

## First Results of the Heart Rate Variability Analysis in Medical and Chronobiological Research under the program "Mars-500"

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*Abstract. Chronobiology studies the effect of time and biological rhythm on living. Research of control groups aimed at the estimation of how far the functional state of healthy people changes under conditions of long-term flight and long-term stay on the earth will take place. The obtained results on the earth show that the method of HRB analysis, including not only spectral analysis, but also variational pulsometry, autocorrelation analysis, statistical analysis and correlation rhythmography well reveals the main features of the organism reactions at the changes of chronobiological conditions.*

### 1 Introduction

Chronobiology studies the effect of time and biological rhythm on living. When controlling season cycles, an important role is played by the light. Plants and animals define season of the year by the duration of the light period in the course of the day and the trend of its development (see the differentiation of spring and autumn periods with equivalent duration of the light period). By such manner we synchronized the seasonal rhythms in plants and in living beings.

Nevertheless the circadian rhythms were studied in detail, while the long lasting ones not. That is why in 2010-2011 in the Moscow Institute of Medical and Biomedical Problems a long-term experiment «Mars-500» is to be realized in which work of the crew making flight to Mars is modelled. The reference groups of volunteers were recruited in five Russian cities (Moscow, Voronezh, Syktyvkar, Ekaterinburg, Magadan), and in the Czech Republic, Germany and Canada. Research of control groups was aimed at the estimation of how far the functional state of healthy people changes under conditions of a long-term flight and a long-term stay on the earth.

### 2 Methods

At examining the control groups, the system of the Heart Rate Variability (HRV) analysis was used. Therefore, in the assumed medical-chronobiological research the HRV analysis takes a very important place. For HRV analysis not only spectral analysis was used, but also variational pulsometry, autocorrelation analysis, statistical analysis and correlation rhythmography. The software in which all the above mentioned methods of analysis are included has enabled to introduce new characteristic parameters: SI, IC, IARS.

**SI** - Stress index: characterizes activity of the sympathetic part of vegetative nervous system and reflects the degree of mobilization and functional reserves during the adaptation of the organism at the conditions of environment.

**IC** - Index of centralization: exponent of the prevalence of the central levels of regulation over the independent ones. It shows how far the independent regulation is weakened.

**IARS** - Index of the regulatory systems activity: a complex parameter that reflects the state of all levels of regulation and allows to make conclusions on the adaptable opportunities of the organism.

In 2009, the preliminary stage of the research falling into the program "Mars-500" in duration of 105 days was carried out. Techniques, equipment and system of data transmission from various regions of the world to Moscow were tested in the analytical center. The data obtained in Prague during the period November-December 2009, January 2010, and those obtained in Moscow during the period April-May-June 2009 were compared. In both cases, the average data were obtained at examining groups of volunteers (10 men aged 25-50 years).

### 3 Results

Fig. 1 shows the results of HRV analysis at group of practically healthy people in Prague. Except the heart rate (HR), values of some of the most informative complex parameters are given.

From Fig. 1 follows that within a 3-months period changes of all the parameters were observed. These changes, apparently, reflect activation of adaptation processes of the organism at transition from autumn to winter: SI grows as well as IC. Values of IARS are reduced to some extent, showing gradual stabilization of the functional state during the winter period.

Fig. 2 shows the results of research carried out in Moscow. They show similar changes of HRV parameters during the adaptation from stable chronobiological conditions in spring time to a more stable period of summer. HR practically does not change, SI is much higher in June. Compared to Prague, changes of IC and IARS have other character: IC is reduced, and IARS grows. Obviously, adaptation reactions of the person at transition from spring to summer and from autumn to winter vary.

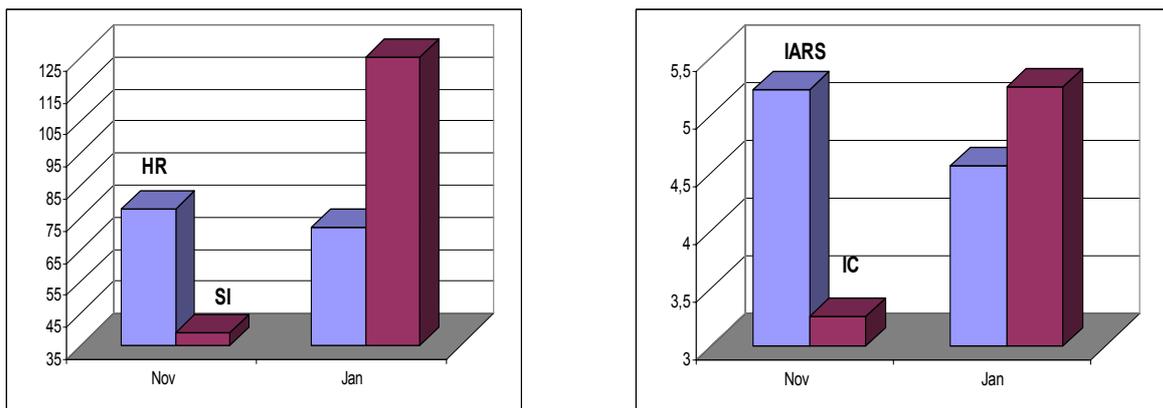


Fig. 1. Average values of HRV parameters in group of volunteers in Prague

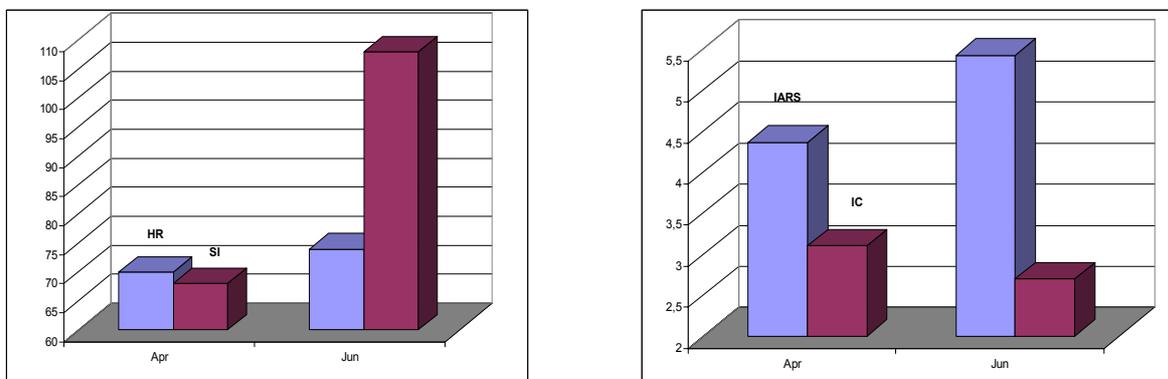


Fig. 2. Average values of HRV parameters in group of volunteers in Moscow

### 4 Discussion

The winter period differs from summer; in cold season the organism is adjusted on economizing the power expenses. Central levels of functions' regulation, incl. the hypothalamo-hypophyseal centers that coordinate many functions, are switching energetic and thermo regulation. During the summer period power opportunities of the organism are higher and IC is reduced. IARS grows due to higher vital activity. It is worth noting that SI grows in both groups, as this parameter does not reflect any specific component of adaptable reactions (the stage of "alarm" of the general adaptable syndrome on Selye is named).

In this context we can consider as interesting the changes of biological rhythms as manifestation of the autonomic nervous system changes. Following the manifestation of myocardial infarction (IM), tachyarrhythmias and sudden cardiac death, typical variability of these diseases was recognized, and during 24 hours with the maximum between 6 and 12 hours. There

exist many effect-modifying factors. Changes of the autonomic nervous system are the double-peak cause of IM between patient with diabetes mellitus and reinfarction, the second peak taking place between 18 and 24 hours. The circadian rhythm of IM may be significantly disrupted between diabetes and heart autonomic dysfunction.

The variability of one year manifestation is very interesting, too. The peak of the IM manifestation takes place in winter months (November, December, January), the lowest manifestation can be found in August. The changes of temperature are defined as the cause of this fact and play a very important role in relation to the cardiovascular diseases.

Measurement of the one year fluctuation of blood pressure (BP) resulted in the finding that the seasonal changes of BP are directly connected with the age. In younger and middle aged persons they are higher in winter than in summer. These changes are interpreted as being caused by higher sympathetic nervous activity in cold months of the year.

The measurements of BP in healthy nurses of 18-25 years have proven the same – they show higher BP in winter months [5].

In clinical medicine, these changes are found in the healthy persons functions, too.

## **5 Conclusion**

The obtained results show that the method of HRV analysis which includes not only spectral analysis, but also variational pulsometry, autocorrelatory analysis, statistical analysis and correlative rhythmography, well reveals the main features of the organism reactions at the changes of chronobiological conditions. We believe that in the assumed basic stage of medical-chronobiological research in duration of 520 days it will be possible to obtain unique data on vegetative regulation of physiological functions of the organism under various chronobiological conditions.

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