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An Influence of Changes of Heliogeophysical Conditions on Biological Systems: Some Results of Studies Conducted in the Azerbaijan National Academy of Sciences

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Part of major results of complex (experimental and statistical) studies carried out in the Azerbaijan National Academy of Sciences on possible influence of changes of heliogeophysical conditions on the emotional - affective sphere and personal characteristics of functionally healthy persons as well as on the sudden cardiac death (SCD) mortality in middle latitudes is described in this paper. It is revealed that geomagnetic disturbances affect mainly the emotional and vegetative spheres of human beings while characteristics, reflecting personality properties, do not undergo significant changes. Results show that number of SCD displays certain periodicities well-known in solar-terrestrial relations. SCD mortality is affected by changes in solar-geomagnetic (inversely) and cosmic ray (directly) activities alongside medical, social and other influence factors.

Introduction

Conditions on the Sun, in the solar wind, the interplanetary space, as well as magnetosphere, ionosphere and thermosphere constitute so called space weather which can have deleterious effects not only on technological systems as well as biological and ecological systems [1, 2]. The problem how changes of heliogeophysical conditions may affect human health on the Earth and all-kind of human activities contains a lot of unknown factors and bears a cross-disciplinary study character. Space weather and its possible effects on human health are being studied extensively in the former Soviet Union and other Eastern European countries while the topic is still in its "infancy" in many Western countries (see, e.g. [3, 4] and references herein).

Study and understanding the physical links between space weather sources and possible short- and long-term effects on human health at different geographic or geomagnetic latitudes will be invaluable, especially for mitigation and preventive measures.

For getting more and better knowledge about solar and geomagnetic storms' potential effects on human life and health, particularly in middle latitudes, we are conducting complex studies in the Azerbaijan National Academy of Sciences [5-7]. Part of main results of these experimental and statistical investigations is provided in this paper.

Results of experimental investigations on possible influence of geomagnetic storms of various strengths on the emotional-affective sphere and personal characteristics of functionally healthy female persons, using Luscher's Color Test and other relevant psychological tests, are described.

Potential effects of space weather changes on cardiovascular diseases-related mortality and sudden cardiac death were studied on a daily medical data base (grand Baku area) with time span 2002-2005.

Emotional sphere of women in the days with different levels of geomagnetic activity (storms)

There are signs that during periods of high-level disturbances in heliogeophysical conditions the number of hospitalized patients notably increases, the cases of myocardial infarctions and cerebral insults, epileptic attacks and different paroxysmal conditions, nervous disturbance disorders and suicidal attempts become more frequent [2-4, 8-12]. At the same time, it should be noted that the tolerance to mental and physical stresses is decreased; there appears a danger of disorders for the people, whose professional work is connected to high-level responsibility.

In spite of the increasing level of interest of scientists from different fields of science to actual problems of heliomedicine and/or cosmobiology, many problems of these multi-disciplinary studies either are elucidated insufficiently (sometimes with contradictory results), or, in general, remain as "non-touched upon".

Within complex solar-terrestrial studies program we are carrying out investigations on influence of geomagnetic storms on the functional state of human brain [5, 6, 13].

Part of results of experimental studies on the possible influence of geomagnetic storms of various strengths on emotional - affective sphere and personal characteristics of healthy adult women in middle latitude location (Baku, Azerbaijan) is provided in this paper.

Experimental methods

The group for experiments was formed on the basis of selection of sex, age and geographical location. Permanent group of practically (functionally) healthy twenty seven women at ages of maturity (between twenty and forty years) and from same geographical region (Baku and Absheron Peninsula) were subjected to investigations in weakly-, moderately- and strongly-disturbed geomagnetic conditions as well as in geomagnetically quiet (favorable) days. All female persons were examined in the inter-menstrual period and their existing social and personal problems were taken into account (by operator of experiments).

Monitoring and analyses of space weather (parameters of solar, geomagnetic and cosmic ray activities) and meteorological (temperature, atmospheric pressure, humidity, wind speed, etc.) conditions were conducted every day. Persons under test were not familiarized in advance with space weather conditions in order to avoid their possible subjective psychological influence upon them.

For determination of the state of high psychological functions and emotional-affective status of the human beings variety of psychological methods of testing are used; they have either positive advantages or negative disadvantages (lacks). Among psychological methods of investigation *non-verbal tests* have number of advantages, which are connected, for example, with the absence of language barrier and necessity of its adaptation to the given population of tested group.

For study of features of personality and actual affective syndromes and for definition of the condition of emotional - affective sphere, the non-verbal psychological test method of diagnosis - the well-known "*Luscher's Color Test*" [14] (developed by Dr. Max Luscher) was used in our experiments. It uses the principles of color psychology, measures a person's psychophysical state, his or her ability to withstand stress, to perform, and to communicate. It uncovers the cause of psychological stress, which can lead to physical symptoms. This analysis allows a rapid and deep personality analysis to be made from color ranking information. Objectivity of this test is that there are no subjective factors either when administering the test or during its diagnostic evaluation. This test reveals the person as he or she really is, and not as he or she perceives him- or herself, or as he or she would like to be perceived, which occurs when questions are asked directly or by questionnaires.

Levels of anxiety (uneasiness) were determined using a *Personality Scale of Manifest Anxiety* developed by J.Taylor [15] and adapted by T.A. Nemchin. Levels of reactive and personality anxiety were determined by the help of *Scale of Self-Rating* developed by Ch.Spilberger and adapted by Yu.Khanin [16]. Depression level was determined by the *Depression Rating Scale* developed in the Scientific Research Institute of Psychoneurology named after V.M.Bekhterev, St.-Petersburg, Russia.

The obtained data on psychological testing had a digital form, which was subjected to analysis and the criterions of reliability for groups were calculated using relevant mathematical methods.

Results and conclusions

Experimental investigations with application of the non-verbal Luscher's Color Test to the persons under test have revealed that the most informative characteristics, connected with the degree of severity of geomagnetic disturbances, are the coefficients (indexes) of vegetative balance, workability (performance efficiency) and stress level.

It was established that unlike characteristics of personality balance, concentricity and heteronomy, the parameters reflecting a state of vegetative sphere, significantly differed and were dependent on the strength of geomagnetic storms (Fig.1a). In the days with moderate storms, the tone of sympathetic nervous system dominated (2.2 ± 0.6 with a reliability of $p < 0.05$) while during periods of increased level of geomagnetic disturbances, characteristics of vegetative balance reflected the prevailing of parasympathetic innervations (-1.8 ± 0.9 with $p < 0.1$).

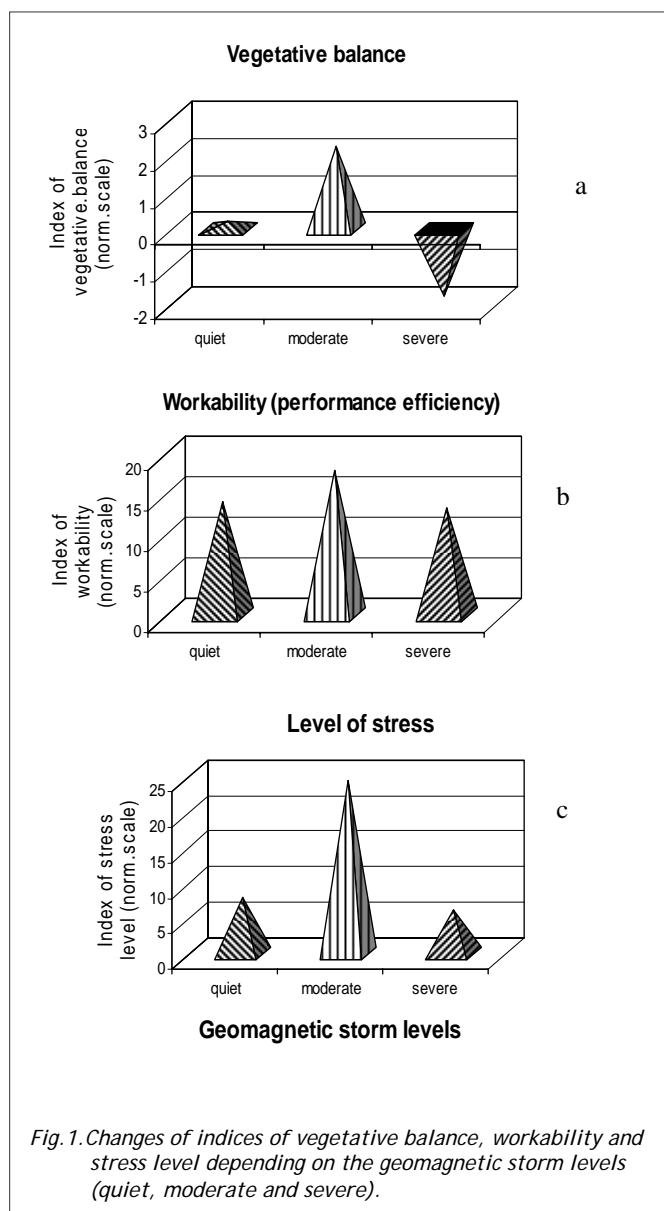


Fig. 1. Changes of indices of vegetative balance, workability and stress level depending on the geomagnetic storm levels (quiet, moderate and severe).

Indexes on workability determined by the help of Lüscher's Color Test had the greatest value in the days with moderate geomagnetic storms (18.0 ± 1.7 with $p < 0.05$). Workability indexes in the days with highly disturbed (severe) geomagnetic conditions (14.0 ± 0.6) did not differ significantly from ones established in the geomagnetically quiet days (13.3 ± 1.0) (Fig.1.b).

Indexes (characteristics) reflecting the stress level have got the significant value in the days with moderate geomagnetic storms (24.4 ± 3.5 with $p < 0.001$). The levels of stress were comparatively low in geomagnetically quiet (7.9 ± 3.1) and highly-disturbed days (6.2 ± 2.8) (Fig.1.c). Observed differences were reliable and testified on increased stress level in days with moderate geomagnetic storms and reduced level in geomagnetically quiet and severely-disturbed days.

Obtained results enabled us to conclude:

- geomagnetic disturbances affect mainly the emotional and vegetative sphere of human beings;
- characteristics reflecting personality properties, do not undergo significant changes;
- the changes of geomagnetic conditions affect, first of all, the activity of regulating systems, which are related to high cortical mechanisms of regulation and sub-cortical integrative apparatuses responsible for organization of routine activity of organism, and for adaptation to changes in the physical environment.

Possible influence of changes of space weather conditions on the sudden cardiac death mortality

This study was undertaken to investigate whether there was any relation between space weather changes (solar, geomagnetic and cosmic ray activities) and the number of sudden cardiac death (Fig.2) in Baku and surrounded big urban area (Absheron Peninsula), which are located in the middle latitudes.

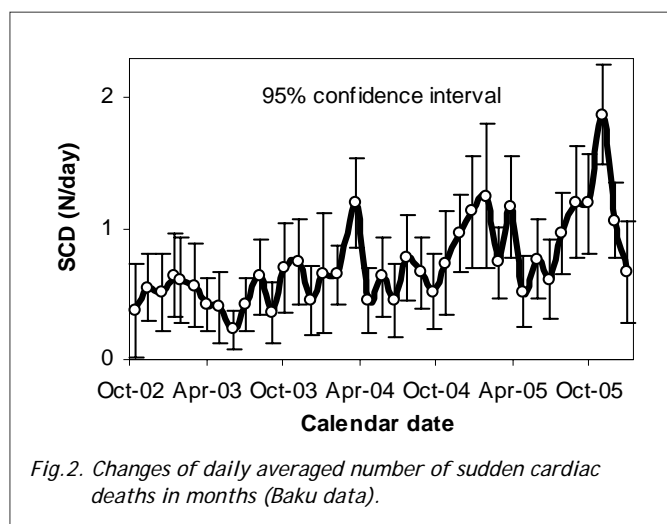


Fig.2. Changes of daily averaged number of sudden cardiac deaths in months (Baku data).

Sudden cardiac death [17-19] (also called a cardiac arrest) is an unexpected death due to cardiac causes, an abrupt loss of heart function, occurring in a short time period (generally within one hour of symptom onset) in a person with known or unknown cardiac disease in whom

no previously diagnosed fatal condition is apparent. Approximately half of all cardiac deaths can be classified as SCDs.

SCD is a major health problem that is received much less publicity than heart attack. All known heart diseases can lead to SCD but most cases of SCD are related to cardiac arrhythmias. Most of the cardiac arrests that lead to sudden death occur when the electrical impulses in the diseased heart become rapid (ventricular tachycardia) or chaotic (ventricular fibrillation) or both. This irregular heart rhythm (arrhythmia) causes the heart to suddenly stop beating. Some cardiac arrests are due to extreme slowing of the heart.

It occurs as the first expression of cardiac disease in many individuals presenting as out-of-hospital patients with cardiac arrest. The time and mode of death are unexpected.

Several millions of people a year die because of SCD without being admitted to a hospital or an emergency room. Therefore, it is very actual problem to study how external physical factors (which can play also a role of trigger) may affect SCD mortality alongside factors of pure medical and social nature.

Material and methods

The relation between the sudden cardiac death and relevant space weather parameters for the thirty nine months from November 2002 – January 2006 was studied (continuous data). This study was based on the population-based daily medical data of deaths collected from all of Emergency and First Medical Aid Stations of grand Baku area (more than 3 millions inhabitants) and registered according to the World Health Organization's (WHO) standards. Sudden cardiac death (WHO's ICD-10 classification-based I46.1 code) was assumed when a person died within one hour after the onset of the symptom.

More than 1,000,000 emergency calls containing 23,292 cases of cardiovascular-related deaths were analyzed. Bank of medical data was "cleaned", as much as possible, from subjective (seasonal, social, etc.) factors. Out-of hospital SCD number that occurred in people was 827. Age limitation was chosen between 25 and 80.

Data corresponds to the period of economical and societal stability in the country and to descending phase of the 11-year solar activity cycle 23 and is therefore is interesting.

Spectral (Fourier), correlation and cross-correlation analyses were applied to the considered data. The following data analysis software were used in the spectral and statistical analyses: STATISTICA-ver.6 (StatSoft Inc., 2001) and SPSS-ver.12.0 (SPSS Inc., 2003).

Results, discussion and conclusions

Spectral analysis of the "cleaned" data has revealed certain periodicities in changes of cardio-vascular-related death and SCD mortality data. 381^d (or 1.04^y), 286^d (0.78^y), 190^d (0.52^y) and other smaller (55^d , 40^d , quasi-weekly, half-weekly, 2.32^d , 2.75^d , so on) periodicities were found in the all-cardiovascular-related deaths data (total about 23,000 cases). Spectral analysis has also revealed periodicities (with dominant period (P) of 384^d or 1.05^y) in SCD data which are displayed in the

Table 1; we call these periodicities as "modes". In this Table correlation coefficients (r) and their probabilities (p) found by the help of parametric (Pearson) and non-parametric (Kendall and Spearman) methods are provided.

TABLE 1

Periodicities (P) in SCD incidence and correlation coefficients between original data and 12 major modes/curves of Fourier analyses

P , days	Correlation coefficients					
	Pearson		Kendall's tau_b		Spearman's rho	
	r	p	r	p	r	p
384	0.0956	0.0012	0.0630	0.0014	0.0964	0.0010
2.3	0.0912	0.0019	0.0507	0.0099	0.0766	0.0092
60.6	0.0942	0.0014	0.0602	0.0022	0.0893	0.0024
3.5	0.1038	0.0004	0.0692	0.0004	0.1046	0.0004
230	0.0940	0.0014	0.0569	0.0038	0.0840	0.0043
2.4	0.0851	0.0038	0.0518	0.0085	0.0769	0.0090
2.2	0.0743	0.0116	0.0465	0.0180	0.0695	0.0183
7.6	0.0906	0.0021	0.0462	0.0188	0.0694	0.0185
3.3	0.1001	0.0007	0.0542	0.0058	0.0812	0.0058
3.1	0.0866	0.0033	0.0452	0.0216	0.0682	0.0206
3.2	0.0873	0.0030	0.0678	0.0006	0.1015	0.0006
5.6	0.0896	0.0023	0.0528	0.0072	0.0796	0.0069

Power spectrum of periods is shown in Fig.3. Periods which are approximately equal and/or close to the above-mentioned determined periodicities are well displayed in changes of heliogeophysical parameters (see: [2, 4, 20]). For example, 1.03 year periodicity was found in the lower frequency part of the power spectrum of variations of the mean magnetic field of the Sun for 1968-2000 [21]. Annual variation is often more clear because the solar wind distribution is asymmetric or shifted with respect to equator. Another reason could be the Earth's orbit around the Sun taking it to different helio-latitudes.

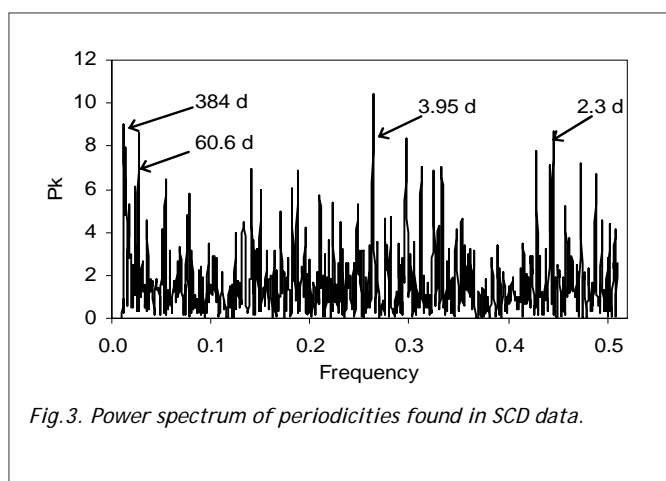


Fig.3. Power spectrum of periodicities found in SCD data.

Cross-spectral analysis (SCD and Ap geomagnetic index) has revealed two main periodicities: 384 and 60.6 days (Fig.4).

Available details of considered medical data enabled us to study sex and age differences in SCD mortality as well as time dependence of occurrence of deaths in different geophysical conditions.

It is revealed that men are affected more than women. The age standardized event rates were more than three-four times higher in men than in women. This fact is in agreement with medical statistics and testifies once again the reliability of "cleaned" data.

Our analysis shows that men are more vulnerable to SCD at ages 40-55. Deaths for both genders have a peak around the age of 50 while there is the secondary maximum of SCD around 76. Distribution of SCD for men has got 2 maxima, around 50 and 30.

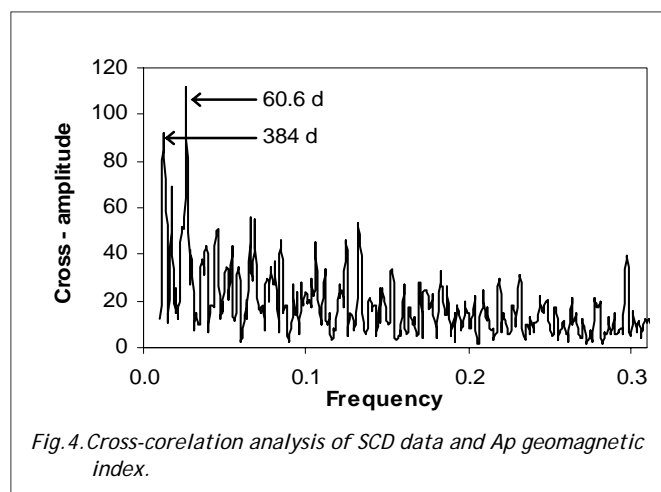


Fig.4. Cross-correlation analysis of SCD data and Ap geomagnetic index.

Monthly changes of ratio of SCD numbers "male/female" show minimums every 3 months with deeper minimum in October. It could be due to seasonal dependence of geomagnetic activity.

Study of SCD for different ages of victims distributed on months of year did not show significant changes. There are slight differences in June and April, shifted a little from the maximum around the age 50 towards younger ages.

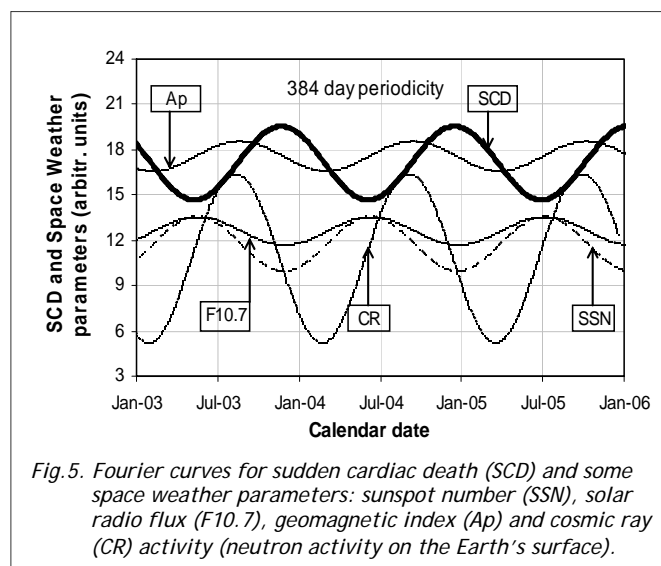


Fig.5. Fourier curves for sudden cardiac death (SCD) and some space weather parameters: sunspot number (SSN), solar radio flux (F10.7), geomagnetic index (Ap) and cosmic ray (CR) activity (neutron activity on the Earth's surface).

Dependence of SCD mortality on time during the considered day for male and female (altogether) has well-displayed minimum between 3 and 4 o'clock at morning and shallow minimums around 19.00 and 14.00 while there appear main maximum in death close to the 18.00 LT (close to the end of working day) alongside with other peaks close to 22.00, 11.00 and 20.00 LT, according to their magnitude. These results could be explained by daily life and physiological factors (stressed or relaxed organism) and, particularly, by the influence of geomagnetic field fluctuations which are relatively increased during daytime.

Fourier analysis was carried out for selected major periodicity of 384 days and certain space weather parameters: sunspot number (SSN), solar radio flux (F10.7), geomagnetic index (Ap) and cosmic ray (CR) activity (neutron activity on the Earth's surface) (Fig.5.). Correlation and cross-correlation analyses were also performed for considered parameters.

Results were outlined:

- Number of SCD displays certain periodicities well-known in solar-terrestrial relations;
- SCD mortality is affected by changes in solar-geomagnetic (inversely) and cosmic ray (directly) activities. Fourier analyses of SCD number and proper space weather parameters revealed that SCD mortality is low in the days with high solar and geomagnetic activity while it increases in the days with high level cosmic ray (neutron) activity
- Correlation and cross-correlation analyses between SCD and selected space weather parameters (sunspot number, Ap geomagnetic index, neutron activity level) have also revealed statistically significant but inverse correlation with solar and geomagnetic activity parameters. SCD number changes in concert with cosmic ray activity;
- These results are in agreement with conclusions of several papers on thematic, for example, [22] (see: references herein) and [23].

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