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The Ecological and Physiological Basis that Builds the Functional Reserves in the Native Peoples of the Arctic Region

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Abstract

This study found that value of the carbon dioxide (CO_2) tension in the capillary blood of Arctic inhabitants is lower during the winter, whereas the CO_2 levels in the atmosphere are lower in the summer. This study also revealed that the heart rate and respiratory minute volume in the Arctic inhabitants are significantly higher in the winter, while the respiratory rate and cardiac output are significantly higher in the summer. IJBM 2012; 2(3):179-182.
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Introduction

Negative anthropogenic factors affect not only the ecological system; they also escalate the reduction of health reserves in individual and population levels, increase the degree of psycho-physiological and genetic stress, foster the growth of specific diseases and the development of new forms of environmental diseases, as well as increase the phenomenon of depopulation in certain regions.

In the Far North, several extreme factors (the low temperature, peculiar photoperiodicity, factors of electromagnetic origin, and severe oxygen and carbon dioxide regimes) adversely affect the human population. The extremes of climatic conditions are significantly lower for the indigenous peoples of the Far North, than for the newcomers, due to the inclusion of genetic mechanisms in the adaptive process [1]. However, the transition to new work forms, a quick change from a nomadic to a settled way of life (from a historical perspective), fundamental changes in living conditions, the types of diet, and other life changes have affected the homeostatic systems of the indigenous people [1, 2].

The complexity of the climatic and ecological factors characteristic of the Sakha Republic in the Arctic region determines the critical requirements for human existence, which leads to high stress of regulation mechanisms of all the human body systems, primarily the cardio-respiratory system. In this connection, the study of the reserve capacity of the body in different ethnic groups of the population assumes great interest.

Material and methods

General characteristics of the study and methods of investigation are presented in Table 1.

Investigation of the parameters of the acid-base status (ABS) of the blood was conducted employing standard techniques using the automated blood gas analyzer ABL-330 (Denmark). Spirometry was performed on the computer hardware-software diagnostic complex to study

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Table 1
General characteristics and methods of investigation

Methods of Investigation	Number of tests
Anthropometry	296
Parameters of blood ABS	296
Computer spirometry	296
Variation pulsometry	296
BP measurement by N. Korotkov	296

the respiratory function (ARSRI of Medical Instrumentation, Russia). Apart from these, the following parameters of variation pulsometry were calculated and evaluated: moda (Mo, sec), the amplitude of the modes (AMo,%), the variation scope of the dynamic range of RR intervals (ΔX, sec), the strain index (SI, CU), the autonomic balance index (ABI, CU), the vegetative rhythm index (VRI, CU), the indicator of the adequacy of the regulation processes (IARP, CU), the respiratory wave (RW, msec^2), slow waves of the 1st order (SW1, msec^2), slow waves of the 2nd order (SW2, msec^2) and the index of centralization (IC, CU).

All of the data was processed according to the variation statistics method using the software «SPSS 13» (O. Rebrov, 2002). The mean (M), standard deviation (SD) and 95% confidence interval (CI) were deduced. Correlation analysis was performed using Spearman's, as well as the F-test in the one-way analysis of variance (ANOVA). For data with normal distribution, inter-group comparisons were performed using student's t-test. p value less than 0.05 was considered significant.

Results and discussion

A comparative analysis of the anthropometric characteristics of the inhabitants of the Republic of Sakha (Yakutia) was done. While, the height and body surface area were significantly higher ($p<0.05$) in Caucasians, but the Quetelet and Rohrer indices were higher in the indigenous people. Quetelet index is an important physiological parameter that characterizes the constitutional features of the human body, the degree of physical resources and level of energy metabolism. Comparative analysis of the gas and acid-base status of blood (Table 2) showed that the oxygen saturation of capillary blood in the subjects examined in the winter season tended to decrease, which is consistent with the research data of other authors. This study found that value of CO_2 tension in the capillary blood of the Arctic inhabitants is lower in the winter, whereas the CO_2 levels in the atmosphere are lower in the summer. At the same time, an inverse correlation between the values of CO_2 tension in the capillary blood and CO_2 levels in the atmosphere was found ($r=-0.4$). In the winter (December), when the CO_2 levels in the atmosphere are high, the CO_2 tension in capillary blood is lower than in the summer (June), when the CO_2 levels in the atmosphere drop. Carbon dioxide is known to have a

Table 2
Parameters of the gas and blood ABS in different seasons (M+m)

Parameters	Seasons			
	Winter		Summer	
	1st group	2nd group	1st group	2nd group
pH, units	7.373± 0.004	7.379±0.002	7.388±0.003	7.397±0.002*
pO_2, mmHg	69.9±0.6	74.9±0.8*	77.8±0.5	81.1±0.8*
pCO_2, mm Hg	39.9±0.3	40.3±0.3	42.4±0.5	41.2±0.4*
Hb, g/l	144.1±1.1	146.5±1.2	146.8±1.2	148.4±1.4*
$SatO_2$, %	92.9±0.2	93.9±0.2*	94.3±0.2	95.5±0.3*
SB, mEq/l	23.6±0.1	23.7±0.1	23.7±0.2	23.9±0.2
BE, mEq/l	-0.72±0.19	-0.61±0.14	-0.58±0.19	-0.36±0.13

Notes: 1st group – Caucasians, 2nd group – Indigenous people.
* - difference is statistically significant compared to 1st group $p<0.05$.

direct and stimulating effect on the respiratory center that promotes frequent and deep breathing and deeper breathing, which help to «wash-out» the CO_2 in the winter.

The respiratory function is one of the major functions, and it is this which determines the efficiency of the organism. Indicators of respiratory function can be divided into two components: characteristics of the actual respiratory system and pulmonary gas exchange parameters which reflect the transport of gases by the blood, heart function and the conditions of tissue respiration.

A comparative analysis of the values of the vital capacity (VC) and the respiratory minute volume (RMV) (Table 3) showed a significant increase in these parameters during the summer compared with the winter ($p<0.05$). The VC and RMV levels were significantly higher in the Caucasians than in the natives ($p<0.05$). It should be noted that the decrease in the VC compared with the estimated vital capacity (EVC) was noted in the winter. At this time of year, higher values of RMV (due to an increase in the respiratory rate) were marked in the Caucasians. The change in pulmonary ventilation observed with prevalence of the respiratory rate could indicate a decrease in the functional reserves of external respiration.

A study of the tracheobronchial airflow showed that the forced vital capacity (FVC) in both groups is, on an average, increased by 3-12% more than those of the European age norms, particularly in the summer. Tracheobronchial airflow significantly decreased in the winter, regardless of ethnicity ($p<0.05$).

Airflow in the different levels of the tracheobronchial

Table 3

Parameters of the external respiration in different seasons (M+m).

Parameters	Seasons			
	Winter		Summer	
	1st group	2nd group	1st group	2nd group
VC, (L)	4.54±0.06	4.32±0.04	4.65±0.05	4.49±0.03*
EVC, (L)	4.79±0.04	4.62±0.03	4.77±0.04	4.64±0.03
VC от EVC, %	94.7±1.2	93.5±1.1	97.5±1.2*	96.8±1.0*
RR, bpm	17.1±0.5	16.9±0.4	16.2±0.4	15.8±0.3*
BV, (L)	0.63±0.02	0.61±0.01	0.72±0.02*	0.71±0.01*
RMV, (L)	10.7±0.2	10.3±0.3	11.7±0.3*	11.2±0.2*

Note: *1st group – Caucasians, 2nd group – Indigenous people.*
** - difference is statistically significant compared to winter p<0.05*

Table 4

Parameters of the cardiovascular system in different seasons (M+m).

Parameters	Seasons			
	Winter		Summer	
	1st group	2nd group	1st group	2nd group
SBP, mm Hg	121.7±1.1	119.7±1.1	118.3±1.3*	118.2±0.9
DBP, mm Hg	79.4±1.1	77.6±0.9	76.6±0.8*	74.8±0.8*
Mean BP, mm Hg	93.9±0.9	91.7±0.6	90.5±0.8*	90.6±0.7
HR, bpm	78.1±0.9	76.7±0.7	73.1±0.5*	71.8±0.8*
CO, L/min	4.49±0.05	4.55±0.06	4.59±0.04*	4.72±0.06*
TPVR, dyn/cm/sec^{-5}	1679±55	1610±61	1549±33*	1519±32
DP, conventional units	95.5±1.1	91.8±0.9	87.4±0.7*	84.9±0.9*

Note: *1st group – Caucasians, 2nd group – Indigenous people.*
** - difference is statistically significant compared to winter p<0.05*

tree was found to be lower in the indigenous inhabitants than in Caucasians. This, apparently, is a compensatory structural-functional component that protects the lung tissue from hypothermia and reflects the physiological regulatory mechanisms of heat transfer through the respiratory tract. At the same time, the narrowing of the bronchi increases the load on the cardiovascular system [4, 5].

Thus, during the contrasting seasons, the dynamics of the respiratory functional parameters were found to be higher in Caucasians than in the indigenous inhabitants, which is indicative of the functional stress placed upon the regulation systems during the winter. The differences in respiratory functional parameters were associated with the peculiarities of the functioning of the cardiovascular system.

Parameters of the cardiovascular system were significantly different during the contrasting seasons (Table 4). Therefore, the heart rate at rest was significantly higher in the winter, while the cardiac output (CO) was significantly higher in the summer, regardless of ethnicity ($p<0.05$). Seasonal changes in the CO_2 content in Caucasians showed 3.3%, whereas in the indigenous population it was 4.4%. These changes indicate a moderate predominance of the tone of the sympathetic nervous system that could contribute to the premature exhaustion of the functional reserves due to the cold stress. At the same time, the blood pressure (SBP, DBP) and total peripheral vascular resistance (TPVR) showed no significant difference during the contrasting seasons; this revealed a more pronounced inertness and stability of these indicators, in healthy volunteers.

The stability of the blood pressure optimizes the microcirculation and transcapillary exchange in the tissues and maintains a steady metabolism, which indicates a higher level of human adaptation to the harsh climatic conditions in the Arctic region.

The degree of tension in the regulatory systems is the integral response of the organisms to the complexity of the factors acting upon it. According to H. Selye (1960), general adaptation syndrome (GAS) is the universal response of an organism to stress of any kind. GAS manifests itself in the mobilization of the functional reserves of an organism.

Based on the comparative analysis of performance variation pulsometry, different degrees of the adaptation were found. Low values of ABI, VRI, and IARP were found in the indigenous inhabitants. This is due to the fact that any activation of the higher levels of control inhibits the reaction of the sympathetic nervous system on exercise stress. Perhaps, the low vascular reactivity is the result of the high activity of the higher autonomic centers.

Conclusion

Thus, the results of our ecological-physiological study indicate the need for a holistic approach in the assessment of the health status and level of functional reserves within an organism in different regions of the Republic of Sakha (Yakutia).

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