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Imbalances of the autonomic nervous system in people living in radioactive contaminated territories: radioactivity and vegetative imbalance

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► ***Short report***

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ABSTRACT

Background: The Ural region is highlighted among other Russian regions for its unfavorable radiation situation and complexity of the overall environmental situation. The source of man-made radioactive contamination is the work of the "Mayak" Production Association. A significant radioactive contamination has happened as a result of several radiation incidents in the early period of the company activity and it has affected a territory total area of over 23,000 km^2 in the Chelyabinsk, Kurgan and Sverdlovsk regions. Our primary aim is to compare the characteristics of Heart Rate Variability among residents of the Ural region, living in the territories with different levels of radioactive contamination. ***Materials and Methods***: The segment of the population exposed to increased radiation exposure amounted to approximately 500 thousand people. We have distinguished three territories in the Urals region to perform a comparative study of environmental factors (the radioactive contamination) on human health. Two of these territories are case territories, which are exposed to environmental hazards, and one of them is the control. Data were collected from 1992 to 1995. ***Results:*** To assess the dependence of the state of adaptation abilities of the organism exposed to radiation contamination of the territory, we used the stress index. We determined the statistically significant influence of man-made radioactive contamination of the environment on the functional adaptation of the body. ***Conclusion:*** Our study showed the predominance of sympathetic regulation of heart rate, which indicates the tension of adaptation capabilities of the organism for the population living in radioactive contaminated areas.

Keywords: *Radiation, heart rate variability, stress index, autonomic nervous system.*

INTRODUCTION

Currently, the method of analysis of the heart rate variability (HRV) is becoming more widespread. This method is designed for the study of the autonomic regulation of physiological functions [1-2]. It is known that the autonomic nervous system controls the energetic and metabolic processes of the body, implements the mobilization of functional reserves under the influence of stress, and ensures their recovery. The mechanisms of vegetative regulation play a leading role in the adaptation reactions of the body and the maintenance of homeostasis of its major systems in changing environmental conditions [3]. Therefore, the analysis of HRV is of great interest in the study of the impact of technogenic

radioactive contamination of territories on the human body.

It was noted that different types of pathologies and multiple diseases occur more frequently among people who have been exposed to increased anthropogenic radiation and their descendants than in control groups [4]. This observation may be explained by the high tension of adaptation capabilities of the organism [5]. However, only few works have focused on the study of the impact of radioactive contamination on the adaptability of the organism by means of HRV analysis [6-7].

The emergency radiological situation arose in the Ural region in connection with the activities of the "Mayak" PA, which has become a source of man-made radiation exposure to the territory and population of the region.

To investigate the symptoms associated with exposure to radiation and their effects on HRV characteristics, we used the index of regulatory systems tension (Stress Index). Stress index, calculated according to the variation of pulsometry, is used in assessing the balance between the sympathetic nervous system and parasympathetic nervous system [3].

We have distinguished three territories in the Urals region to perform a comparative study of environmental factors (the radioactive contamination) on human health. Two of these territories are case territories: the East-Ural Radioactive Trace (EURT), and the coastal area of the Techa River, which are exposed to environmental hazards. As a control territory, we selected Koryukovo village (figure 1).

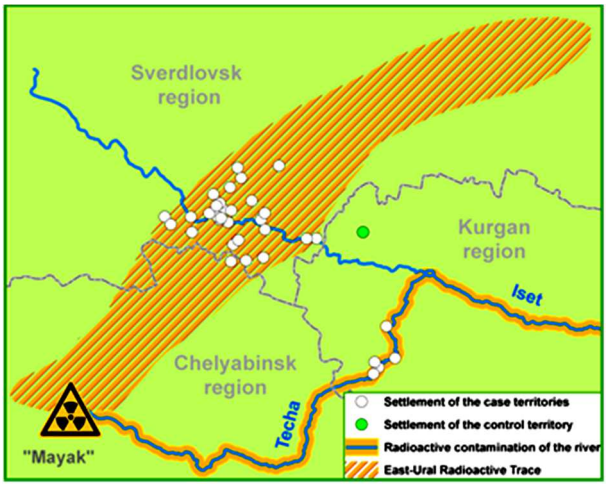

Figure 1. The scheme of radioactive contamination of the soil [7] and the location of the settlements of the population surveyed.

Our primary aim was to study the effect of prolonged exposure to low and medium doses of radiation on the adaptive capacity of the body.

The task of study was to compare the characteristics of HRV among residents of the Ural region living in territories with different levels of radioactive contamination.

MATERIALS AND METHODS

The research participants amounted to 990 people living in the three analyzed territories. The study included adults aged 18 to 88 years (50.1 ± 16.6). Inclusion criteria for our study were residence in these territories for at least last five years. Exclusion criteria included people younger than 18 years old since HRV analysis [3] is certified only for adults. The mean age of inhabitants of all studied territories was about the same.

This research was conducted in accordance with the standards of the Ethics Committee of the Institute of Industrial Ecology of Ural Branch of Russian Academy of Sciences, and with the Helsinki Declaration (revised in 2000).

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The equipment used included a cardiograph CPC 202140 (produced by the UOMP, USSR) and a blood pressure cuff (sphygmomanometer) C75-A (produced by the SKTB "BIOFIZPRIBOR", USSR). The short cardiointervalogram was recorded in conditions of relative calm using the Baevsky R.M. method [3].

The analysis of the records was performed using the statistical parameters of the distribution of cardio intervals. According to the data of HRV parameters studies, a number of derivatives indicators can be calculated, among which is the widely distributed index of tension of regulatory systems or the stress index (SI), which is calculated as follows [3].

$$SI = \frac{AMo}{2 \cdot Mo \cdot VR} \quad (1)$$

Where; AMo is the Mode amplitude (the number of cardiointervals, corresponding to the value of Mode, in percent to the sample size); Mo is the Mode; and VR is the Variable Range (the difference between maximal and minimal meanings of cardiointervals).

SI reflects the degree of centralization of heart rhythm management and characterizes the activity of the sympathetic part of the autonomic nervous system. SI is measured in conditional units. In norm (at rest), it changes within the limits of 50-150 conditional units [3].

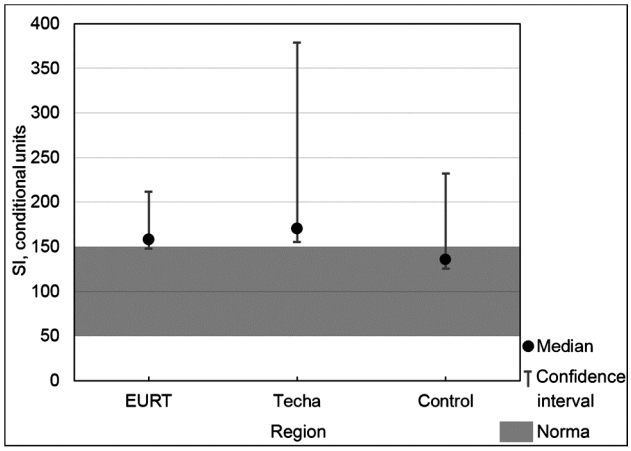

Figure 2. Median value of the stress index in the studied territories.

Statistical analysis

For data analysis, STATISTICA software (version 10.0) was used and comparison of the groups was performed using non-parametric Kruskal-Wallis analysis of variance (ANOVA) and Median test. P value less than 0.05 was considered significant in the comparison of the groups.

RESULTS AND DISCUSSION

We used the median value for the analysis because the SI is not subject to a normal distribution. The median values of the stress index in the territory EURT and Techa River basin are 152.0 and 170.0 conditional units, respectively. For residents of the control territory, the median value of the stress index is 134.0 conditional units. Thus, the median value of the stress index does not exceed the threshold norms only in the control territory (figure 2).

Consider the distribution of the values of the stress index in the territories (table 1).

Table 1. Percentage distribution of the SI values in the studied territories.

The range of SI values, conditional units	Territory		
	Techa River basin, %	EURT, %	Control territory, %
0–49 (below the norm)	6.8	13.5	20.0
50–150 (the norm)	33.1	36.0	37.1
>151 (above the norm)	60.2	50.5	42.8

Table 1 shows that the percentages of residents with an SI value in the normal range for all studied territories are nearly identical, and this value ranges from 33 to 37. At the same time, the proportion of residents having SI above the norm varies considerably in different territories. The largest percentage of residents with interval SI values > 151 conditional units

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was observed in the basin of the river Techa (60.2), and the lowest was observed in the control territory (42.8); a difference in the median values of the SI was statistically significant at $p < 0.05$. The excess of norm in terms of the SI is an indicator of activation of the adaptive capabilities of the organism, expressed through an imbalance of the autonomic nervous system due to sympathetic predominance. Prolonged vegetative imbalance with the predominance of the sympathetic autonomic nervous system, accompanied by an increase in energy needs, results in depletion of the energy reserves and, consequently, to diseases of various etiologies [5].

Below normal SI values were most often recorded among residents of the control territory (20% of the population). The low SI values were less often detected among residents of the basin of the river Techa (only 6.8%). Below normal SI values may indicate parasympathetic predominance of regulation in these inhabitants [3].

Thus, we see more severe long-term consequences in the form of disturbances of the HRV among inhabitants of the coastal area of the Techa River, where liquid radioactive waste was discharged over the 1949-1956 period. The spring floods led to a high radioactive contamination of coastal soil. The inhabitants of the coastal area still continue to use the contaminated river water for domestic use [8].

In a similar study, Litvin *et al.* [8] showed the estimate of the state of the mechanisms of vegetative regulation by HRV analysis among inhabitants exposed to low levels of radiation due to the Chernobyl disaster. They fixed values of SI above the norm (SI = 199 c.u.) among participants aged 16-21, which were higher than values obtained by us (table 1). It should be noted that research on the effects of the Chernobyl disaster and in the Urals were carried out 20 and 40 (respectively) years after the incidents. Perhaps, in this regard, the effect of radiation exposure on the population in the Chernobyl zone was higher [8].

Thus, the results showed the presence of changes in parameters of heart rhythm among inhabitants of contaminated areas compared with controls. A deviation from norm of SI shows the reduction of adaptation reserves of the body. Probably, this reduction of adaptation reserves is the overall response of the body to the action of prolonged radioactive contamination. Therefore, the health of residents of contaminated areas is at greater risk of disease than controls, in connection with the general weakening of the body.

***Conflict of interest*:** *Declared none.*

REFERENCES

1. Thayer JF, Hansen AL, Saus-Rose E, Johnsen BH (2009) Heart rate variability, prefrontal neural function, and cognitive performance: the neurovisceral integration perspective on self-regulation, adaptation, and health. *Ann Behav Med,* ***37 (2)****: 141-53.*
2. Baevsky RM and Ivanov GG (2000) Heart rate variability: theoretical aspects and possibilities of clinical application. *Medicine Publ.*, Moscow. Russian.
3. Kireeva GN, Malahova SI, Karimova IP, Zhukovskaja EV (2012) The health status of children living in settlements Chelyabinsk region affected by anthropogenic radiative forcing. *Vestn Ural Med Akad Nauki,* ***2(39)****: 117-8.* Russian.
4. Thayer JF, Yamamoto SS, Brosschot JF (2010) The relationship of autonomic imbalance, heart rate variability and cardiovascular disease risk factors. *Int J Cardiol,* ***141(2)****: 122-31.*
5. Varaksin AN, Shershnev VN, Chukanov VN (2002) Determining factors causing disturbance of adaptation mechanisms in residents of radiocontaminated territories in the Ural region. *Radioprotection,* ***37(C1)****: C1-1341-6.*
6. Zaretskaya IM (2004) Features of arterial hypertension in the Chernobyl nuclear accident liquidators (dissertation).Chelyabinsk: Urals State Medical Academy. Russian.
7. Izrael YuA, editor (2013) Atlas of the East Ural and Karachay radioactive trace including forecast up to 2047. *IGCE Roshydromet and RAS, «Infosphere» Foundation*, Moscow. Russian.
8. Litvin FB (2006) Morphofunctional restructuring of the microcirculation system in children, adolescents and young adults living in places with different radioecological conditions (dissertation). Moscow: The Peoples' Friendship University of Russia. Russian.

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