CONGRESS SESSIONS
Northern Adaptations

Temperature Homeostatis and Work Efficiency in the Cold

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Abstract
The data concerning thermal homeostasis maintenance and energy cost of muscle work in a cold environment and at cold adaptation are presented. It was shown that 10 days' experimental acclimatizing to cold at daily two hour +13 °C sessions result in different individual adaptive forms, "euthermic" and "hypothermic", which have specific thermogenesis and body shell vascular reactions in a cold environment. Complex investigations were made on selected groups of people on the basis of professional work with the count of cold exposure time and level of muscular activity in cold. It was shown that daily repeated cold exposure lasting many hours at a circumscribed moving activity results in a reduction of performance efficiency and optimum muscular work power. On the other hand, the power of optimum load and efficiency of performance increases with regular physical exercises in a warm environment. Repeating muscular work in a cold environment does not change performance efficiency, rather it increases the power of optimum load. After acclimatization to cold, additional energy costs of muscular work come to light in the augmentation of the oxygenous debt. Physiological mechanisms of this energy consumption rise are linked to sympathetic nervous system activation and change of tissue sensitivity to its mediator – noradrenalinum.
Key words: thermal homeostasis, cold

It is known that body cooling results in a thermoregulatory rise of metabolism for support of thermal homeostasis. When the core temperature of the body is maintained at a constant level, the response is considered euthermic and it is found in Eskimos and Caucasians[1]. If cooling produces a decrease in body temperature, it is referred to as the hypothermic type and is typical of human populations associated with uncomfortable living conditions and exposures to contrasting temperature shifts[2]. The aim of this investigation was to study the effect of experimental cold training on the type of core temperature reaction and respiratory response to cooling[3, 4]. Twenty-four apparently healthy young males were tested. In the course of 10 days they were exposed daily to total cooling in the climatic chamber, naked for two hours at 13 °C. The results of the study show that subjects were subdivided into hypothermics and euthermics by changes in body temperature. The hypothermic adaptive response was accompanied by the development of hypoventilation in cold and decrease in blood oxygenation. The euthermic response was mostly associated with an increase in the intensity of metabolic and respiratory reactions[3,4].

It is well-known that skeletal muscles are an important thermogenic effector in an organism. They have a great relative mass and ability to increase metabolism and thermogenesis strongly and rapidly. The contractile activity of skeletal muscles in cold has the form of thermoregulatory tone and cold shiver. These functions were studied by well-known Russian scientists from different towns: Ivanov K.P. (S.-Petersburg)[5,6], Lupandin Ju.V. (Petrozavodsk)[7], Bazhenov Ju.I. (Ivanovo)[8], and Haskin V.V. (Yaroslavl)[9].

In Novosibirsk, there **was** a working group of Jakimenko M.A., Tkachenko E.Ja., Divert V.E, and some others. They have performed an experimental analysis of the efficiency of muscle work after the organism's adaptation to cold and physical training[10]. The selection of people for examinations **is** an important part of the study. Physiological parameters of muscle work have been investigated by a uniform procedure during a number of years among four groups of persons: the first group – control – university students leading an ordinary way of life; the second group – cold-adapted persons – soldiers working as security guards on watchtowers who were spending eight hours a day in the open air and with very little motion activity for more than a year; the third group – biathlon sportsmen – physically trained under cold conditions; and the fourth group – athletes – physically trained in warm premises[10,11].

A stepped bicycle ergometry from 50 to 250-350 W with five minutes for every one step was used in the examination. Metabolic and ventilation parameters were measured by the Metabolic Measurement Cart (a.k.a. MMC) - the device of the Beckmann Company. Muscle work efficiency was calculated by standard way as a ratio of mechanical work to total energy cost of an organism (in percent). Mechanical work was calculated by the intensity of bicycle ergometry load multiplied by time. General energy cost of an organism was calculated by oxygen consumption, taking into consideration the respiratory coefficient and corrections in caloric equivalent of oxygen, and also the oxygen debt during the recovery period. The curves of work efficiency and power load look like a parabola with a maximum on the optimal power load when energy cost is minimum (Fig. 1). This important point allowed us to analyze and compare different groups. Results show that the energy cost of muscle work increases and power load drops during cold adaptation. The optimum shifts in the reverse direction – to a larger load and greater efficiency – at physical training in warmth. Physical training in cold is accompanied by an increase of optimal power load, but the value of maximum work efficiency does not change[10,11,12].

It is possible to consider the true oxygen (TO, also called the coefficient of oxygen utilization – OUQ, or fraction of oxygen - FO) as a common index of pulmonary and circulatory function. Changes in TO for the groups at different power load appeared to be close to the changes of work efficiency in general (Fig. 2). However, maximum of TO did not shift within the scale of power load for persons physically trained in cold[11]. It is an important result. It shows the limitation of oxygen-transport function opportunities at a longtime cold influence.

The influence of external cooling on oxygen consumption at muscle work was examined in special studies. Bicycle exercises were performed several times (but only one time a day) at different environmental temperatures of 26, 19 and 13 °C. At cooling, the respiratory coefficient dropped by 10% of the maximum possible changes[11]. Our calculations show that it corresponds to the increase of fat use by 23%, and at the same time oxygen consumption grows.

The significant regression between the drop of respiratory coefficient and the increase in working oxygen consumption indicates the presence of a fast mechanism for raised heat production in cold (Fig. 3). It is linked to the growth of fat utilization for muscular contractions by means of a conjugacy decrease of oxidation and phosphorylation processes. The activation of this mechanism takes place under the influence of cold.

The sympathetic nervous system and its mediator noradrenalin participate in the lipolysis activation. They affect the beta-adrenoreceptors of muscles in cold environment. We tested it during the experiments on rats with use of a beta-adrenoreceptor blocker, Inderal (Obsidan)[13]. Beta-blockage does not influence oxygen consumption in a warm environment at low activation of the sympathetic nervous system (Fig. 4). In cold, the influence of the blockage is very much expressed both in rest and during the treadmill run. Thus, oxygen consumption among cold-adapted animals was close to the control level.

The ways to optimize muscle performance in a cold environment are quite definite. The recommendations on this matter are rather contradictory. It is known that pre-cooling of an organism reduces the strain of heat emission mechanisms, heart rate, and lung ventilation and that all this helps the work performance. On the other hand, low muscle temperature increases oxygen consumption during physical work.

The following question arises: Is it possible to save energy expenditure during muscle work by locally applied heating of muscles? We tested this hypothesis experimentally by preheating thigh muscles before work in a cold environment. The results have shown that the energy expenditure during work decreases approximately by 12%[14].

It is known that at the beginning of muscle work in cold a sharp fall of internal (especially tympanical) body temperature is often observed. The cause may be either local brain cooling by reinforced ventilation, or the inflow of cooled blood from the body shell to the body core. We tested these hypotheses experimentally[15,16]. The inhalation of cool air during work under warm conditions did not reduce the tympanic temperature. On the other hand, breathing the warm air during work in cold reduced tympanic temperature. Figure 5 shows that these downstrokes were more the lower the initial skin temperature. The obtained data prove the role of cooled blood coming from the body shell at the drop of tympanic temperature during work in a cold environment.

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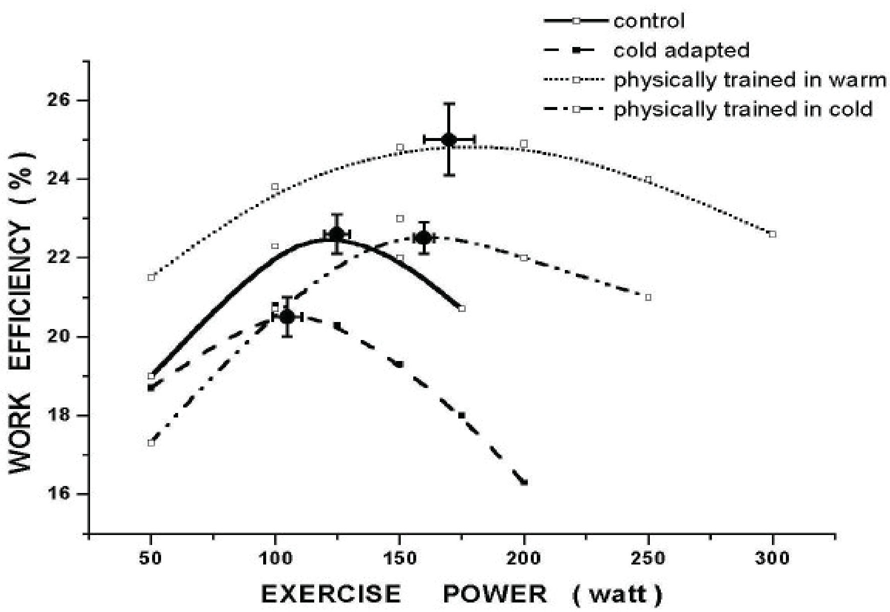

Fig. 1. Muscle work efficiency at different power load bicycle exercises in the four tested groups

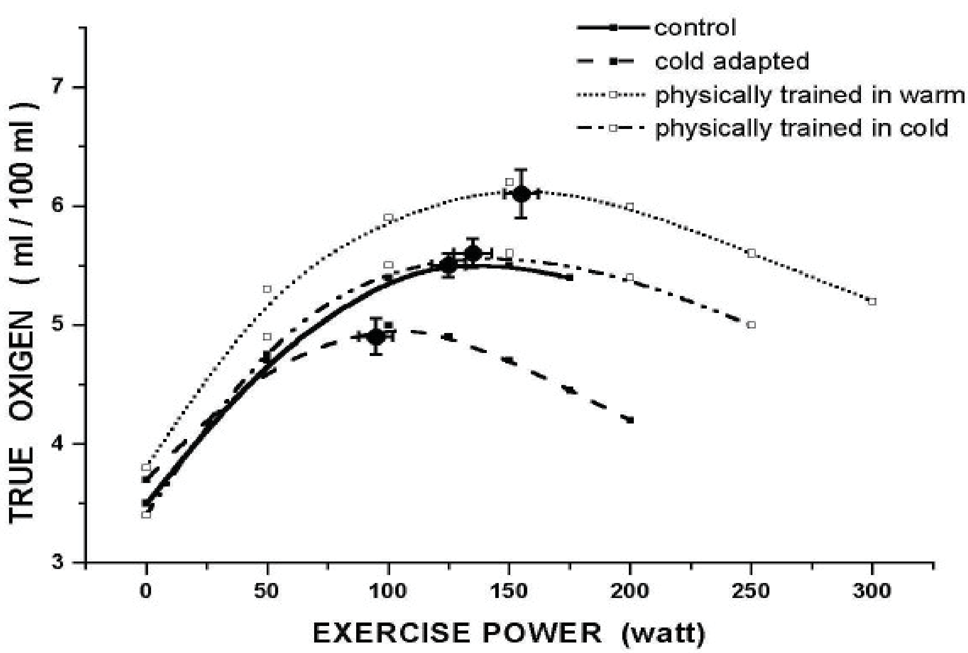

Fig. 2. True oxygen levels at different power loads in the four tested groups

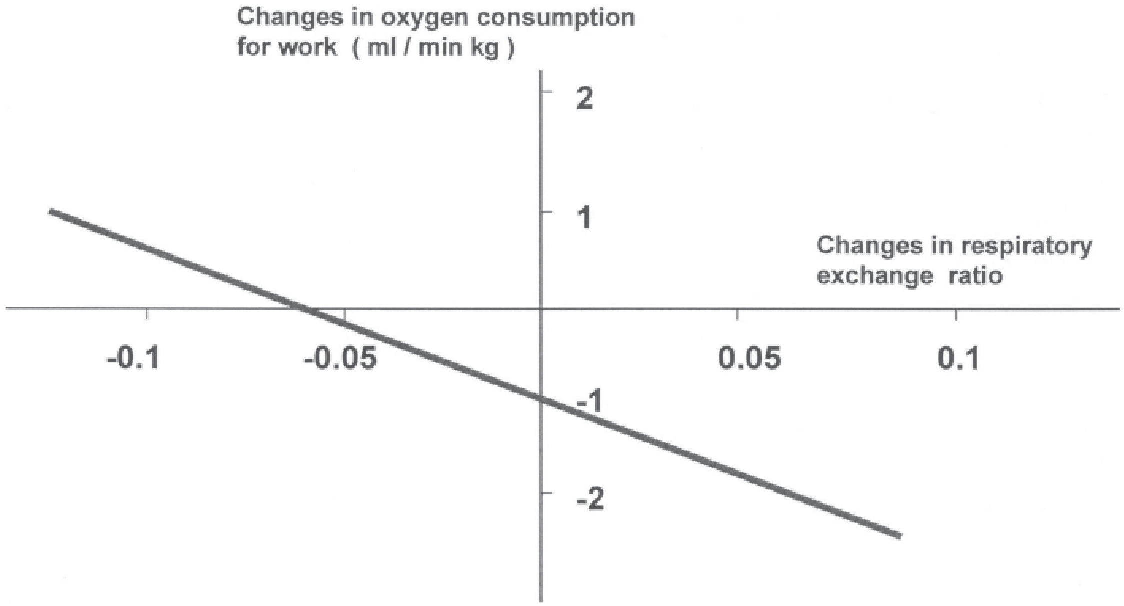

Fig. 3. Fatty acid substrates activation ***at*** *bicycle exercises in cold environment*

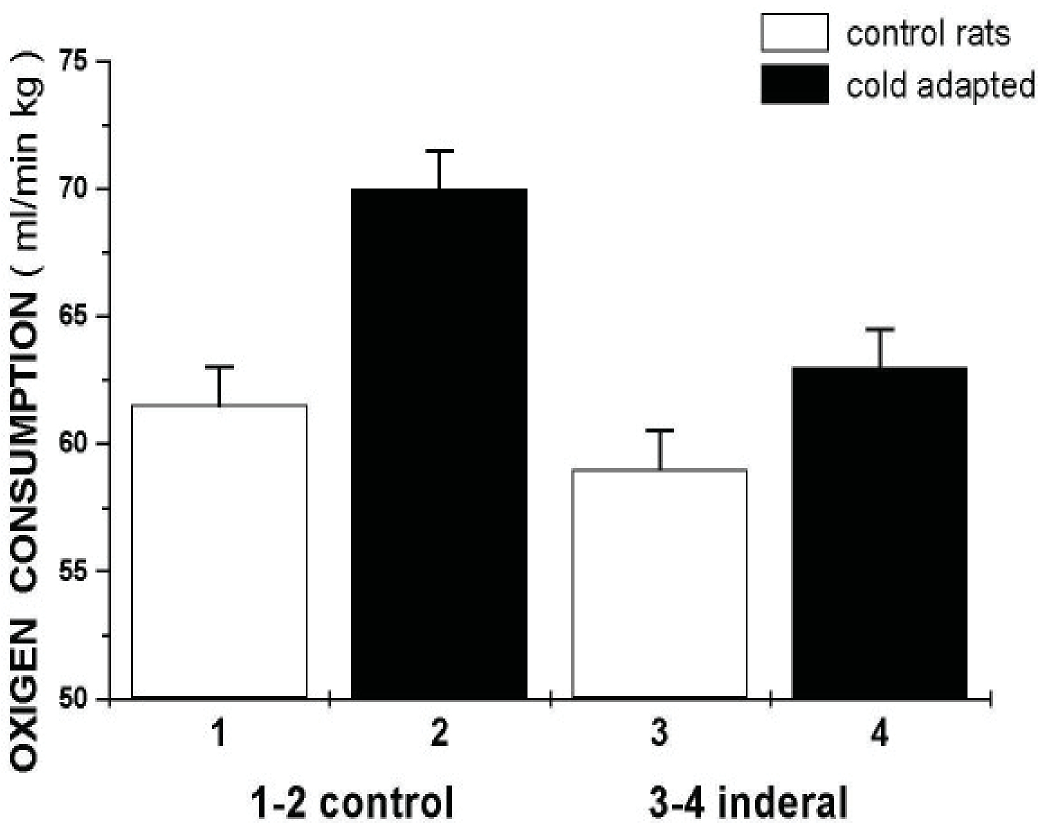

Fig. 4. Inderal treatment on control and cold-adapted rats running on treadmill

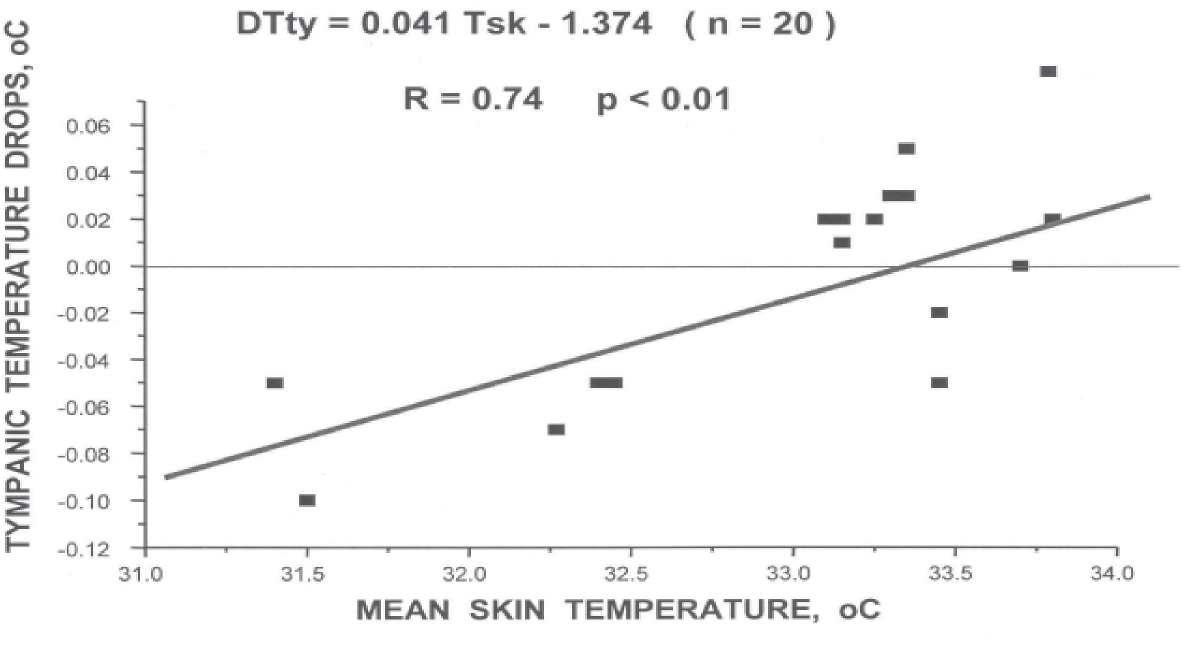

Fig. 5. The drop of tympanic temperature at the beginning of exercise in different environmental temperatures

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Working Potential Evaluation in the Territory of an Oil-and-Gas Complex Development in Siberia

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Abstract
Health estimation as the main component of the quality of working potential (WP) of Natives was studied in the territory of an oil-and-gas development complex. Social-medical and epidemiological methods were used on potential adult and teenaged workers in the northern territory of the Irkutsk region. The realization of an adventurous and active strategy of personnel policy is discussed. The adaptation of temporary workers from central regions to unfavorable social, climatic and occupational factors is difficult. It may lead to the appearance of psychosomatic diseases and a decreased capacity for work. The attraction of Natives' WP is connected with the expenses for conversion training and the development of a social infrastructure. The estimation of risks of main pathological syndromes has shown a low share in basically healthy persons among the adults and teenagers (27.5% and 44.4%). In adults, the most frequent risks were of neurological infringements, arterial hypertension and cordial ischemia, in teenagers it was for disorders of the gastro-intestinal systems, boundary mental frustration, and neurological infringements. For development resources of the Irkutsk region, the realization of a program of social and economic development as part of a region's overall development is necessary. It must include the development of the labor market, maintenance of employment of Natives and formation of qualitative WP, and corporate health management.
Key words: working potential, adventurous and active strategy of personnel policy, health

INTRODUCTION

The Irkutsk area has significant oil and gas potential. At the present time the level of prospecting of the initial summary resources is only 17%. Experts discuss the factors influencing the possibilities of a large-scale development of a powerful oil-and-gas province. On the one hand, the developers have to consider climate - geographical features and also the social problems of the region of new development. There's also the importance of political factors. On the other hand, oil and gas mining will be realized in remote regions with extreme climatic conditions, low development of the infrastructure, and first of all, transport, low density of the resident population. Social problems are aggravated by adverse medical-demographic processes. Since 1995, a steady decline in population has been noted in northern areas. Dangerous, heavy and tense labor in gas mining presents high requirements for workers' health and makes it necessary for the estimation of health level as part of the WP of the population of an oil-and-gas complex development territory. The demographic situation in the Irkutsk area is negative and quantitative losses of WP are significant. Therefore, the check of health in potential adult and teenaged workers is important.

MATERIAL AND METHODS.

The following methods were used: sociological, psychological[1,2], estimation of risk of main pathological syndromes (ERMPS)[3], epidemiological, and mathematical[4]. The objects of the study were adults and teenagers - inhabitants of one of the northern regions of the Irkutsk area.

RESULTS

The efficiency of investments into the technical development of an industrial complex depends on the level of development and efficiency of use of WP. Despite frequent use in the literature of the term "working potential", its substance isn't treated uniquely. It is characterized not only by the presence of people possessing work capacity during the given period, but also by the potential possibility of changes (simultaneously physical, psycho-emotional, vocational, and educational and spiritual potentialities of people to realize labor activity). The WP structure is considered a system of a person's abilities, such as psycho-physiological particularities (sex, age, psychosomatic health, intellect, type of nervous system, etc.), defined as formed natural potential; occupational abilities (general and special knowledge, professional skill, professional mobility, etc.); and social-psychological particularities (attitude to labor, goal orientation, interests and needs, self-actualization needs, manifestation of the initiative, etc.). The two latter components form the obtained potential, received by means of education, qualifications, social interactions, etc.

Low levels of anthropotechnicogenic influences and social-economic development, and average levels of general morbidity and death rates are noted among the Natives in areas of development [5] (Figure 1). Adult Natives have significant relative risk of a pathology of the blood circulation system (RR=1.8), skin (RR=2.3), and support-motor apparatus (RR =1.9). Teenagers have a high relative risk of a pathology of the nervous system and sense organs (RR=2.9) and the urinogenital system (RR=1.6). According to the ERMPS, the share of basically healthy persons among adults is 27.5% and among teenagers, 44.4%. Eighty-two percent of adults who have an exceedingly high risk of disease have a combined pathology (neurological breaches, arterial hypertension and cordial ischemia). In adults, the most frequent were risks of neurological infringements, arterial hypertension and cordial ischemia, in teenagers they were gastro-intestinal disorders, boundary mental frustration and neurological infringements.

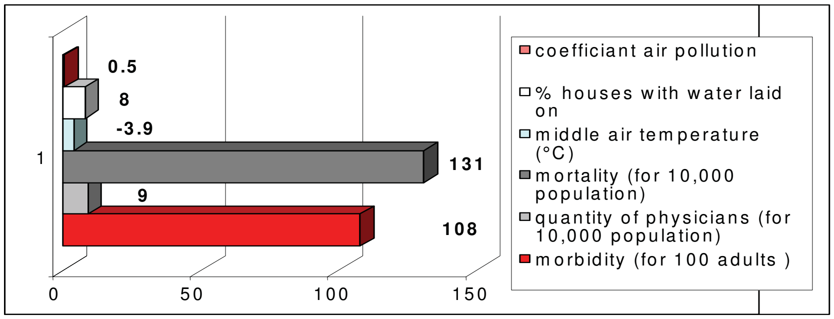

Fig.1 Description of Development Region

DISCUSSION

A different strategy of personnel policy is possible in the new development territory. The realization of an adventuristic strategy without a scientific diagnostic of WP of the local population and in the first place its health and factor of its development can only bring temporary success for the enterprise, not the population. The adaptation of temporary workers from central regions of Russia who leave family for unfavorable social, climatic and occupational factors is difficult. Failure to adapt is possible, as are psychosomatic diseases. There is also a negative social-psychological mood in Natives who were disappointed during economic reforms with the lack of work and good financial opportunities for themselves. Only 50% of able-bodied people are working. Only 19% of those who have no work are officially "unemployed." Eleven percent of the unemployed have no trade, 40% have no full secondary education, and 34% have only general secondary education. Trades which could be in demand (drivers, mechanics, technologists and welders) make up only 10% of the structure of trades for the unemployed. The situation becomes complicated because the share of unemployed youth in the area of new development is high, higher than in the Irkutsk region. The low level of the youths' economic activity is fraught with growing social-psychological tension and deviating behavior. A third of Natives show a moderate level of social dissatisfaction (Tab 1). The levels of social frustration are especially high with concerns about low income and the condition of health and housing/home. People are also not satisfied with educational levels and leisure time. Programs for social-psychological rehabilitation are necessary for many of them and the material welfare of strange persons aggravates the social frustration in Natives. More than 50% of Natives have a significant gap between the importance and availability of vital values. The tension with some needs (health, good conditions in the country, confidence in oneself, independence) and non-urgency with others (the beauty of art and the nature, creativity, an active vital position) leads to an imbalance in the spectrum of vital values that can cause a disturbance of the psychological status and a negative influence to health. The crisis of social values, restriction of social and professional mobility, social frustration and stressogenic occupational and environmental factors cause the syndrome complex, "social weariness"[6]. It can lead to mis-adaptation expressed in the transformation of vital values and motives, personality deformation, decreased adaptability, and psychosomatic diseases. The realization of an active strategy will allow involving the WP of adapted Natives. However, it will be connected with expenses for social development. The realization of an active strategy with the attraction of Native's WP is also connected with expenses for on its conversion to training and development of the social infrastructure. Under conditions of the realization of various strategies in the formation of a workforce in development territories, it is necessary to examine the conditions for socio-occupational

Table 1

The Main Factors of Social Frustration

Factors	Share of persons, %
Income level	44
Physical condition	29
Housing-home condition	27
Educational level	36
How undertake free time	24

adaptation and quality of health of the local and alien population, to create adequate technology on estimation of quality of WP, and to develop a model of optimum control of its quality. By modeling the dynamics of parameters of morbidity (Dr. Gornov A.J.) for northern territories, the most pessimistic forecast is established has been received under conditions of development, accompanied by growth of technologic loading, preservation of adverse social conditions, and low resources of public health services. The estimation of population health quality by multi-criterial analysis of the hierarchies (Prof. Finogenko I.A.) has shown its low levels that specify the necessity of introductions of urgent preventive medical actions. For development of resources, it is necessary to realize a program of social-economic development of the Irkutsk region. It must include development of the labor market, maintenance of employment of Natives and formation of qualitative WP, and corporate health management.

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The Influence of Cold on Energy Expenditure at Rest and During Exercise in Person in the North

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Abstract
In the majority of research on human adaptation in the North signs of hypoxia[1-3] were found. In physiology studies of animals it is established that adaptive changes to cold and hypoxia have much in common, for example, the decrease of spent energy (hypometabolism). This phenomenon has been studied much less in humans than in animals[4]. The first study was that of A. Hemingway and L. Birzis[5] which showed that under the influence of air temperature of -3° C on natives of Kalahari deserts the average body temperature and level of metabolism decrease. The reduction of lung ventilation and decrease of heat loss in humans was interpreted as the result of cold[6,7]. However, it is obvious that ventilation decrease in humans in cold air leads to reduction of oxygen consumption, i.e. to hypoxia. It is possible to assume that adaptation of Northerners is closely connected with cold and hypoxia. At hypoxia and under cold conditions the decrease of energy expenditure is the natural phenomenon. Y.Gauiter and M Bonora, S.Wood[6,8] consider that the fall of body temperature observable at hypoxia is a consequence of the decrease in oxygen consumption and reduction of energy expenditure. Besides, the decrease in oxygen consumption (Vo_2) always precedes the fall of body temperature[8]. In the work of C. Pedraz, J. Mortola[9] it is shown that the external warming at hypoxia in newborn cats and dogs during restoration of body temperature up to the reference values is not accompanied by authentic change of metabolism. It remains lowered as under the previous conditions of hypoxia (before warming). It specifies that the fall in body temperature at hypoxia is a consequence instead of the reason of Vo_2 fall. This is an important question for the human's adaptation – the influence of cold and hypoxia on spent energy. The paper presents the results of research into the effects of cold on resting and exercise energy expenditure among Northerners of the Russian North.
Key words: Northerners, cold air, hypoxia, oxygen consumption, energy expenditure, exercise, adaptation

MATERIAL AND METHODS

The pulmonary gas exchange at rest and during exercise was studied in 140 healthy male inhabitants of the North (from 20 to 40 years). All of them migrated from the European regions of temperate climate and have lived in the North more than one year. All subjects were workers and did approximately six hours of manual work in the open air. Research was carried out in the winter season. The daily average temperature of air during this period was from -23° up to -27°C. Energy expenditure was measured with indirect calorimetry (oxygen consumption) at rest and during exercise. Parameters of pulmonary gas exchange were as follows: ventilation of lungs (V_E); breathing frequency (f), tidal volume (V_T), oxygen consumption/min adjusted to STPD conditions (Vo_2), carbon dioxide production/min adjusted to STPD (Vco_2), alveolar carbon dioxide tension (P_{ACO2}) it was registered on the metabolic complex MMC of the "Beckman" firm, and also the open system by the Douglas method. The respiratory quotient (RQ), physiological dead space (V_D), alveolar oxygen tension (P_{AO2}) were calculated. Efficiency of ventilation (Ko_2) was estimated on a ratio of Vo_2/V_E corrected BTPS-STPD (norm for healthy men at rest: 35-45).

The parameters of pulmonary gas exchange at rest recorded at physiological rest in sitting position, from 1.5 - 2 hours after breakfast. The five min continuous bout of exercise 1.5 W/kg was performed on a bicycle ergometer, the pedal rate was 60 min^{-1}. The energy expenditure and other parameters of gas exchange were measured at a steady state within 3-5-th min of exercise.

For comparison, one- and multi-factor analyses (ANOVA/MANOVA) were used. For the analysis of the change of parameters the Student criterion was used. The correlation analysis was done with use of parametric and nonparametric criteria.

RESULTS

1. Resting energy expenditure (REE) at cold. The investigation of subjects for 30 minutes in cold under natural winter conditions was accompanied by an increase of Vo_2 and Vco_2. For estimation of respiratory reaction in cold, the temperature range was divided into three equal parts. Men were accordingly divided into three groups. The subjects of the first group were studied in cold temperature between -12° to -19°C, the second group at -20° to -27°C, and third group at -28° to -35°C (Table 1). The greatest interest is aroused by data that show a gain in oxygen consumption. Vo_2 increased (reaching on the average 129%) in the process of air temperature drop down to -27°C. Then a paradoxical decrease in Vo_2 gain was observed at lower temperatures (up only to 111%).

The increase of Vo_2 in the third group is less than in the second ($p < 0.05$). However, Vco_2 increased to the same degree as in the second group. These distinctions were observed at equivalent gain in Vco_2 that were reflected in parameter RQ of the third group. It was greater in the first and the second groups by above 20%. In the initial condition the RQ difference was within the limits of 5% ($p > 0.1$). It remained stable up to -27°C (0.81–0.83) and in the coldest range RQ increases to 0.95±0.13 ($p < 0.02$). In cold the efficiency of ventilation (Ko_2)

was increasing only up to -27°C. Further strengthening of cold leads to Ko_2 reduction.

We believe that reduction in the gain of Vo_2 within the range below -27 °C was a result of respiratory hypoxia. The reduction of oxygen consumption leads to the development of energy deficiency. In this temperature range the deficiency of oxygen consumption had reached approximately 15%. It caused the activation of anaerobic processes, therefore the RQ of subjects increased. Thus, at air temperature below -27 ^oC the hypometabolism was in healthy individuals even at rest. It is obvious that the performance of physical activities aggravates hypoxia.

2. Exercise energy expenditure and gas exchange at cold

Initially, pulmonary gas exchange was assessed (resting and exercise) at breathing warm air. Then the same research was carried out on these subjects in cold air. Studies in this series of breathing the room-temperature air during exercise showed that pulmonary gas exchange was ensured by effective ventilation. The exercise of the same value and breathing the low-temperature air (-19^{o}C) was also ensured by effective ventilation (Table 2). However, the Vo_2 was less than during exercise under room conditions. Together with this essential reduction of Vo_2 , pulmonary ventilation was also less (the difference was 18 and 12%, respectively, $p<0.02$). The fact of pulmonary ventilation decrease in cold has been repeatedly reported[3]. However, it was not known that the V_E decrease was accompanied by oxygen consumption.

To study the respiratory hypoxia during exercise in cold, parameters P_{AO2} and P_{ACO2} were measured in various temperature ranges (Table 3). P_{AO2} and P_{ACO2} remained constant at temperatures between +22 to -24^o C. In the low-temperature range (from -33^o to -25^o C) P_{AO2} was less than the initial value recorded under warm conditions. The average difference was 8 mm Hg ($p<0.02$). Correlation analysis shows that close connections between alveolar O_2 tension are observed only at temperatures lower than -21^o C: the correlation coefficient was 0.49 ($p<0.05$). Thus the effectiveness of pulmonary gas exchange starts to decline at the temperature of inspired air down to -21^o C.

3. Adaptation decrease of resting energy expenditure in the North

REE (Vo_2) was studied in immigrants after various years of their residing in the North. All subjects were worker-builders 20 to 33 years old . They were builders, and each of them was outdoors for 5-6 hours, performing physical work in cold. The men were divided into four groups depending on their experience of residing in the North (Table 4).

It was established that in the fourth group (living for 5 to 10 years) REE are lower than in workers residing in the North for less than three years (in the first and the second group; $p<0.05$). Hence, in the process of adaptation the decrease of resting energy expenditure is observed. The research of oxygen consumption by Northerners was made repeatedly under similar conditions before our studies. The results had an inconsistent character. In one case there was increase of Vo_2, in others a decrease. We believe that besides specific features the problem consists in the complex dynamics of Vo_2. It depends both on the season of the year and on the mode of work of the Northerner. Therefore, the phenomenon of hypometabolism demands additional proofs.

With this purpose, 20 men carried out repeated inspections within a year in the same settlement in February. The anthropometrical data of subjects did not differ significantly from the common group, and their change during one year remained within 1% which is essentially within the results of the present research. Subject's stay on the North was between one and six years, three years at the average. Therefore, the duration of subjects' residence in the North was within the limits of the most essential morpho-functional reorganizations in the adaptation.

The results of one year comparison are presented in Table 5. The dynamics of Vo_2 corresponds to the results of four groups where the comparison of different length of stay in the North was presented (Table 4). The reduction of oxygen consumption reached 18% within one year. The comparison with predicted REE (the Harris Benedict and Schofield equations) demonstrates the decrease from 103% in the first to 85% in the second year of the study. The changes in Vo_2 considerably exceeded the known variability of REE[10]. According to the decrease of oxygen consumption, the reduction of lungs ventilation due to a decrease in tidal volume (V_T) is observed. The efficiency of ventilation (Ko_2) has remained constant. It confirms the fact that the reduction of Vo_2 is a display of slow developing physiological reaction. Another prominent feature is CV – coefficient of a variation equal to (M/SD) $\cdot$100%. CV of varied functional parameters decreased from 22-29% to 18-22%. It is obviously caused by the increased interaction of the systems providing gas exchange in the organism.

DISCUSSION

The data obtained confirms that breathing cold air leads to pulmonary ventilation decline. The decrease in the volume of cold air that comes in contact with the mucous membrane of the airways upon inspiration obviously contributes to their defense from cooling. The reduction of lung ventilation leads to decrease of heat loss with breathing. In the previous research we have shown that the decrease in ventilation of breathing air with a temperature below +13^{o}C is accompanied by a decrease in oxygen consumption[3]. It is most probable that thermoreceptors of the upper airways participate in the development of these reactions. The revealed reactions are quite natural for man and are realized by the signal variant triggering the program of defense of the respiratory organs from the effects of cold. They bring into action such known reactions as limitation of respiratory volume, increase in bronchial resistance and a decrease in functioning respiratory surface[11]. The reduction of ventilation and oxygen consumption occurs already under a rather weak cooling effect on the upper airways and remains unchanged upon its enhancement. Up to a certain degree of cooling, these reactions are accomplished without hindering alveolar gas exchange. In particular, in migrant - Northeners working in cold, this border is found within -24 to - 21^{o}C. A further increase in cold load causes respiratory hypoxia, which can play an important role in the formation of the decrease of energy expenditure in cold. It is obvious that performance of physical activities will aggravate hypoxia. The sizeable decrease of P_{AO2} and Vo_2 is difficult to explain. The simple explanation of the reflected reduction of V_E does not agree with the magnitude of the decrease of Vo_2. Similar data was presented in studies[12] under conditions of high-altitude hypoxia, the same volume of performed work as that at sea level at lower levels of O_2. In that case, the authors could not explain the revealed phenomenon. It is quite possible that there is a certain mechanism of energy expenditure decrease in extreme conditions at the expense of heightening work effectiveness and/or decrease in heat loss from the body surface. One of the triggering signals to bring this mechanism into action is the cooling effect on the airways. Till now paradoxes of metabolism at high-altitude remain unclear. In the review of P.W. Hochachka e.a.[13] this problem was discussed in terms of "lactate paradox in human". But authors had recognized that "underlying mechanisms have remained obscure".

We consider that the decrease of energy expenditure at rest and at exercise is closely connected. The repeated reduction of oxygen consumption in cold may be the reason why there is a decrease in REE in workers with long northern experience. The obtained facts reflect the adaptation of the human organism which consists in the decrease of energy spent, i.e. it is the minimization of physiological functions. Such supposition was presented by A.D. Slonim in 1979[14].

It is possible to conclude that primary hypometabolism is a consequence of respiratory hypoxia. It is a result of the protective reactions directed on the restriction of the inhalation of cold air in respiratory ways. The primary hypometabolism is partially compensated by the strengthening of anaerobic processes. The second type of hypometabolism develops as a result of adapting to the repeating condition of energy deficiency (work in cold). Such hypometabolism we consider adaptive. This "metabolic" slow reaction is directed at the reduction of energy spent by the organism. In the result of extreme effects the systems of the organism decrease the expenditure of energy . Thus the essence of person's adaptation to cold in the North consists in the reduction of energy expenditure. We have named such a reduction in oxygen consumption the "adaptive hypometabolism". This is determined by proved morphological reorganizations in the respiratory system.

RESUME

The paper presents the results of research into the effects of cold on energy expenditure among Northerners at rest and during exercise. The cold effects on pulmonary gas exchange were studied in 140 healthy inhabitants of the North (men, age - from 20 to 40 years). All of them migrated from the European regions with a temperate climate and lived in the North more than one year. Rest and exercise energy expenditure were estimated by an indirect method of calorimetry - oxygen consumption (Vo_2). *REE in cold*: Vo_2 increased (reaching on the average 129%) in process of air temperature drop to -27°C. Then paradoxical decrease of gain $_{of}Vo_2$ (up to 111%) was observed at lower temperatures within -35 °C and -28 °C. *The exercise in cold*: The oxygen consumption and pulmonary ventilation at the same exercise were less in low-temperature air (-19 °C), then room-air. The differences of Vo_2 and V_E were 18 and 12%, respectively ($p<0.02$). P_{AO2} and P_{ACO2} remained constant at temperatures from +22°C to -24 °C. In a low-temperature range (from -33° to -25° C) P_{AO2} was less than the initial value recorded under warm conditions (8 mm Hg, $p<0.02$). The correlation coefficient between alveolar P_{AO2} and air temperature cold (within -21°C to - 33 °C) was r=0.49 ($p<0.05$). *Living for a long time in the North and reduction of REE*: REE of the workers living for a long time within 5-10 years are less than REE of the workers living up to three years (3.93±0.46 vs 4.34±0.40 ml/kg, $p<0.05$). The study during one year in 20 subjects has shown the decrease of Vo_2 and V_E by 18 and 16%, respectively ($p<0.01$). *Conclusion:* The primary hypometabolism is the result of respiratory hypoxia that is the consequence of the protective reactions to inhalation of cold air. The essence of adaptive hypometabolism in the North consists in the minimization of physiological functions and reduction of energy spent.

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Table 1

Changes (I - change of % to initial in room conditions) and levels (II - M±SD) parameters of pulmonary gas exchange at breath by cold air with differences temperature

Parameters	Temperature					
	-12...-19° C		-20...-27° C		-28...-35° C	
	I	II	I	II	I	II
Vo_2, ml/min	115	324 ± 21	129*	362 ± 49	111*	314 ± 63
Vco_2, ml/min	113	262 ± 33	124*	292 ± 45	123*	300 ± 49
RQ	100	0.81 ± 0.05	96	0.81 ± 0.10	111*	0.97 ± 0.10
V_E, l/min	121*	10.2 ± 1.5	122*	10.1 ± 0.9	116*	9.96 ± 2.08
Ko_2	95*	38.8 ± 3.3	107*	43.2 ± 4.7	96	38.8 ± 7.5

** - dynamics of a parameter concerning initial in heat is significant, p <0.05*

Table 2

The breathing air at +22°C and - 19°C at rest and during exercise of 1.5 W/kg, M± m (n=15)

Parameters	Rest			Exercise		
	22°C	-19°C	*p*	22°C	-19°C	*p*
V_E, l/min	8.5 ± 0.3	10.1 ± 0.2	<0.05	46.1 ± 0.4	41.01 ± 0.3	<0.05
Ko_2 (Vo_2/V_E)	40.6± 0.3	40.9 ± 0.4	<0.05	49.8 ± 0.5	42.3 ± 0.2	<0.01
Vo_2, l/kg min	3.34 ± 0.11	3.66 ± 0.12	<0.05	23.42 ± 0.2	19.02 ± 0.3	<0.001
P_{AO2}, mm Hg	110± 0.9	110 ± 1.1	>0.05	100 ± 1.1	98 ± 1.3	>0.05
P_{ACO2}, mm Hg	36.5± 0.7	36.6 ± 0.9	>0.05	44.4 ± 0.8	44.5 ± 1.0	>0.05

Table 3

O_2 and CO_2 tension in alveolar air at exercise in condition of breathing air of differences temperature ranges, mm Hg, M+ m (n = 32)

Parameters	Temperature ranges				
	+21...+23°C	-16...-4°C	-20...-17°C	-24...-21°C	-33...-25°C
P_{AO2}, mm Hg	100 ± 1.2	104 ± 1.1	97.5 ± 1.0	100 ± 1.2	92.6 ± 1.5
P_{ACO2}, mm Hg	44 ± 0.9	42 ± 0.6	49 ± 1.2	42.7 ± 1.2	44.8 ± 1.4

Table 4

The lung gas exchange (M ± SD) at immigration of North and experience of residing in the North

Parameters	group 1 0 – 1 year n = 8	group 2 1 - 3 years n = 54	group 3 3 - 5 years n = 26	group 4 5 - 10 years n = 31
Vo_2 to predicate (%)	100	99	95	93
Vo_2, ml/min ·kg (body mass)	4.34 ± 0.40	4.32 ± 0.50	3.97 ± 0.55	3.93 ± 0.46 *
V_E, l/min	11.3 ± 2.2 *	10.2 ± 2.2	9.8 ± 2.0	9.0 ± 1.8
V_D, ml	—	233 ± 42	235 ± 51	206 ± 42 *

** - differences between groups are significant, p <0.05*

Table 5

The parameters of pulmonary gas exchange at immigration of North within one year (M ± SD)

Parameters	February 1987	February 1988	*p*
Vo_2 to predicate (%)	338 ± 72	277 ± 49	<0.01
Vo_2, ml/min ·kg (body mass)	4.50 ± 1.00	3.69 ± 0.72	<0.01
V_E , l/min	10.5 ± 2.7	8.81 ± 1.8	<0.01
f, min^{-1}	13.6 ± 3.2	14.7 ± 3.2	>0.1
V_T, ml	800 ± 210	615 ± 135	<0.01
Ko_2	40.6 ± 12.6	39.2 ± 8.6	>0.1
Vital capacity, l	5.43 ± 68	5.43 ± 64	>0.1

Geophysical Pertubations as the Main Cause of Northern Human Stress

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Abstract
It was shown that frequent geomagnetic perturbations and also meteorological, climatic, photoperiodic, and gravitational changes in high latitudes are the main cause for human chronic stress in the North Free-radical damage of cellar and subcellar membranes (oxidative stress), disturbance of ferments' functions and changes in metabolism, connected with it; decrease in functional, detoxical, secretory and other functions of liver and other barrier organs; tension of endocrine adaptive functions; decrease in immune protection; psychoemotional strain are the main elements of geophysically conditioned northern stress. The slow wave regularity of stress reaction course has been found. Dependence of pathological reacting to meteo-geophysical factors of northern stress manifestation has been found out. The data of mechanisms providing stability to geophysically conditioned stress have been presented.
Key words: northern stress, geophysical perturbations, adaptation, disadaptation, meteosensitivity

INTRODUCTION
A number of investigations (Kaznacheev, 1980; Kulikov et al., 1980; Tkachev et al., 1992; Hasnulin, 1998; Selyatickaya, 2004; Boiko, 2005) have shown that the problem of human health preservation is largely related to ecology dependent on northern stress named also a syndrome of polar stress. This problem was studied under supervision of well-known polar explorer N.R. Deryapa within the framework of complex scientific programs "Sun-Climate-Man" and "Global experiment" at the scientific centers of Novosibirsk, Krasnoyarsk, Yekaterinburg, Vladivostok, Tashkent, Kazan, Arkhangelsk, Irkutsk, Moscow, St.Petersburg, Tomsk, and Norilsk. In this paper, the results of our studies in the northern regions of Russia revealing the significance of meteo-geophysical factors of high latitudes in northern stress formation, are presented.

MATERIALS AND METHODS OF INVESTIGATION
Estimation of peculiarities of ecology dependent stress in the North was carried out on the data of selective investigations of inhabitants in the cities of Norilsk (793 persons), Mirnyi (134 persons), Surgut (269 persons), Nadym (92 persons), Kirovsk (Murmansk Province, 32 persons), Khanty-Mansyisk (85 persons), the settlements of Kazym (Beloyarsk Province of the Khanty-Mansyisk Autonomous Region, 305 persons) and Yamburg (479 watch workers), and, as a reference group, 278 inhabitants of middle latitudes (the city of Novosibirsk) have undergone a complex selective dynamic clinic-laboratory, functional, biochemical, immunological, and hormonal investigation.

Screening of disadaptive functional and pathological states was made by means of the SCREENMED computer program developed by SCCEM SB RAMS (State Registration ‡970035 from 29.01.1997). Content of hormones in blood serum was determined with the use of standard commercial packets produced by Native and foreign firms. Determination of lymphocytes and their populations (CD_3^+ –T-lymphocytes), $CD_3^+CD_4^+$ – T-helpers), $CD_3^+CD_8^+$ – cytotoxical T-lymphocytes) was performed by the method of immunocytometry with the use of packets of monoclonal antibodies to superficial differential antigens marked by phikoerytrin (II MH RF production). The program of biochemical investigations included determination of the following indices in blood serum: total cholesterol, total fraction of lipoproteins of low and very low density (-lipoproteins), triglycerides, glucose, bilirubin (direct and indirect), transaminazes, alkaline phosphatase, lipid perβxidation, and antioxidant activity.

The results obtained were statistically processed by means of standard methods of mathematical statistics, including correlation analysis, with the use of software package STATISTICA 6.0 for personal computers.

RESULTS AND DISCUSSION
It has been found that biological effects forming the picture of stress reaction are caused by one or other combination of correlating changes in meteorological, geomagnetic and gravitational factors of high latitudes. This interrelation is revealed from the data of the reliable increase (by more than 20%) in attacks of angina pectoris and hypertension crises in the periods of geophysical perturbations and on the day after perturbation. For example, in Spitsbergen and in the settlements of Barentsburg and Pyramid the number of hypertension crises, attacks of angina pectoris in patients with coronary artery disease, acute conditions of chronic bronchitis during the periods of geophysical perturbations increased by one third. The same picture of health worsening in patients with coronary artery disease, arterial hypertension, and bronchial asthma was observed in periods of geomagnetic perturbations in Norilsk, Dudinka, Surgut, Khanty-Mansyisk, Nadym and the settlement of Yamburg. It appeared that in periods of geophysical perturbations psychoemotional stress

increased in 89.4% of sick and tired persons. A decrease in nervous excitability and strengthening of inhibition processes of central nervous system were observed in most of sick persons and persons with pre-pathological states. One further proof of the influence of geophysical perturbations on people with decreased adaptive reserves is a 1.5–2 times increase in pathological reacting to changes in geophysical or meteorological situation (pathological meteosensitivity). Moreover, analysis of correlation between the total number of urgency calls in the North, cardio-vascular crises growth, acute conditions of inflammatory diseases, traumas and the intensity of geophysical perturbations confirms the high dependence of human health on abrupt changes of meteorological and geophysical factors (Table 1).

– psychoemotional stress,
– meteopathy

Table 1

Coefficients of correlation between meteorological and geophysical factors and the number of urgency calls (Yamburg, 2002? 2003, watch workers)

Meteorological and geophysical factors	Visits to doctor per day	Total urgency calls	Cardio-vascular crises	Inflammatory diseases	Traumas
Gradient of daily gravitation	0.19	0.05	- 0.11	- 0.36	- 0.55
Mean daily atmospheric pressure	- 0.46	0.70*	0.99*	-0.16	-0.39
Amplitude of temperature changes	0.91*	- 0.39	- 0.71	- 0.48	- 0.25
Planetary (Ar) index of geomagnetic perturbations)	0.27	- 0.90*	0.80*	0.80*	0.92*
Solar activity (Wolf number)	- 0.30	- 0.40	0.99*	- 0.34	0.55
Total K-index	- 0.50	- 0.20	0.99*	- 0.12	0.36
Maximum K-index	- 0.12	- 0.60	0.97*	- 0.50	0.69
Radio emanation on a frequency of 10,7 sm	0,72*	- 0,99*	0,39	- 0.99*	- 0.99*

** Reliability of differences in the groups.*

Our investigations have shown that healthy and sick people differently react to changes in geophysical and meteorological conditions (Table 2). Healthy human organisms, owing to high reserves of possibilities in proper time, reform their internal processes in accordance with the changed conditions of the environment. All homeostatic systems liven up: immunological defense strengthens, metabolic processes improve, nervous reactions and endocrine system are accordingly restored; capacity for work is preserved or even increases.

After biologically significant changes of geophysical, meteorological, climatic, rhythmological or other ecological factors, the adaptive stability of human organism, due to mobilization of its internal reserves, increases noticeably. This is accompanied by increase in functional activity of all homeostatic systems. In this case the high level of functioning of life-providing organs and systems remains during 2–5 days depending on intensity of the influencing factor and the level of reserve possibilities (Fig. 1).

All these phenomena are perceived by a healthy person as an improvement of feeling, and increase in good mood. There may be some euphory, complacency, overestimation of one's own possibilities. Just on this basis confidence in independence ofnature appears and a search for scientifically grounded explanation for this confidence starts. A different reaction to changes of geophysical and meteorological factors is observed in people with exhausted adaptive reserves. This group includes sick, weakened and tied people. In the days characterized by sharp changes in one or more geophysical conditions, indices of energetic and immunological defence, state of cardio-vascular, gastrointestinal, urinary, and respiratory systems in such persons worsen. Reactions of central nervous system become slower and capacity for work decreases. The organism begins to lose capability for quick adapting of its internal reactions to changed conditions of the environment. This is manifested by subjective sensation of feeling worse, appearance of headache, short breath, hypertension crises and other so-called subjective meteopathic reactions (see Table 2).

Table 2

Indices of the main homeostatic systems functioning in healthy and sick persons in the periods of geophysical and meteorological perturbations (in % to normal)

Indices	Healthy persons	Sick persons
Rate of simple sensomotor reaction	+ 3-8	- 6-7
Capacity for work	+ 4-5	- 10-15
Endurance	+ 6-7	- 5-10
Cholesterol	+ 5-10	+ 24-31
Lipid peroxidation	+ 6-9	+ 100-300
LPLD and LPVLD	- 5-11	+ 15-25
Total bilirubin	- 4-8	+ 30-35
Glucose of blood	- 6-12	+ 15-22
Gamma-glutamiltranspeptidase	- 7-12	+ 20-65
Alaninaminotranspherase	- 4-9	+ 18-29
Alkalaine phosphatase	- 4-8	+ 9-15
Cortisol	+ 14-19	+ 50-80
Insulin	- 2-4	+ 75-150
T-lymphocytes	+ 15-25	- 20-35
Circulating immune complexes	- 8-14	+ 60-140

The integrated index of adaptive stability in sick people shows that owing to mobilization of internal organism's reserves biologically significant changes of geophysical, meteorological, climatic, rhythmological or other ecological factors cause insignificant short-term (during 2-4 hours) increase in adaptive stability followed by its considerable decrease (Fig. 2).

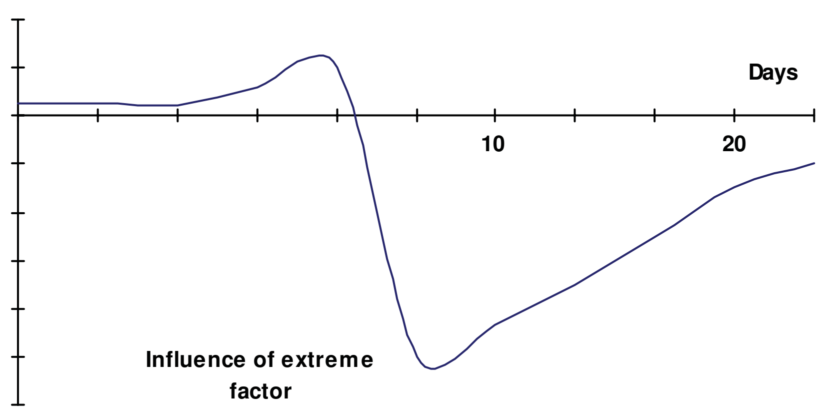
This is accompanied by decreased functional activity or disturbances of function in most of homeostatic systems. The low level of life-providing organs and systems functioning remains during 2-5 days depending on the extremity of the intensity factor and the level of organism's reserve possibilities.

The data obtained show that practically all disturbances in homeostatic systems functioning are manifested in appearance of more or less intense meteopathic reaction. This is proved by the correlation of pathological meteosensitivity with the intensity of disturbances of lipid (r = 0.68) and pigment metabolism (r=0.36), injury of cells membranes (r=0.43), increase in the level of corticosteroids in blood (r=0.50), increase of arterial pressure (r=0.79), sensation of internal time (r=0.88), and intensity of nervous processes inhibition (r=0.47).

Simultaneously, besides more frequent complaints about meteopathic reactions, our dynamic observations of patients showed an increase in cholesterol, triglycerides, lipoproteins of low and very low density, cortisol, circulating immune complexes in blood, a decrease in the number of T-lymphocytes and in the antioxidant defence of cell membranes. In other words, we observed almost a full complex of stress manifestations connected with the changes in meteorological and geophysical factors of the environment.

As an example, the data on changes of psychophysiological, metabolic, and endocrine indices reflecting human organism stress in periods of geomagnetic perturbations and on days with quiescent geomagnetic conditions in the North are presented (Table 3).

Fig. 2. Changing of a sick man's adaptive stability after the influence of extreme geophysical factor



T a b l e 3, Indices of some psychophysiological functions of the organism in the inhabitants of the North in periods of geophysical perturbations

Indices	Days with high values of K-indices	Days with low values of K-indices
Time of reaction of the right hand, ms	196.4 ± 5.4	181.9 ± 3.2
Time of reaction of the left hand, ms	191.0 ± 5.2	181.6 ± 3.1
Capacity for work	7.58 ± 0.12	8.56 ± 0.11
Individual minute, s	51.6 ± 0.5	44.6 ± 0.3
Correction test, units	7.9 ± 0.4	14.9 ± 0.6
Situational meteoreaction, units	1.50 ± 0.03	0.63 ± 0.04
Cholesterol, mmol/l	5.95 ± 0.09	5.50 ± 0.08
B-lipoproteins, g/l	60.2 ± 0.4	45.6 ± 0.3
Psychoemotional stress, units	19.4 ± 0.7	11.9 ± 0.5
Total bilirubin, mmol/l	12.6 ± 0.1	11.4 ± 0.1
Glucose of blood, mmol/l	5.3 ± 0.1	5.6 ± 0.1
Gamma-glutamiltranspeptidase, mmol/l	73.9 ± 2.7	33.8 ± 2.1
Alaninaminotransferase, mmol/l	38.5 ± 0.6	29.1 ± 0.4
Cortisol, nmol/l	345.6 ± 12.3	266.2 ± 14.5
Insulin, mcU/ml	13.5 ± 0.2	11.3 ± 0.3
TTG, nmol/l	2.59 ± 0.12	2.32 ± 0.11
T_3, nmol/l	1.95 ± 0.03	2.18 ± 0.06
T_4, nmol/l	87.0 ± 2.4	102.6 ± 3.0
Urea, mmol/l	4.76 ± 0.12	4.65 ± 0.04
Creatinin, mkmol/l	86.9 ± 1.5	96.4 ± 1.6
Urea acid, mkmol/l	343.9 ± 8.2	278.2 ± 7.4
Peroxide lipid oxidation, units	0.297 ± 0.025	0.075 ± 0.006
AoA, hour·ml/g	114.3 ± 10.2	152.2 ± 13.6
Alpha-tokopherol, mkmol/l	0.80 ± 0.02	1.09 ± 0.02

As is evident from Table 3, strong "geomagnetic storms" help inhibition of sensomotor reactions, worsen the rate of verbal information processing, change lipid metabolism in the direction of atherogenic factors accumulation, and worsen the liver function. These manifestations of stress reaction take place against the background of typical changes in endocrine indices and increased oxidation stress. An increase in meteoreacting and decrease in physical capacity for work arise from these functional changes.

Considering the obtained results we can imagine the succession in the northern stress development. It differs from the stress reaction typical of psychoemotional or social stress, pain and a number of similar states described by many researchers.

We can describe such a disadaptive stress as a pyramid consisting of blocks of disadaptive processes. Disadaptive reactions of central nervous system and imbalance of psychoemotional protective mechanisms are at the apex of the pyramid; next are disturbances of endocrine system function, immune insufficiency, disturbances of metabolism, disfunction of the main organs and systems. Membrane-cellular and molecular disadaptive defects occurring under the influence of these disturbances are the base of the pyramid.

In contrast to the described picture of stress, known from literature, northern stress in the high latitudes occurring as a result of geophysical factors unfavourable to man, develops in a different order. Primary effects of strong fluctuations of geomagnetic fields in the auroral zone of our planet occur practically in all cells of human body, causing at certain stages of decrease in protective mechanisms the molecular-membrane defects named by some scientists an "oxidation stress". Free radicals and not fully oxidated products occurring in this case are the main pathogenetic factors of the cascade of function disturbances of liver cells, cells of blood, immune system, endocrine glands, vessels, heart, and other life-providing systems. As a result, the functional activity of cerebral hemispheres that regulate, with participation of hypothalamus, reticular formation and endocrine system, the overstrained tuning up of homeostatic systems to changing conditions of the environment begins to decrease. The decrease in this regulatory activity causes pathological human organism's reacting to sharp changes of meteorological and geophysical conditions (meteopathies), and also leads to desynchronization of internal rhythms with the rhythms of the environment. Increasing endogenously conditioned psychoemotional tension completes the picture of stress in the North.

In other words, we have the turned-over pyramid, in which the beginning of "diseases of disadaptation" is in its base – membrane-cellular reaction of all organs and systems to geophysical influences. Of course, the presented scheme picture of the development of disadaptive processes in the North does not completely describe the selective mechanisms of stress development in the high latitudes.

The summarized data, concerning the syndrome of northern stress allow us to determine the main constitutive chains of this polysyndrome:

– lipid hyperperoxidation (oxidation stress),
– insufficiency of detoxication and secretory processes,
– disturbances of the northern type of metabolism,
– northern tissue hypoxy,
– immune insufficiency,
– polyendocrine disturbances,
– regenerate-plastic insufficiency,
– disturbances of electromagnetic homeostasis,
– functional dissymmetry of intercerebral interactions,
– desynchronosis,
– psychoemotional stress,
– meteopathy

It is shown that the process of adaptation to chronic influence of unfavourable geophysical and meteorological factors in the North displays biorhythmical slow-wave regularity. The periods of relative stabilization and optimization of life-providing processes approximately every three year of living in extreme geoecological conditions are followed by the periods of destabilization, characterized by the appearance of a host of disadaptive disturbances and falling on the 1st, 4th, 6–7th, 10–11th, 16–17th years of staying in the North (critical periods of adaptation). At the same time, every next phase of disadaptation is accompanied by the more considerable exhaustion of organism's adaptive reserves and increase in disadaptive processes.

Prolonged tension of regulatory systems functioning and increasing exhaustion of compensatory-recovering possibilities of an organism result in formation of pathological states and premature ageing. It has been also found that the efficiency of compensatory-recovering possibilities depends on pheno-genotypically formed types of adaptive reacting. These types are conditioned by peculiarities of cerebral hemispheres individual functioning, imprinting of stability to helio-geophysical and climatic factors; rate and intensity of reaction to the influence of one or other extreme factor of the environment and time of the following restoration of reserves.

Among the data (Table 4) obtained a special attention should be paid to interconnections between disadaptive reactions which occur at ineffective course of stress reaction and manifestation of pathological reacting to the changes in meteo- and geophysical factors (pathological meteosensitivity, or meteopathy).

Table 4

Correlation of pathological meteosensitivity with functional disadaptive disturbances of separate systems (according to the data of correlation analysis)

Disturbances	Correlation
Syndrome of psychoemotional stress	0.86
Functional disturbances of digestive organs	0.78
Surplus body mass	0.78
Disturbances of liver function	0.70
Endocrine disturbances	0.70
Immune deficit	0.60
Function disturbances of osteal-muscular system	0.58
Arterial hypertension	0.57
Manifestations of angina pectoris	0.56
Functional disturbances of ear, nose and throat	0.55
Functional disturbances of skin	0.52
Allergic disturbances	0.50
Functional disturbances of urine-secretory system	0.50
Functional disturbances of nervous system	0.40
Functional disturbances of respiratory organs	0.36

In conclusion the concepts of physiological and pathological meteosensitivity may be formulated. Physiological meteosensitivity is a property of a human organism to maintain its health through constant synchronization of internal life-providing processes with cosmic, solar, planetary, geophysical, meteorological, field and rhythmological processes in the environment. Thus this term means the possibility of healthy organism to follow constantly external pulsations of the Sun, and cosmos, geophysical, meteorological, and other natural phenomena. It may be said that meteosensitivity, i.e. human organism reacting to changes of weather, geophysical and cosmic conditions of our existing, is the most ordinary, normal physiological reaction, aimed at the perfection of living matter and supporting of harmony with our constantly changing world. This possibility of timely and adequate organism's reacting to the influences of the environment, especially in the regions with extreme climatic and geophysical conditions, depends on individual phenol-genotypical peculiarities of adaptation mechanisms, level of their exhaustion in a given period, combination of meteorological or geophysical factors, local geomagnetic, gravitational, geochemical, and anthropogenous background. It has been shown that internal processes at the appearance of physiological meteoreaction are useful and expedient for an organism and do not cause any painful sensations in man. It has been found that physiological meteosensitivity takes place only in a healthy man with good reserve possibilities. Pathological meteosensitivity takes place in case of weakening of organism, disease, stress, lingering or higher intensity of external influence.

Pathological meteosensitivity is the reacting of an organism to perturbations of meteorological and heliogeophysical factors by the development of disadaptive or pathological meteopathic reactions which are manifested by worsening of subjective feeling and formation of numerous functional disturbances. Pathological meteosensitivity appears at exhaustion of reserve adaptive possibilities of an organism. This just leads to inadequate reactions of homeostatic systems to meteo-geophysical fluctuations, manifested by changes in subjective feeling and a number of functional disturbances. Other names for pathological meteoreactions are meteotropic or meteopathic reactions, while the whole complex of meteotropic reactions is referred to us the syndrome of meteopathy.

At last, we consider it possible to propose the term "situational meteopathic reaction (situational meteoreaction)" designating pathological reacting of human organism to changes of meteogeophysical factors at certain instant of time.

The revealed peculiarities of the northern stress development, providing the stability to unfavourable influence of meteo-geophysical factors, allow us to propose the system of medical and nonmedical prevention and correction of disadaptive meteopathies. In combination with long-term medical-geophysical prognoses this system may lay a foundation for perceiving a necessity to follow the principles of healthy way of life. To prevent meteopathies it may be recommended in the days of the coming geophysical perturbations to keep to the rational regime of work and active rest; there is a need of dosed-out physical training, sparing but valuable ration of nutrition, stimulation of functional activity of the right cerebral hemisphere with the help of natural or artificial remedies; stimulation and recovering of functional systems reserves providing stability to meteo-geophysical factors. In case of considerable meteopathic disturbances prevention of acute conditions may include medical or nonmedical influences timed to the periods of geophysical and meteorological perturbations.

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Performance and Energy Expenditure in Cold Environments

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Abstract
This paper reviews the associations between physical performance and energy expenditure in cold environments. The basic question in cold is how to maintain adequate thermal insulation without marked cold or heat strain and with minimal impairment on physical performance. 24-hour energy expenditure is increased by 105-156 kJ when ambient temperature decreases by 1 °C either due to increased clothing, lowered body temperatures or environmental conditions like snow, ice or darkness. Clothing and other protective garments decrease performance due to the weight, bulkiness and friction, and by covering body areas which are important for sensory functions. Each additional kg in clothing weight increases energy costs approximately by 3% and each additional layer by 4%. Increased energy costs are associated with a decrease in physical performance: the decrease is task specific, and roughly comparable to the changes in the energy costs. The decrement in performance can be minimized by decreasing clothing weight and bulkiness as well as the friction between the clothing layers as well as the number of clothing layers. Minimal friction is important in sites where large range of movements is expected like in trouser legs and sleeves of jackets.
Key words: cold environment, cold stress, cooling, performance, energy expenditure

INTRODUCTION
Body heat balance depends on environmental cold strain, heat production by physical work and thermal insulation of clothing. Adequate thermal insulation of clothing is a prerequisite for comfort, performance and health in cold environments. While clothing is necessary for performance, it may also decrease performance and/or increase the energy cost of work.

The requirements of optimal thermal protection are difficult to fulfill in cold work both in outdoor and indoor conditions. In outdoor work the thermal environment may change quickly, as well as the levels of physical activity. Each 1 °C change in temperature corresponds to 0.1 clo change at rest and 0.03 clo in heavy work[1], and continuous adjustment of thermal insulation of clothing is not practical in working conditions.

Observations both from outdoor and indoor conditions show that in spite of marked development in cold protection, marked cold hazards still exist. The main problem seems to be the cold protection of extremities, especially hands.

PHYSICAL PERFORMANCE IN COLD
Human performance is a combination of sensory, cognitive and motor functions. The final task is often done with hands and therefore manual performance is important especially in occupational cold exposures. Unimpaired cardiovascular and respiratory functions are needed to support the function of muscles and nervous system. Moreover, good energetic and fluid balance is prerequisite for optimal performance in cold.

Physical performance usually refers to the function of the musculoskeletal system. At muscle temperatures between 27 and 40 °C, maximal isometric force decreases maximally by 2% when muscle temperature decreases by 1 °C. During sustained isometric exercises cooling, on the contrary, may even have a beneficial effect: the endurance time is increased and the rate of fatigue is slower. In general, the ability to perform dynamic exercises is more readily disturbed by cooling than isometric exercise. Regardless of the exercise type, cooling seems to decrease dynamic performance approximately of the order of 2 - 10%/°C decrease in muscle temperature[2].

Manual performance and finger dexterity are mostly affected by skin temperature of fingers and hands. Also severe decrease in mean skin temperature can impair manual performance, but core temperature has only minor effect[3]. Finger dexterity decreases slightly at finger skin temperatures of 20 - 22 °C and markedly at finger skin temperatures of 15 - 16 °C. Finger or hand skin temperature between 13 and 18 °C is critical for manual performance[4].

AMBIENT TEMPERATURE AND DAILY ENERGY EXPENDITURE
24-hour energy expenditure has been shown to increase 105 - 156 kJ, when ambient temperature decreases by 1 °C[5,6,7]. The increase in energy expenditure is a sum of all direct or indirect effects associated with ambient temperature like cold stimulated thermogenesis, increased muscular work caused by clothing, and/or snow, ice and darkness. As daily energy expenditure covers all activities from sleeping to the highest level of exercise, it is difficult to estimate the quantitative role of clothing in energy expenditure. When only active phases are included, it can be calculated from IREQ (Insulation Required[1]), that to maintain thermal balance below thermoneutral zone, 1 °C decrease in ambient temperature must be compensated by a 5.5 - 8.0 W/m^2 (corresponding 830

- 1200 kJ/24 h) increase in metabolic rate, when clothing insulation is 1 - 2 clo, respectively.

CLOTHING AND ENERGY EXPENDITURE

Carried load, including clothing, increases energy cost by ca. 3%additional kg[8,9]. The effect of load is dependent on the body site: in comparison to a no load condition, the ratio is 1.2 for the head, 1.9 for the hands and 4-6 for the feet[10].

Increased energy costs are associated with a decrease in physical performance. The decrease is task specific, and roughly equal to the changes in the energy costs[11].

In the study of Oksa et al.[12] male subjects performed a 60 minute jogging exercise on a treadmill (1° inclination) at 50% of maximal oxygen consumption. The exercise was performed in a random order at 20, 0 and -15 °C, while wearing one, two or three-layer clothing, respectively. The weight of the clothing was 1.0, 3.6 and 4.9 kg at 20, 0 and -15 °C, and the estimated thermal insulation was 0.8, 1.2 and 1.8 clo, respectively. At the end of exercise, oxygen consumption was 1.67, 1.78 and 1.88 l/min corresponding 2.7 - 3.3% increase in energy cost/ additional kg of clothing. As mean skin temperature was stabilized to 31.5, 29.5 and 30.0 at 20, 0 and -15 °C, respectively, the observed increase in energy cost was not directly related to body cooling but rather reflects the effect of clothing and confirms the rule of ca. 3%/kg.

Friction between clothing layers also markedly increases the energy expenditure. Teitlebaum and Goldman[13] compared 1 - 2 layer clothing to 6 - 7 layer clothing with equal weight and found in the latter 14 - 18% higher energy cost when walking at a speed of 5.6 - 8 km/h, respectively. Amor et al.[8] found at various walking speeds (3.6 - 6 km/h) an 8 and 21% increase in energy cost when 2 - 3 and 4 - 6 layer clothing was compared with 0 - 1 layer clothing. The both studies show a 3 - 4% increase in energy cost/layer probably due to friction.

The effect of clothing friction on performance was studied by comparing normal 3 layer military clothing with minimal friction test clothing[14]. In the test clothing the underwear and middle wear were made of 100% polyester, and outerwear had satin lining. Material tests showed a 50% decrease in the friction between the layers. Performance tests were following: crawling for 60 s, walking on treadmill on 0° for 20 min, walking uphill (10°) on treadmill for 20 min, squatting 20 times, climbing over 130 cm obstacle for 60 s and running up and downstairs. All other tests except running stairs were performed at -10 °C to prevent sweating and wetting of clothing. The results show that low friction clothing improves performance by 0 - 7.2%. Most marked effect was seen in exercise types with wide range of movements, like walking uphill and climbing obstacles.

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The Structure of Sympathetic Trunk of People Living in Siberian Region

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ABSTRACT
The research performed by histological methods has established structural maturation of human sympathetic ganglia during ontogenesis and revealed functional stability of sympathetic division of autonomic system in young people.
Key words: sympathetic, ganglia, ontogeny, structure

The vegetative nervous system innervates internal organs and blood vessels and determines their function[1]. The important role in realization of adaptive reactions under complex climatic conditions belongs to a sympathetic section of the vegetative nervous system[2,3].

OBJECTIVES
The present research is aimed at the study of morphogenesis of ganglia of sympathetic trunk of people living under conditions of Siberia during the pre- and postnatal periods of ontogenesis.

STUDY DESIGN
Ganglia of human sympathetic trunk in different age groups were taken as the material for investigation.

METHODS
Histologic study followed by morphometric and statistical processing has been carried out.

RESULTS
It is revealed that ganglia's morphogenesis of human sympathetic trunk is characterized by change in heterogeneity of cells population and alternation of the periods of acceleration and deceleration. In different age periods ganglia differ in the compactness of cells location and the development of connective tissue streaks. The difference in neuronal-glial interrelations and the development of the simple and specialized interneural contacts has been revealed. It has been found that in young people neurons and gliocytes of sympathetic ganglia have the largest total area, while in old people the neurons' area and their density in the unit of tissue decrease that results in enlargement of connective tissue.

Structural-functional formation of neurons depends on their vascular-trophic provision: the formation of bloodstream and glial capsules correlate with neurons' maturation. Vascularization and extension of capillary-glio-neurocellular contacts are maximal in fetuses; however, the estimated neuron-glial index characterizing neurons' trophism has its maximum in the nodes of young people that coincides with the period of the highest functional activity.

In the structural organization of ganglia of sympathetic trunk a cranial-caudal gradient has been revealed showing the reduction of the neurons and gliocytes total area as well as the capillary density that correlates with smaller functional load of low ganglia in human sympathetic trunk.

CONCLUSION
The study has shown that the structural maturation of sympathetic ganglia takes place during ontogenesis. The functional stability of sympathetic ganglia is reached in young people who are the most resistant to the impact of adverse factors of Siberian region.

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