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Review Article

The Influence of Environmental Factors in The Arctic Zone on The Psychophysiological State of Humans: Application of the Gas Discharge Visualization (Gdv) Method

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Abstract

This study aims to investigate the impact of geophysical and climatic factors in the Arctic Zone of the Russian Federation on the human psychophysiological state using the Gas Discharge Visualization (GDV) method. This method enables the registration of bioelectrical activity that reflects the state of the autonomic nervous system, the body's energy resources, and the level of adaptation.For the first time, statistically significant differences in GDV indicators were identified between indigenous and non-indigenous residents, including both children and adults from various regions. These findings indicate the existence of ethnospecific and regionally determined adaptation patterns.The results show that indigenous Saami populations exhibit more balanced metabolic and autonomic responses, likely reflecting genetically based mechanisms of resilience to geocosmic stressors. A conceptual model is proposed that links GDV parameters with environmental characteristics, including solar activity levels, geomagnetic turbulence, and temperature fluctuations.

Keywords: gas discharge visualization (gdv); optoelectronic emission; psychophysiological state; euro-arctic zone; psychophysiological indicators; environment

Introduction

Psychophysiological adaptation in the Arctic environment is not only a medical-biological issue but also a socio-cultural one. Geophysical and climatic factors of the Arctic Zone exert a systemic impact on the central and autonomic nervous systems, leading to changes in the body's regulatory mechanisms. Special attention is given to the development of non-invasive methods for rapid assessment of the psychophysiological state, which can be used both for research and practical purposes, especially in remote and extreme regions.

The GDV method allows for the quantitative recording of changes in the energy and autonomic profile of an individual, making it a promising tool for both individual state monitoring and population studies within the context of human ecology.

Relevance of the Study

The relevance of this study lies in the need to develop new methods for monitoring the psychophysiological state of populations living in conditions of extreme natural factors. GDV-based methods can significantly improve the diagnosis of health conditions, assist in the early prevention of diseases caused by climatic and geophysical anomalies. This is especially important for the population of the Arctic Zone, where living conditions differ significantly from those of temperate climate regions [1-3].The advantages of the GDV method, such as low cost, accessibility, ease of use, and high sensitivity to changes in the body, make it especially valuable for determining psychophysiological states [4]. This method can detect any changes induced by various environmental and social factors, making it ideal for screening and dynamic studies covering large population groups, such as professional, sports, or territorial groups [5].In the Arctic Zone, geophysical and climatic factors significantly influence the psychophysiological state of residents [6]. Disruptions in circadian rhythms caused by "polar" day and night phenomena can also have a considerable impact on health [7, 8]. Studying the effect of the environment on human health, changes in psychophysiological states under the influence of Arctic natural factors, and differences in sensitivity among various population groups is crucial for the socio-economic development of the North [9, 10].Additionally, the use of the GDV method within wellness and corrective programs allows for the assessment of their effectiveness both at present and during the dynamic process of recovery, which has practical value for both individual and group programs [11].Thus, the study of the informativeness of the GDV method (bioelectrography) is justified by the need to develop a methodology for non-invasive rapid assessment of the psychological and psychophysiological state of residents in the Arctic Zone with subsequent correction [12].

Aims And Hypothesis of The Study

The study aims to assess the impact of ecological (geophysical, climatic) factors of the Arctic Zone on the psychophysiological state of the population using the GDV method, as well as to identify ethnic and age-related differences in the adaptive responses of the body.

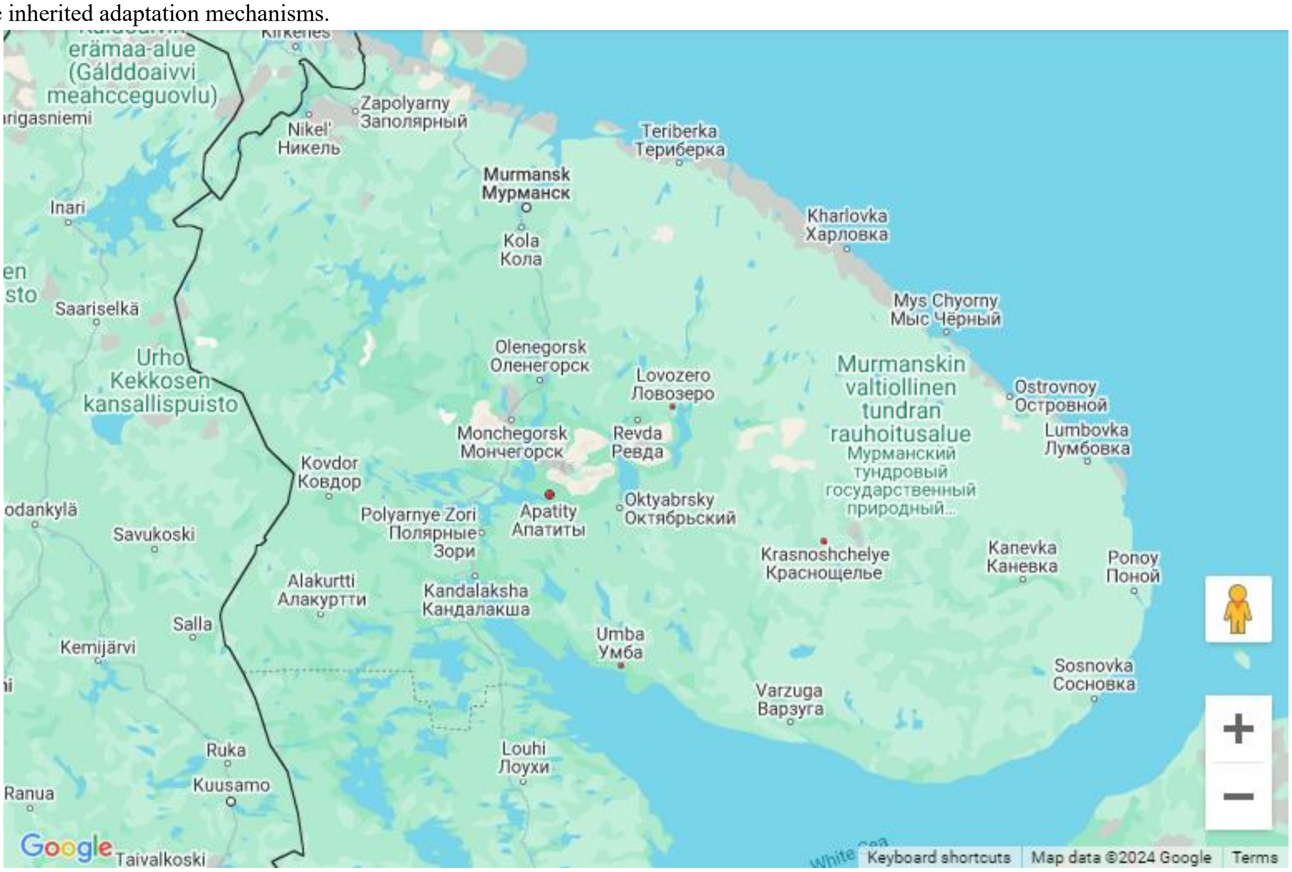
Hypothesis:

Geocosmic factors (geomagnetic storms, solar activity, interplanetary magnetic field), as well as local climatic conditions, cause significant changes in GDV parameters that reflect the functional state of the autonomic nervous system and the energy balance of the body. Indigenous populations exhibit distinct response patterns, which may indicate inherited adaptation mechanisms.

Methodology

The study used the Gas Discharge Visualization (GDV) method, which is based on the registration and analysis of the glow induced by an impulsive electromagnetic field in biologically active points (fingertips). This allows for the assessment of parameters that reflect the psychophysiological state of the body.The indicators extracted from the GDV graphs (glow area — S, form coefficient — Kf, entropy — E, symmetry — Sym) were analyzed in relation to their connection with the activity of the sympathetic and parasympathetic systems, energy metabolism, cognitive, and emotional background.In addition to the standard procedure, a correlation matrix was developed between GDV parameters and external geophysical agents (Dst index, F10.7, ionizing radiation fluxes, etc.), allowing for the consideration of biophysical indicators as markers of environmental impact.

The study involved 1,520 individuals from major age and ethnic cohorts. Participants were divided into the following categories: preschool children (n=181), schoolchildren (n=220), students (n=109), adults (n=1,010), with 40 individuals identifying themselves as indigenous (Saami). The geographic area covered key points of the Kola Polar Region and the Svalbard Archipelago [13, 14].To enhance the accuracy of the analysis, not only the "GDV Energy Field" program was used but also signal pre-filtering based on geomagnetic activity phases (NOAA, SPIDR data), and stratification by climatic zones. In the future, integration with machine learning algorithms (e.g., clustering and principal component analysis) may be possible, which will help uncover hidden patterns of biophysical adaptation [15, 16].



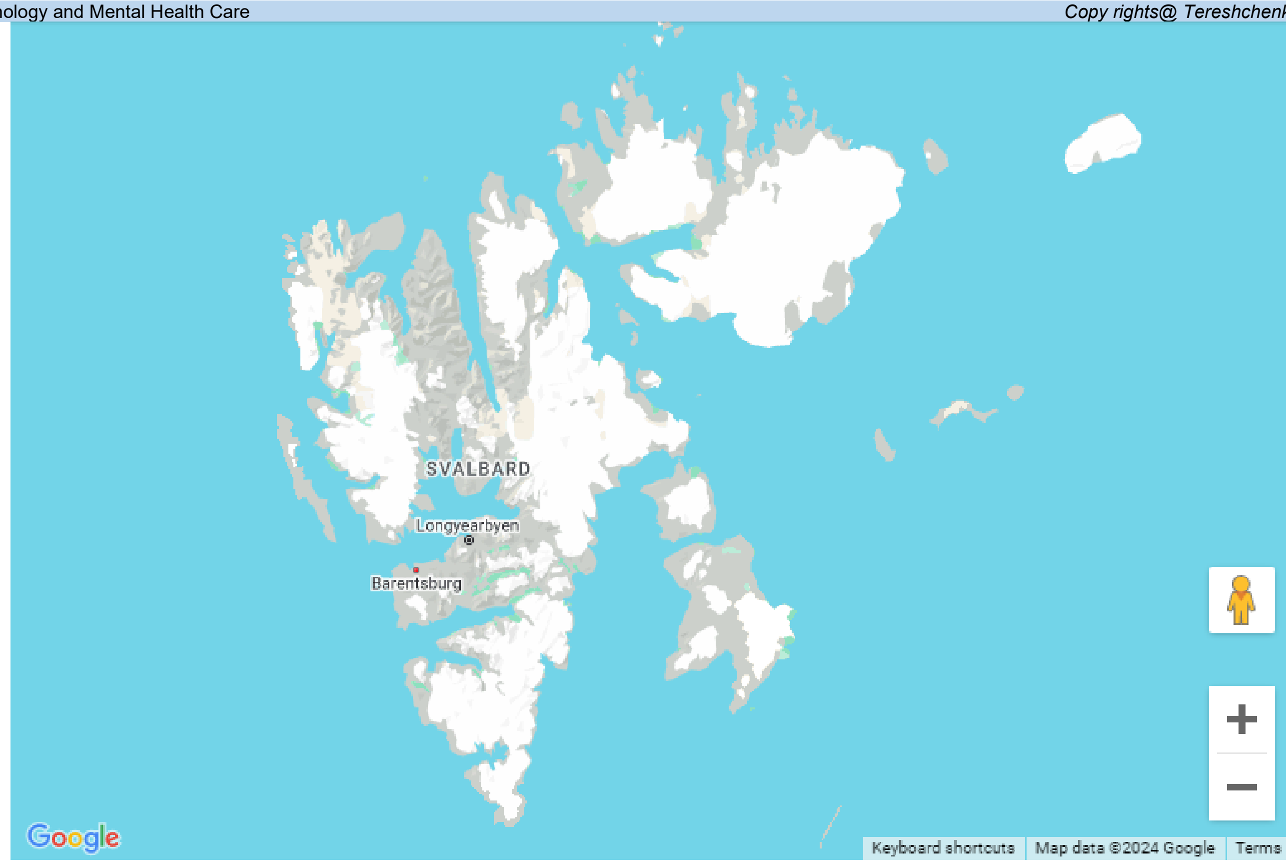


Figure 1: Comparison territories (village Krasnoshchel'ye, settlement Lovozero, town Apatity, settlement Umba) on the map of the Murmansk region, Svalbard Archipelago (settlement Barentsburg)

Results

Positive correlations were found between GDV indicators and the results of the HRV method (heart rate variability), GSR (galvanic skin response), blood oxygen levels, immunological blood tests, anxiety, well-being, mood, activity, and the duration of an individual minute. Additionally, correlations were observed with the daily average values of geocosmic agents [15-23].

GRV indicators	MF vector, |<B>|	Bulk speed	sigma-n	Plasma beta	DST Index	R >10 MeV	R >60 MeV	F10.7 Index	NCR
S	**-0,56**	**0,47**	-0,21	**0,56**	**-0,49**	**-0,56**	**-0,52**	-0,36	**0,73**
E	-0,19	**0,47**	**-0,64**	0,00	**-0,63**	-0,25	-0,39	-0,36	**0,53**
Kf	0,09	0,29	-0,31	**-0,45**	**-0,52**	**0,55**	-0,30	**-0,60**	0,20
Sim	-0,26	0,25	0,11	-0,04	-0,09	-0,30	**-0,59**	**0,45**	**0,49**

Table 1. Correlation coefficients between daily values of GDV indicators and daily average values of geocosmic agents. ($p<0.05$) (Solovyevskaya N.L. et al., 2019).

The obtained data demonstrated significant correlation links between GDV indicators and geocosmic factors. The glow area (S), entropy (E), and form coefficient (Kf) showed statistically significant deviations with fluctuations in the values of the Dst index, F10.7, and proton fluxes of various energies.

Note:

IMF vector, |<B>|	Daily average value of the IMF vector module (Interplanetary magnetic field)
1 **nT** = 10^{-9} **T** (Tesla)	Solar Wind Speed
Bulk speed, km/csigma-n, $см^3$	Variability of particle density in Solar Wind Speed

Plasma beta	The ratio of kinetic plasma pressure to magnetic pressure (Beta = [(T·4.16/105) + 5.34] · Np/B2).
Dst index, Kr- index	The intensity index of the geomagnetic storm, with an increase in the intensity of the storm, the Dst index decreases
PR>10 MeV, PR >60MeV	The density of the flow of protons with energies >10 MeV, >60 MeV
F10.7 index, (10^{-22})	Solar radio flux at a wavelength of 10.7 cm (f = 2800 MHz, solar flux units (sfu), 1 sfu = 10^{-22})

Table 1: Correlation coefficients between daily values of GDV indicators and daily average values of geocosmic agents. ($p<0.05$) (Solovyevskaya N.L. et al., 2019).

This confirms the applicability of the method for studying the influence of the environment on the psychophysiological (functional) state of humans. A previously unreported relationship was found between the symmetry of glow (Sym) and the level of solar radiation (F10.7 index), with a non-linear (U-shaped) dependence observed. The minimum symmetry values corresponded to both extremely low and highly active phases of the solar cycle. A comparative analysis of the integral psychophysiological state (PFS) indicators of indigenous and non-indigenous residents of the Arctic Zone (AZ) revealed significant differences in the PFS of indigenous Saami, distinct from those of non-indigenous populations living in the same region. During the expedition in the compact settlement of Saami in the village of Lovo zero, we studied mixed groups consisting of men and women self-identifying as Saami (41 individuals) and those not identifying as Saami (52 individuals), living in the same area. When comparing the GDV psychophysiological indicators of indigenous and non-indigenous residents, we found significant differences. The glow area (S) ($p<0.05$) in the Saami was higher than in the non-indigenous residents of the same area, while the form coefficient (Kf) ($p<0.05$) and entropy (E) ($p<0.05$) were significantly lower. It should be noted that the higher values of the glow area and symmetry (Sym) with lower values of the form coefficient (Kf) and entropy (E) in the Saami, compared to the non-Saami, indicate higher energy resources in the Saami and a more balanced homeostasis ($p<0.05$, Kolmogorov-Smirnov test).

Indicator	Saami (n=41)	Not saami (n=52)	p
Age	48,93±14,04	45,10± 11,88	
Area coefficient	28896±2588	25585±2388	< 0,05
Symmetry indicator	94,21±1,48	93,97±1,58	< 0,05
Entropy coefficient	3,69±0,14	3,71±0,11	< 0,05
Form coefficient	13,04±0,91	14,25±1,41	< 0,05

Table 2: Comparative analysis of the integral PFS indicators of indigenous and non-indigenous residents of the Arctic Zone (AZ).

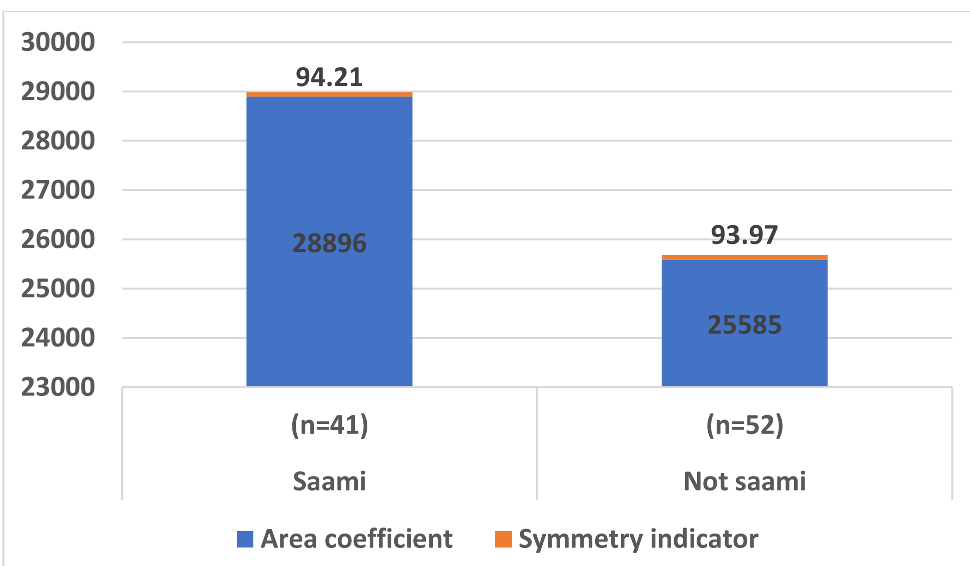


Figure 2: Comparison of integral GDV psychophysiological parameters between Saami and non-Saami.

Assessment and comparison of integral PFS indicators in children living in different areas of the Arctic Zone (AZ): Lovozero village: preschool children (71 individuals), schoolchildren (61 individuals) Umba settlement: preschool children (64 individuals), schoolchildren (85 individuals) Apatity city: preschool children (39 individuals), schoolchildren (50 individuals)

The comparative analysis showed that the most reliably low GDV indicators ($p<0.05$, Kolmogorov-Smirnov) characterizing the psychophysiological state were found in children from Lovozero village, while higher indicators were observed in children from Umba settlement. Fig. 1 illustrates the most significant differences in psychophysiological indicators using the glow area (S) as an example ($p<0.001$).The comparative analysis among children revealed significantly lower GDV parameters in preschoolers from Lovozero village compared to those from Umba settlement and Apatity city, especially for the glow area (S) parameter (24056±2110 vs. 28208±2635, $p<0.001$), indicating a higher strain on the adaptation systems of younger groups in more extreme ecological zones.Among schoolchildren, the lowest glow area (S) values were observed in Apatity city (24404±2641), followed by Lovozero village (25465±2815), while the highest values were found in Umba settlement (30365±3931, $p<0.001$).

Settlement point	Preschoolers				
	average age	S	E	Kf	Sym
Lovozero	5,32±1,3	24056±2110	3,67±0,12	12,36±1,65	91,99±3,64
Umba	4,93±1,28	**28208±2635**	3,74±0,13	12,58±1,25	90,52±3,99
Apatity	4,31±0,97	24348±1370	3,78±0,13	12,33±1,15	90,42±3,5
	Schoolchildren				
Lovozero	11,62±2,32	25465±2815	3,70±0,14	12,39±1,24	92,62±2,83
Umba	11,79±1,7	**30365±3931**	3,78±0,15	12,21±3,6	91,55±4,83
Apatity	12,38±2,17	24404±2641	3,67±0,14	13,58±1,24	93,57±2,41

Table 3: PFS indicators in children living in different areas of the Arctic Zone (AZ). The highlighted indicators show significantly higher PFS values ($p<0.05$, Kolmogorov-Smirnov).

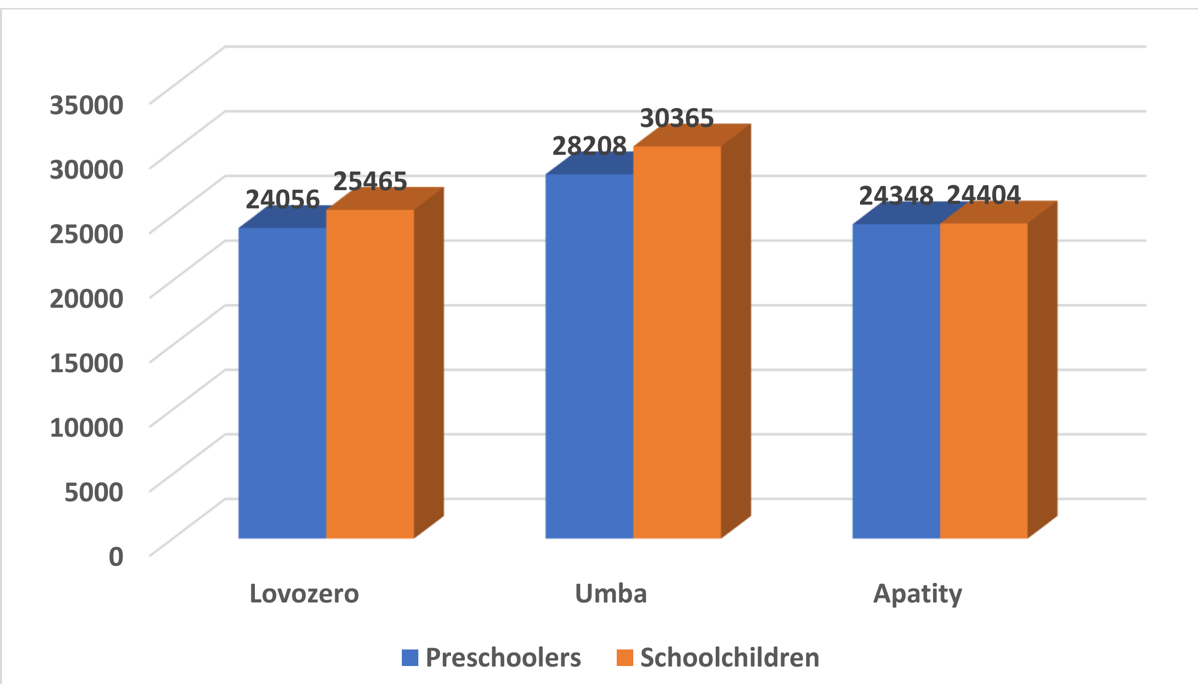


Figure 3: GDV parameters (S) of children living in different areas of the Arctic Zone (AZ).

The comparative analysis showed that the most reliably low GDV indicators characterizing the psychophysiological state were found in preschool children from Lovozero village, while higher indicators were observed in children from Umba settlement. Among schoolchildren, the lowest values were found in children from Apatity city.Assessment and comparison of integral PFS indicators in adults, based on the examination of mixed groups of adult populations: 52 residents of Lovozero village, 73 residents of Apatity city, 88 miners from the Karnasurt mine, 50 miners from Barentsburg settlement, Svalbard Archipelago, 100 residents of Krasnoshchel'ye village.

	S	E	Kf	Sym
Lovozero not saami	25585±2388	3,71±0,11	14,25±1,41	93,97±1,58
Umba	28529±2409	3,71±0,12	12,92±1,14	93,96±1,01
Apatity	26281±2492	3,64±0,13	14,24±1,67	93,48±1,34
Krasnoshchel'ye	24404±2390	3,74±0,11	14,30±1,47	93,74±1,16
Barentsburg miners	31054±2853	3,66±0,15	13,50±2,50	93,00±3,23
Mine Karnasurt miners	25544±1796	3.71±0,12	14,49±1.46	93,76±1,46

Table 4: PFS indicators in adult residents of various areas of the Arctic Zone (AZ).

Miners from Barentsburg settlement on the Svalbard Archipelago demonstrated significantly higher PFS values, indicating a relatively high psychophysiological status at the time of the study. The high average values of the glow area (S) (31054±2853) were significantly higher than those of miners from Karnasurt (25544±1796), non-indigenous residents of Lovozero village (25585±2388), residents of Apatity city (26281±2492), and even higher than the most favorable group in terms of psychophysiological state, the residents of Umba settlement (28529±2409, p<0.05, Kolmogorov-Smirnov).The maximum values of the energy parameters (S) were recorded in the miners from Barentsburg (31054±2853), which may indicate hypercompensatory activity of the adaptation systems under conditions of high geomagnetic loads and hypoxic background. For the miners from Karnasurt, these values were significantly lower (25544±1796), despite having a similar work profile, highlighting the role of latitudinal and atmospheric differences.

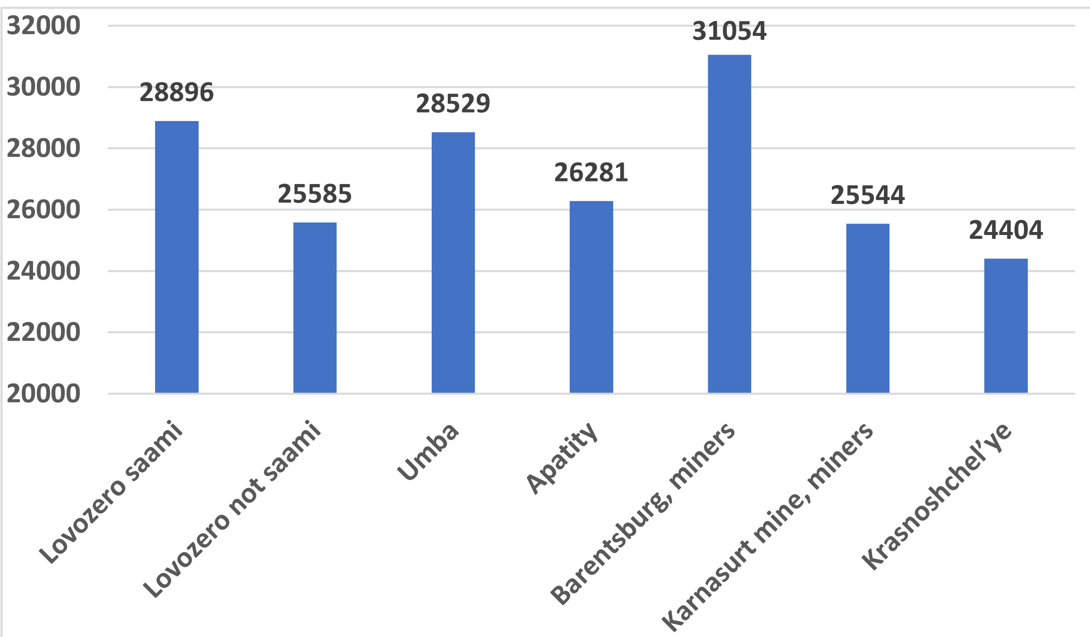


Figure 4: Comparison of GDV glow area (S) values in adults from different territories of the Arctic Zone (AZ).

When analyzing ethnic differences, it was found that the Saami demonstrate a more balanced GDV profile: high values of S and Sym with low Kf and E. This can be interpreted as an expression of a stable vegetative balance and harmonious metabolic homeostasis, likely formed as a result of multi-generational adaptation to polar conditions.

Discussion

The results of the study confirm that the GDV method has high sensitivity to a wide range of external influences — from climatic fluctuations to geomagnetic storms. This makes it a promising tool not only in occupational medicine but also in fundamental research on the body's adaptation mechanisms.

In a comparison of two identical groups by age and composition of residents living in the same area in Lovozero village on the Kola Peninsula, it was shown that residents self-identifying as Saami had significantly higher psychophysiological state (PFS) indicators than the adult population of the village that did not identify as Saami ("non-Saami"). The Saami exhibited higher energy resources and a more balanced state, as confirmed by higher glow area values and a lower form factor compared to non-Saami.Among the investigated territories on the

Kola Peninsula, the most favorable PFS indicators were found in the settlement of Umba, both for adults and children. Likely, the living conditions in the urban-type settlement of Umba, located on the Ter coast of the White Sea, are the most comfortable. This could be related to more favorable ecological and climatic conditions, a special microclimate, and access to medical care. These results emphasize the contribution of territorial characteristics and environmental conditions to the health of the population.The comparison of PFS among residents of Barentsburg settlement (Svalbard Archipelago) with other areas of the Arctic Zone showed that the subjects from Barentsburg had significantly higher GDV glow area (S) values compared to other groups ($p<0.05$). This may be due to specific geophysical factors influencing the polar cusp region during certain periods of geomagnetic activity.An important direction for future research is the study of the contribution of ecological and other natural environmental factors to the PFS of residents living in different Arctic territories. Statistically significant differences in PFS across relatively small areas of the Euro-Arctic zone support this statement.Of particular interest are the significant differences observed in the miners from the Karnasurt mine in the village of Revda and the miners from Barentsburg (Svalbard Archipelago), located at much higher latitudes. The miners from Barentsburg showed significantly higher PFS indicators ($p<0.05$). These differences could be linked to the influence of geocosmic factors, which manifest most clearly in the so-called "polar cusp" region surrounding the North Pole and have a distinct effect on people's PFS during geomagnetic activity and other cosmic cycles.Considering that instantaneous studies of psychophysiological status in large populations are challenging with other instrumental methods, which require long times for research and data processing in hospital settings, the optoelectronic emission method (GDV) shows its potential. It allows for the examination of a large number of people and the collection of data via computer systems in real-time. Since environmental conditions constantly change, long-term studies may distort results regarding the impact of the environment on health. We have previously described the registration of the influence of geomagnetic factors on psychophysiological state and correlations of GDV indicators with other methods of PFS research. This confirms that the GDV method is effective for both comparing the PFS of residents from different territories and tracking the impacts of various environmental factors [13, 14].Special attention should be given to the identified phenomenon of ethnic resilience: the differences between the Sámi and non-Sámi populations persist under identical living conditions, indicating the possibility of genetically and culturally mediated adaptation strategies. This could serve as a foundation for further research in the fields of ethnoecology and personalized medicine.

The established connections between HRV indicators and geocosmic agents (Dst index, >10 MeV fluxes) allow HRV to be considered as a biosensor technology for monitoring the impact of space weather on health. Such data are particularly relevant in the context of increasing solar activity and the potential influence of geoclimatic changes on vulnerable populations.

Conclusions:

1. **Age-related differences in psychophysiological state.**

   The study revealed significant differences in gas discharge visualization (GDV) indicators between children and adults living in various regions of the Kola Peninsula. This confirms the influence of age factors on the psychophysiological state. Children exhibited higher levels of stress and anxiety under the impact of environmental and climatic factors, highlighting the need to develop specific adaptation strategies for this age group.

2. **Ethnic and social differences.**

   Differences in psychophysiological status are observed among adults belonging to different ethnic groups living in the same region. These differences may be influenced by cultural and social factors, such as traditions, lifestyle, and perception of the environment, which affect stress perception and adaptation to extreme conditions. It is important to consider these factors when developing healthcare programs aimed at supporting ethnically diverse populations.

3. **Geophysical impact on the health of workers.**

   Significant differences in GDV indicators were identified between miners from the Kola Polar Region and Barentsburg (Svalbard Archipelago). This may indicate that various geophysical and environmental conditions—such as climatic features, environmental pollution levels, and geomagnetic activity—have different effects on the health of workers. Such an analysis helps to identify the need for adapting working conditions and providing specialized medical services based on geographical and environmental specifics.

4. **Application of GDV method for health monitoring.**

   The obtained data confirm the high informativeness of the gas discharge visualization (GDV) method for assessing an individual's psychophysiological state. This method can become an important tool for comparative rapid assessment of the impact of various environmental factors on public health, opening new possibilities for health monitoring in extreme ecological conditions. Its application in healthcare could contribute to more accurate and rapid diagnosis of health conditions, as well as early prevention of diseases related to climatic and geophysical influences.

5. **The need for further research.**

   The results of the study highlight the necessity of continuing research on the impact of ecological, meteorological, and geocosmic factors on the psychophysiological state of the population. Further research will provide a deeper understanding of the mechanisms by which these factors affect human health, as well as help develop effective strategies and programs for healthcare in the context of a changing climate and environmental changes. This will also aid in identifying potential risks and predicting possible long-term health consequences, which is particularly important for residents of Arctic and sub-Arctic regions.

Conclusion

Our research highlights the importance of studying the impact of ecological and geophysical factors on the psychophysiological state of people living and working in the extreme climatic conditions of the Arctic and Antarctica. These regions, subject to severe climatic fluctuations, geomagnetic anomalies, and changing environmental conditions, require special attention in terms of disease prevention and improving the quality of life for their inhabitants. Comprehensive studies aimed at identifying the specific consequences of these factors will help create more accurate health forecasts for the population, as well as develop effective methods for the prevention and correction of psychophysiological conditions. It is important to consider individual and group characteristics, such as ethnicity, age, and professional activity, which will allow for the creation of more adaptive and personalized healthcare programs. Moreover, the results of this study can serve as a basis for developing more adaptive and effective programs aimed at improving living and working conditions in extreme climatic and geophysical environments. We advocate for interdisciplinary collaboration among specialists from various fields—medicine, ecology, sociology, psychology, and others—to develop integrated approaches that promote the health and well-being of Arctic and Antarctic residents. It is crucial to take into account global climate changes and their impact on ecosystems, as well as to develop new diagnostic and treatment methods based on innovative technologies such as the GDV method.Work was carried out as part of the budget-funded research project #122022200516-5Special thanks are extended to T. A. Yusubova, R. R. Yusubov, and Biotechprogress LLC, St. Petersburg, for their assistance in the research gdv.kti@gmail.com, as well as "Kirlionics Technologies International" (LLC "KTI"), St. Petersburg gdv.kti@gmail.com.

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