
METHODS

Telecommunication Monitoring Is a Method for Studies of the Effect of Heliomagnetic Fluctuations on Cardiac Function

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This paper presents the results of 9-year biogeophysical monitoring (1998-2007) of spatial and time effects of space weather and atmospheric and climatic factors on the status of normal subjects, which was carried out simultaneously in geographical areas situated at different latitudes. Requirements to conditions of long-term telecommunication biogeophysical monitoring studies are formulated, providing the reliability and reproducibility of the experiment results. The results indicate that the role of atmospheric and climatic factors in modification of dynamic regimens of human body functioning is significantly higher in subjects living at lower latitudes. The spatial and time regularities of the effects of space and physical factors on human body were detected (the latitude, time, trigger, amplitude, synergetic, and cumulative effects of the population averaging of the reaction). These effects indicate that human body belongs to a class of open nonlinear dynamic systems with all characteristics intrinsic of it.

Key Words: *telecommunication monitoring; geomagnetic storms; cardiac function*

Numerous data on the effects of external fields on biological objects can be found now in reports of scientists of different specialization; the interpretations of these data are ambiguous and have no satisfactory theoretical validation. The majority of biomedical experiments are carried out in one geographical area of the Earth, and sometimes a local effect is extrapolated to the entire population without good reasons. The assumption that magnetic storms affect only some susceptible individuals or patients is an illusion of the mass media. The idea

that sharp variations in the magnetic field of the Earth exert exclusively negative effects is erroneous. Telecommunication heliomedical monitoring carried out in different parts of the European Russia and Siberia helps to solve many problems of such basic sciences as medicine, physics of the Sun-Earth bonds, biology and psychophysiology, investigating the effects of weak external fields on biological systems, and demonstrate the dynamics and geographical changes in the prevalence of seasonal exacerbations of socially significant chronic diseases in Russia, and help develop a practical methodology of long-distance medical diagnosis and preventive medical measures. The results of 9-year biogeophysical monitoring of the spatial and time effects of space weather and atmospheric and climatic factors on the permanent groups of normal subjects, which was carried out in 1998-2007 si-

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multaneously in geographical areas of different latitudes from St. Petersburg and Yakutsk in the North to Naples and Baku in the South, have been published [1-5]. More than 500,000 measurements were carried out, during which more than 380 magnetic storms occurred.

MATERIALS AND METHODS

Development of technology on the base of the data of many-year monitoring experiments on studies of the effects of weak external fields on human body showed that the results were reproducible, if 8 requirements to these experiments were strictly adhered to: the same duration of total time of spatial distribution monitoring, the same place, time of the day, equipment, noninvasive methods, and permanent composition of the group of examined subjects, optimization of the duration of a single step of measurements. The following functional parameters were selected with consideration for these requirements for daily registration in a permanent group of examinees: 1) daily measurements of the parameters of electrocardiogram 1st lead (arm-arm; more than 12,500 measurements); 2) variability of cardiac contractions; 3) plotting of phase portraits of the reference cardiocycles (Phasagraph-M computer complex, more than 2500 measurements); 4) arterial pressure (AP) and pulse (more than 50,000 measurements); 5) electric conduction of bioactive points on human skin (more than 350,000 measurements); 6) evaluation of subjective status (physical, emotional, intellectual).

The resultant time series were compared with daily values of Wolf number (W), atmospheric pressure (P), indexes characterizing the turbulence of geomagnetic field (A) and space rays, obtained from the IZMIRAN database. "Heliomed" telecommunication monitoring at different latitudes was carried out in 2003-2007. A telecommunication

network was created, uniting research centers for long monitoring of human physiological parameters and environmental parameters, working with the same equipment and using the same protocols with on-line registration of current data on the same portal server (Moscow, St. Petersburg, Kiev, Simferopol, Yakutsk). A specific feature of the monitoring was computerized on-line phase space analysis of ECG in lead I (Fig. 1). Registrations at rest, after standard psychological test, Roufiet test, and 10 min rest after exercise and AP registration in these states were carried out 4 times daily. On-line analog information from a distributed network of research groups through the Internet was delivered into the center of data collection, and after monitoring all participating groups received the same Excel tables with digital data of deciphered electrocardiosignals, including summarized base of results in all cities.

RESULTS

The reaction to solitary magnetic storms includes three phases (synchronization, desynchronization, and relaxation) and the presence of the reaction does not depend on the gender, health status, and age of the examined subjects. Individual features manifest by the proportion of amplitudes and duration of individual phases. The synchronization phase predominates in healthy subjects, while desynchronization prevails in patients. The following spatial and time effects of space physical factors on humans were detected. Simultaneous experiments at different latitudes showed coincidence (within 24 h) of variations in the measured physiological parameters (the latitude effect). At higher latitudes, the number of examined subjects reacting to sharp variations in the space physical factors is greater: from 50-60% in Odessa and Kiev to 90% in St. Petersburg, the amplitude of reaction increasing 1.4 times. Human reaction to the natural external fields is characterized by the trigger effect. The amplitude of physiological reactions to sharp changes in the geophysical fields does not depend on the increase in the external fields amplitude, but is determined by the internal characteristics of the biological system. Analysis of long (one-year) series of observations showed a trend to an increase in the mean monthly values of individual physiological values during the period of increase and peak of solar activity and a trend to a reduction of the mean monthly values of individual norm during the solar activity reduction phase (the time effect). It is noteworthy that 2007-2008 is the period of the minimum solar activity, characterized by reduction in

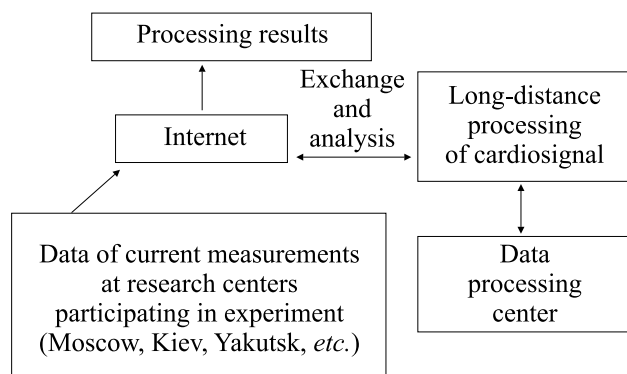


Fig. 1. Functional scheme of distributed telemedical system for scientific experiment monitoring.

the total incidence of negative reactions of the population to geomagnetic turbulence in parallel with an increase in the percentage of severe clinical reactions (grave infarctions, strokes, mental disorders, up to lethal outcomes and suicides). There is an “intensity corridor” for magnetic storm biological efficiency. The “amplitude window” indicates realization of the parametrical properties of the studied biosystem under conditions of exposure of humans to natural external fields (the amplitude effect). The influences of external factors are amplified in a synergic manner in case of parallel exposure and are effective even if the amplitude of each individual external factor is low for triggering a stress reaction (cumulative effect).

Theoretical analysis of the results showed that the role of atmospheric climatic factors in modifica-

tion of dynamic modes of human body functioning is appreciably higher in residents of the lower latitudes. Hence, the problem of complex effects of heliogeophysical factors on the population is a truly pressing one for the Russian Federation, situated predominantly at latitudes northwards from 50° North.

Telecommunication heliomedical monitoring on evaluation of the effect of atmospheric climatic and heliogeophysical factors on human cardiovascular function carried out simultaneously in different cities in 2006-2007 has helped to form an Internet database of more than 12,000 measurements reflecting the time and spatial dynamics of human cardiovascular activity in various regions of Russia and Ukraine, which is universal for all participating cities.

Arrhythmias, 2-3-fold increase in the T wave symmetry coefficient, changed dynamics of adaptation after excessive exercise, and centralization of body regulation are observed in the majority of examined subjects on the days of magnetic turbulence. Men are more sensitive to magnetic storms, while endogenous rhythms predominate in females.

Similar changes in the cardiac activity parameters were detected during an isolated magnetic storm in all cities simultaneously. Two stages of adaptation changes in the functioning are observed. During stage 1 (24 h before the magnetic storm) an extra exercise leads to alteration of cardiac activity regulation mode (from normal to stress; a common effect for all groups and examined subjects) in the majority of examinees. During stage 2 (directly on the day of the magnetic storm), pathological changes in the amplitudes of the measured parameters are observed. The type of changes depends on the individual characteristics and compensatory potential of the individual.

A significant effect of simultaneous outbreak of physiological parameters in different cities is observed during combined exposure to sharp variations in the space physical factors and several types of external loading (synergic effect); it manifests maximally in normal subjects. The maximum amplitude effect is observed in the examined men exhibiting the minimally chaotic basal physiological parameters at rest.

The most important results of telecommunication monitoring at different latitudes for chronomedicine, physics of Sun-Earth bonds, and heliobiology is the evidence of polyvalent biotropic role of sharp changes in the space and geophysical factors. It is universally acknowledged that the effects of magnetic storms and changes in all spheres of the Earth (from lithosphere to ionosphere) associated with these storms are exclusively negative.

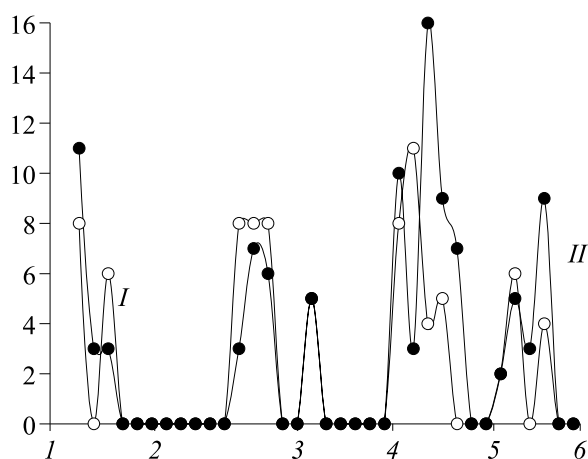


Fig. 2. Sum of individual atypical ECG cycles at rest (*I*) and during exercise (*II*) in April, 2007 in residents of Moscow. 1) 26.03.07; 2) 02.04.07; 3) 09.04.07; 4) 16.04.07; 5) 23.04.07; 6) 30.04.07.

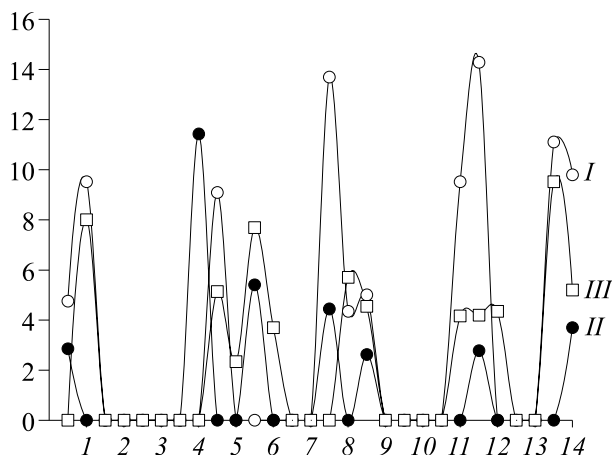


Fig. 3. Synchronization of parameters of different examinees in manifestation of individual arrhythmia during magnetic turbulence periods for Yakutsk (*I*), Moscow (*II*), and Kiev (*III*) in April, 2007. 1) 02.04.07; 2) 04.04.07; 3) 06.04.07; 4) 08.04.07; 5) 10.04.07; 6) 12.04.07; 7) 14.04.07; 8) 16.04.07; 9) 18.04.07; 10) 20.04.07; 11) 22.04.07; 12) 24.04.07; 13) 26.04.07; 14) 28.04.07.

The same assumption predominates in all scientific reports on the problem. However, the results of many-year monitoring showed that the maximum synchronization of all body systems is observed during the most active periods of the 11-year solar cycle; for the seasons it occurs in March-April and September-October (the equinox periods are the seasons of the highest magnetic activity) in all the cities included in the experiment (from Yakutsk to Simferopol) irrespective of the temperature and atmosphere of the environment. The subjective status of normal subjects deteriorates, if no magnetic storms occur during a long (more than 1 month) period, and the severity of the biosystem chaos in general increases.

Hence, we conclude from many-year geomedi-cal monitoring experiments carried out at different latitudes that space physical factors play the role of synchronizing external signals providing internal autosynchronization of various hierarchical levels of biological objects. These factors provide synchronization of individual time of the biological objects during their interactions. For example, the atypical ECG cycles at rest and exercise during April, 2007 in the Moscow group indicate that during magnetically inert days the total number of extrasystoles in the group was zero even after Roufiet test, while synchronized manifestation of arrhythmia was noted in the majority of the examined subjects during magnetic turbulence (Fig. 2).

In addition, the space and physical factors act as a mild training factor for the adaptation-resistant members of the population, serve as a channel for

rejection of nonviable members of the population, synchronize the total population rhythms (Fig. 3), and create conditions for generation of new information in the process of evolution adaptation of biological systems in general.

The detected effects indicate that human organism as a universal system belongs to a class of open nonlinear dynamic systems with all characteristics intrinsic of it. These systems are characterized, among other things, by the amplitude and frequency reaction windows, several levels of the system's status with different and variable probability of being in every state, effects of saturation and threshold response of the system, the "hysteresis loop" during system's recovery from disturbed to basal status, and realization of the regulating response of the system not only through various total systems resonance, but also through re-structuring (autoorganization) processes within the system proper.

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