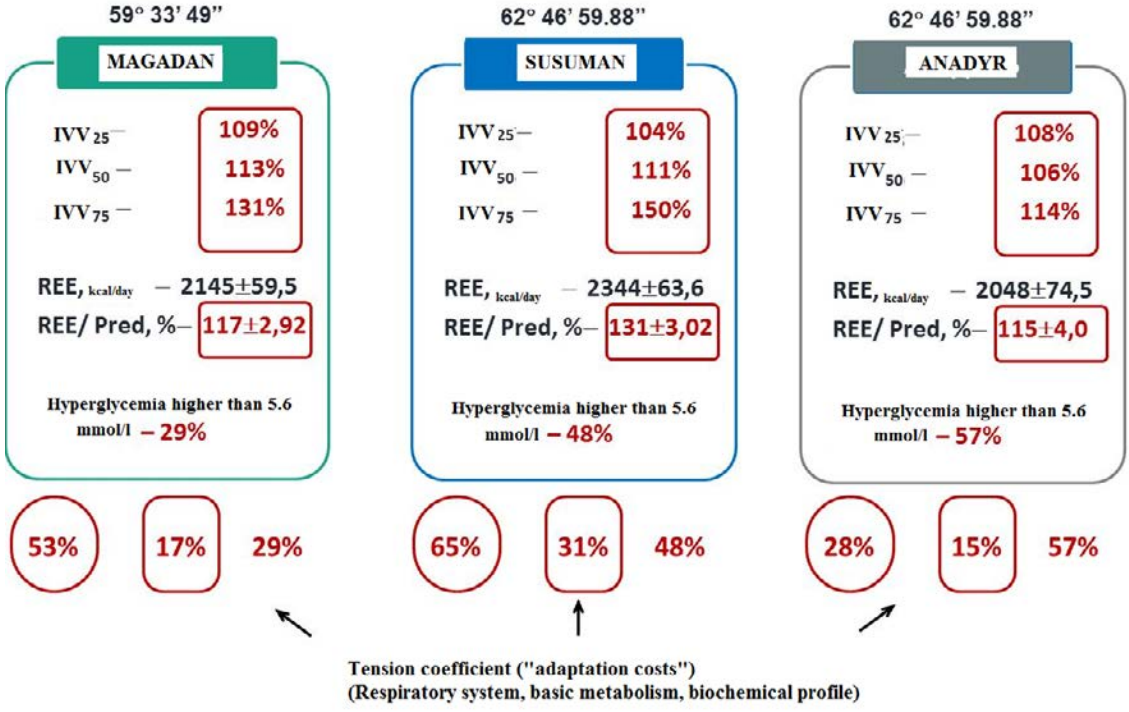

Figure 2. Tension in certain parameters of the external breath function, gas exchange, and biochemical profile in young males from different regions in the Far East

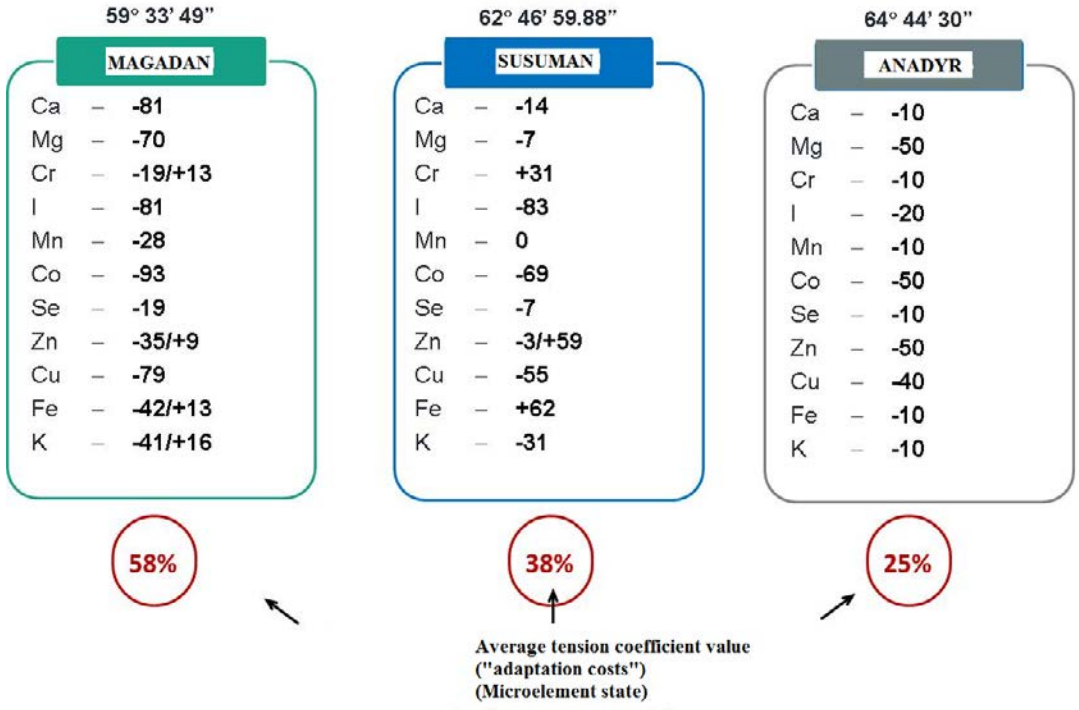

Figure 3. Tension in microelement profile of young males from different regions in the Far East

Figure 3 shows deviations from the standard values in microelement profiles of young males from different regions in the Far East; tension in the parameters was given as a sum of surpluses and deficiencies (divided by 100 to make calculations more convenient). It amounted to 58 % for young males from Magadan; 38 %, for young males from Susuman; and 25 %, for young males from Anadyr. All the examined young males had Co, Ca, Mg, and Se in their bodies in concentrations lower than the lower limit of reference values [23].

Figure 4 shows a combined profile of allosteric tension in body functional reserves of young males who live in zones with more favorable climatic conditions; the profile is drawn up as per results given by authors who performed their research in the Central regions in Russia [15–20]. Average tension as per analyzed parameters amounted for 45 % for people living in those regions and we took this value as a conditional standard.

Basing on the data shown in Figure 4, we calculated «adaptation costs» as a sum of tension coefficients for physiological systems; it was a sum of deviations from the physiological standards divided by 100 (Figure 5). A coefficient calculated for young males from Magadan amounted to 3.2 arbitrary units; young males from Susuman, 3.4 arbitrary units; young males from Anadyr, 2.9 arbitrary units; young males from central regions, 0.46 arbitrary units. Therefore, our data clearly indicate that more extreme climatic factors result in tension occurring in functioning of basic physiological systems in a body; it becomes apparent via apparent deviations from physiological standards.

To sum up, we performed complex estimating of basic parameters that described functional activities of body systems being in the greatest tension under exposure to unfavorable or extreme environmental factors. The results indicate that even people living in different northern regions have different functional state of their bodies. These differences are even more apparent when the examined parameters are compared to those of people living in the central part of the country. Our approach is based on determining tension in basic physiological systems functioning that becomes apparent via deviations in the examined parameters from physiological standards. We can recommend using it as a tool to determine an extent to which a body is adapted to extreme conditions in the arctic zones

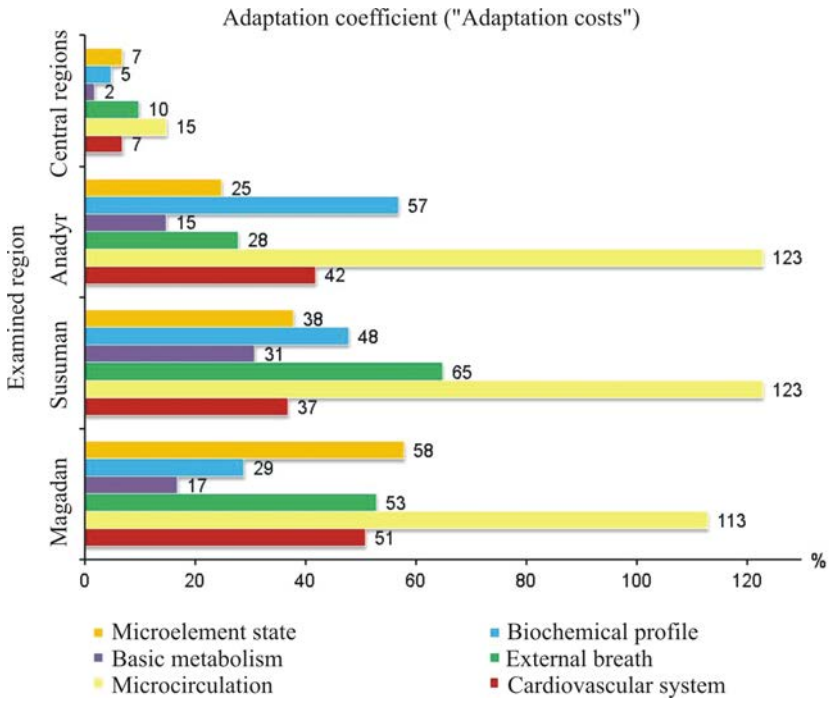

Figure 4. Aggregated pool of tension coefficients for the functional state of basic systems in young males from the Far East region in comparison with young people living in central regions in the country

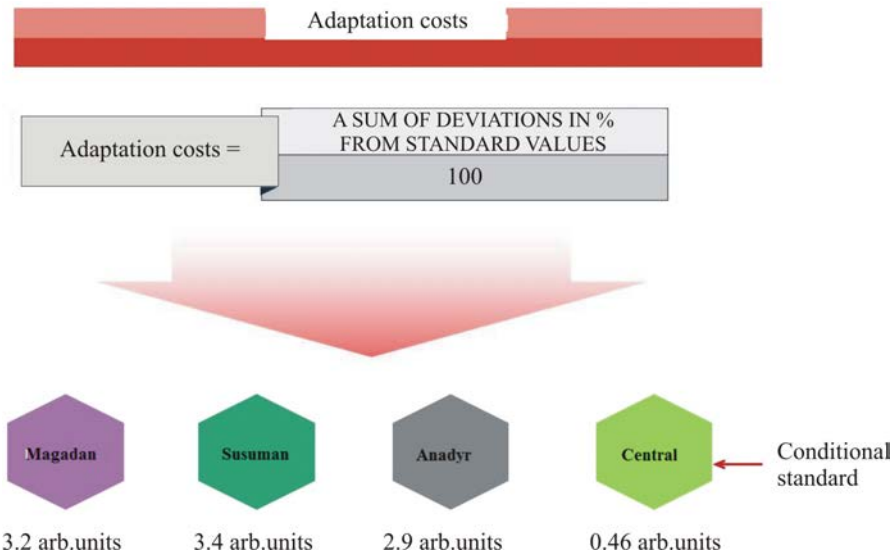

Figure 5. «Adaptation costs» coefficient in young males from Magadan, Susuman, Anadyr, and central regions in the country

(«adaptation costs»). Medical and biological estimation will allow detecting the most vulnerable physiological systems and revealing health risk factors; it will also help create strategies aimed at improving life quality of people living in northern and arctic regions.

Ecologic and climatic conditions in the arctic zones produce specific effects on body systems functioning requiring a lot of efforts aimed at preserving constant internal environment in a body. Our research was performed on different population groups living in Magadan region, all being naturalized Caucasians, borne in the region in the 1st–3rd generation; our participants were young males who attended higher and specialized secondary education establishments. The research revealed that regional peculiarities detected in morpho-

functional characteristics of people living in different climatic geographic zones had certain differences. Specific attention should be paid to the external breath system that is the first to be exposed to negative impacts exerted by cold air; another attention focus should be on probable changes in metabolic processes in people who have long been living under the given extreme climatic conditions. And here we should take into account that exposure to environmental factors can also be different varying from moderate cold pressure to extreme combined effects produced on a whole body. We also performed a comparative analysis of metabolism and external breath functions in young males constantly residing in different climatic geographic zones in the Far East in Russia; the analysis revealed that compensatory-adaptive restructuring in physiological systems functioning occurred in young males from all the examined groups. They were the most apparent in young males from the continental part of Magadan region; adaptation shifts in people from this group were aimed at minimizing apparent effects produced by cold that was typical for that climatic zone. Young males from this group also spent the greatest amount of energy per day as they needed it to maintain elevated heat production. We also detected that they had the highest patency of distal bronchioles among all the examined groups; it was necessary for both adequate oxygen supply and protection from cold temperatures.

Analysis of the obtained data revealed that Magadan city territory that belongs to the Arctic zone is not less and in some cases even more uncomfortable in terms of its medical and biological properties than subarctic zones in Magadan region (Susuman city) and arctic zones (Anadyr, Chukotka Autonomous Area). Accordingly, discomfort coefficients totally amounted to 3.21 arbitrary units in Magadan; 3.42 arbitrary units in Susuman; 2.9 arbitrary units in Anadyr, Chukotka Autonomous Area; and 0.46 arbitrary units in the central regions in the RF. Given all the above stated, we can conclude that Magadan region territory is a zone with considerably uncomfortable conditions and it is the most apparent in its continental part.

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Conflict of interests. The authors declare there is no any conflict of interest.

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