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SEARCH OF AURORAL DISTURBANCES SENSITIVE PEOPLE (ADSP) BY HEART RATE VARIATION ANALYSIS

S. Chernouss, O. Benkevich *(Polar Geophysical Institute, e-mail: Chernouss@pgi.kolasc.net.ru, OBen@pgi.kolasc.net.ru)*
E Vlassova *(Hospital with Clinic, e-mail: Vlassova@mail.ru)*

Abstract. Aim of the study is to find out the dependence of different cardiac rhythm parameters of human organism on local geomagnetic activity. A pilot experiment by Russian «Cardioanalyzer VR» carried out in the Polar Geophysical Institute is under consideration. There are shown dependence of Heart Rate Variability indices on local geomagnetic field variation existence. In general, more then 65 % of people under experiment undergo the impact of geomagnetic field disturbances. So called Auroral Disturbances Sensitive People – (ADSP), demonstrate valid reaction of different parameters of HRV during two series of testing in 1998-1999, moreover different groups of tested persons show a different reaction direction to geomagnetic variation depending on age and accentuation of the autonomic nervous system. Most sensitive parameters of ADSP Heart Rate variability are spectral features of the rhythmograms.

Introduction

Solar – Terrestrial processes impact on human health is well known after pioneering works by Chyzhevsky, who was the heliobiology founder and described it in numerous publications, for example [1]. Most of them are based on statistical data of different heavy events like death, miocardial infarction, insults and others. There are not so many direct experimental evidences of geophysical factor impact on different systems of human organism like [2]. We try to make up the lack of this kind of data by search of ADSP people [3] using HRV methods [4-6]. Out task is to obtain quantitative response of human organism by direct measurements of both geophysical and biomedical parameters. We believe that the most accepted place to measure and estimate influence of geomagnetic disturbances on human health is auroral zone, where geomagnetic variations are most spectacular and go through wide dynamic range of values almost daily. Comparison of time series at HRF for the selected groups of tested people with parameters of time series of local geomagnetic variation is the main subject of this paper.

Experiment and methods

The way to obtain information on the response of human organism to the geomagnetic factors is to carry out real time measurements of HRV parameters and geomagnetic field variation in the same point. In 1998-1999 the experiment has been performed at the Polar Geophysical Institute, Apatity, Murmansk region, Russia (φ=68°N, $\phi' \approx$ 64° N). Parameters of local geomagnetic field variation were obtained from the PGI observatories Apatity and Lovozero. Heart Rate Variability parameters of tested people were obtained in Apatity by «Cardioanalyzer-VR» monitor designed by V.Pivovarov and described in [5]. Cardiac rhythmology method originally was proposed by R. Baevsky to perform a remote check of the health of Russian cosmonauts in a free space flight [4]. Then the method was tested in a number of clinics over the world and was confirmed by the World Health Organization and advanced by both European Society of Cardiology and North American Society Pacing and Electrophysiology [6]. The basis of the method is cybernetic analysis of the time series of cardiac intervals (R-R intervals) as stochastic processes. There were used 12 parameters of HRV verified status of different organism systems, as one can see 28 volunteers of the Kola Science Centre in Apatity were invited for everyday recordings of their HRV parameters. Two series of measurements (30 and 60 days) were carried out at the Polar Geophysical Institute during morning local time (from 09 00 to 12 00). Measurements of HRV were fulfilled in the same time of the day in order to exclude the cyrcadian variation of the cardiac rhythm parameters. Twelve indices were daily calculated automatically according to verified algorithms [4-6] due to characteristics of an adaptive power and functional status of individuals.

Spectral analysis of HRV time series was used to obtain quantitative parameters of the response of the sympathetic and parasympathetic branches of autonomic nervous system (ANS). The spectral power of the cardiac rhythm at the frequency range of 0,15-0,4 Hz (High Frequency-HR) corresponds to the parasympathetic activity while the frequency range of 0,04-0,15 Hz reflects the sympathetic influence. Fig.1 demonstrates the final data after processing by appropriated software. Below are shown the results of analysis of more then 1600 cases of these kind of measurements and their relationship with the geomagnetic field variations.

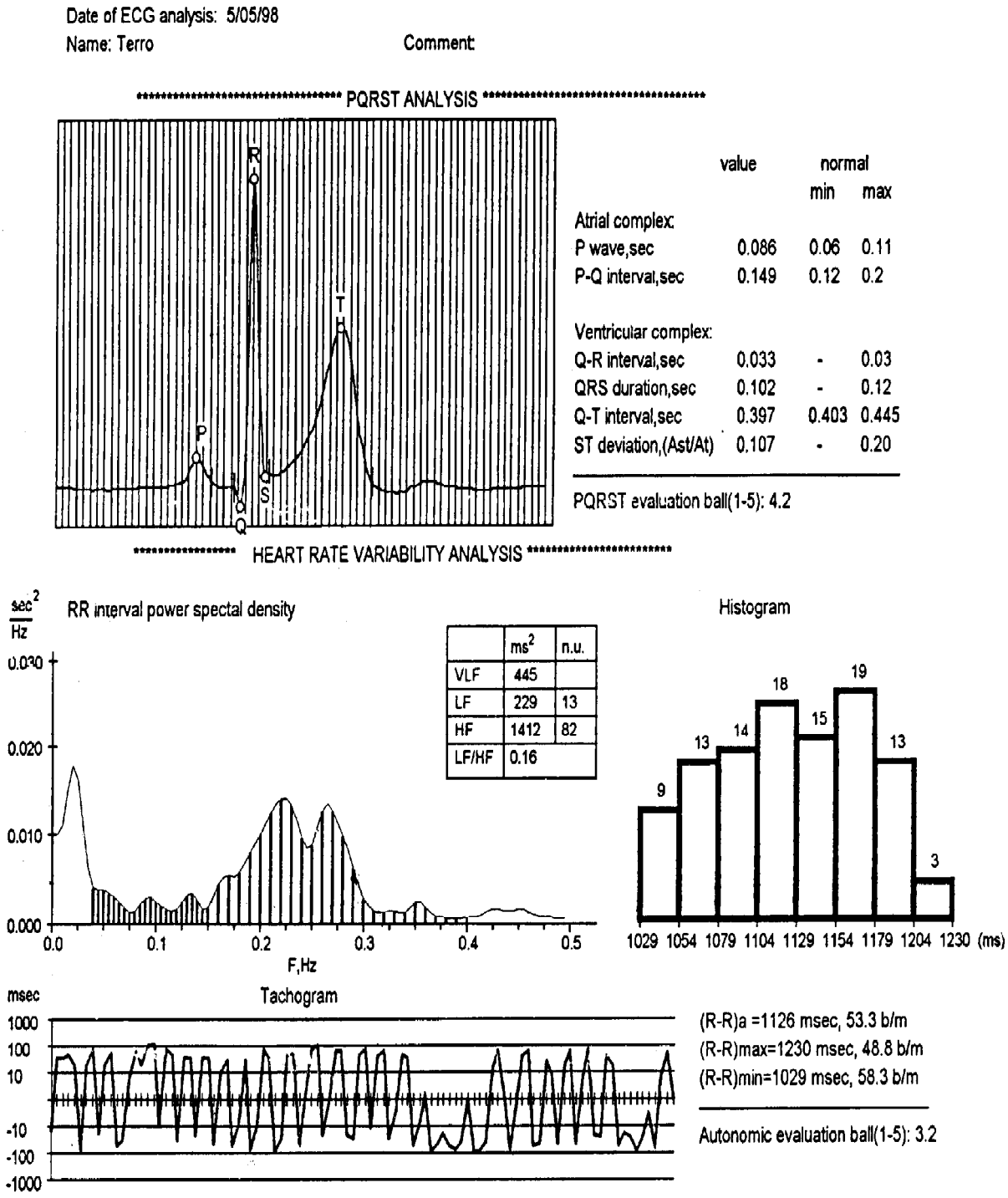


Figure 1. Example of HRV registration and analysis

The analysis was performed by traditional methods of mathematical statistics to obtain correlation coefficients, characterized by values with significance level <0,05 lie, i.e. 95% probability if regression is present. The main parameters of HRV are taken into account as follows:

1. Heart Rate (beat/see)
2. VLF (Very Low Frequency index (ms), represented by the HRV governed by central contour.
3. LF and HF (see the description above) in absolute (ms) and normalized units (n. u.)
4. Amax (ms), the extreme deviation of measured R-R intervals time series.
5. Amo (%) – mode amplitude represented relative to the amount of the modal value in R-R intervals time set.
6. Mo (ms) – mean value of R-R intervals distribution.

7. SI – stress index. Most sensitive index of organism adaptation reaction to stress. (Amo/Amax*Mo)

All those parameters are possible to calculate from the data and plots at Figure 1

Results

Generalization of HRV indices correlation with geomagnetic one hour K-indices at the Lovozero observatory are presented in Table 1.

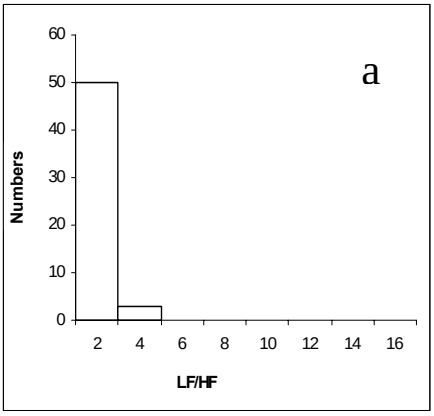
Total data of cases during measurements were separated into different age groups with 10 year age interval (20-30 years, 30-40 years, >50 years), because of the dependence of adaptation function of human organism on age, first of all. In the first horizontal line calculated percentages of tested people, HRV indices (at least one of them) reactions of which to geomagnetic disturbances take place. Obviously, that more than 65% of tested people on average have HRV parameters dependence on geomagnetic field variation. It is necessary to memorize that only values of correlation coefficient r>0,3 with significance level <= 0,05 were taken into account. It is necessary to point out that in individual cases correlation coefficient of individuals varied from r=0,31 up to r=0,69. The maximum r is reached by testing people of 20-30 years. One can see from table 1 that the most sensitive people are found in groups of 20-30 years and >50 years. Most sensitive to the geomagnetic field variations appear to be spectral indices at R-R interval time series (VLF, LF, HF) and Amo and the minimal reaction was registered in the heart rate data. Thus, the impact of heliogeophysical disturbances on human health is confirmed by synchronous HRV and geomagnetic indices time series analysis and we really can consider the problem of Auroral Disturbances Sensitive People. In general view we have got undoubted evidence of the dependence of cardiac rhythm parameters on geomagnetic activity parameters but individual relationship between those parameters is rather complicated. As it was shown before [7], people with sympathetic and parasympathetic accentuation of ANS react to geomagnetic disturbances by different way for example stress index increase for SP decrease and for PP in similar geomagnetic activity situation and these facts are evidence of an active adaptation processes of SP during geomagnetic disturbances and vice versa, decrease of the SI indicates damping of adaptation processes of PP. It was supposed [5] that the leading role of the response to the environment conditions on ANS could be a balance between two branches of ANS. This balance is characterized by the balance coefficient N=LF/HF where LF is spectral power of time series of R-R intervals in range 0,04-0,15 and HF is spectral power in the range 0,15 –0,4 Hz.

Table 1. Correlation of HRV indices correlation with one-hour K indices of the Lovozero observatory.

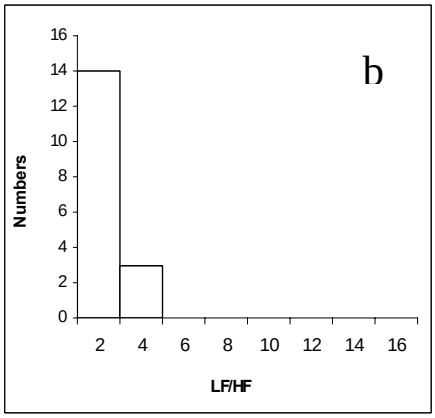
	All	**20-30y(%)**	**30-40y(%).**	**40-50y(%)**	**>50y(%)**
at least					
One parameter	74	63	100	50	90
Heart rate beat (s)	11	13	0	0	20
VLF(ms^2/Hz)	26	25	67	0	30
LF (ms^2/Hz)	19	25	0	0	30
LF (n.u.)	19	25	0	0	30
HF (ms^2/Hz)	15	13	0	17	20
HF (n.u.)	26	25	0	17	40
Amax (ms)	22	13	0	0	50
Amo(%)	26	25	33	33	20
Mo(ms)	11	13	0	0	20
SI (%/ms^2)	15	13	0	17	20

Typical distribution of LF/Hf coefficient for tested people of different age is represented in Figure 3. One can see that average balance coefficient for PP (top side of Figure 2) is about or smaller than 1,0 and the number of events is characterized by a sharp peak at 0-2 values of LF/HF. On the other hand, the distribution of the number of events is rather smothering for SP (bottom side of Figure 2) and varies from 2 up to 8-12. Next Figure 3 demonstrates dependencies of LF and HF indices of four selected persons (the same as in Figure 2 of PP and 2 of SP) of different age on local K-index. All curves were constructed as statistical linear trends using a standard EXEL 6.0 software. It is possible to see the different ANS accentuation. But reaction of people about the same age does not sharply depend on their ANS accentuation. There are no contradictions between the results published before and the

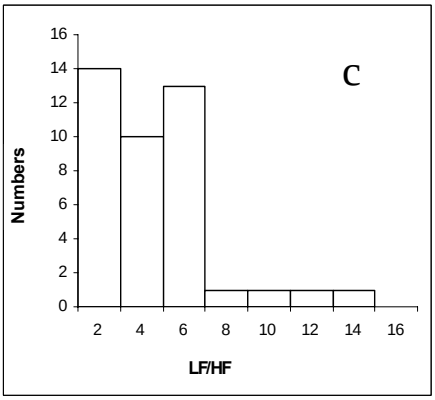
ones presented here because authors [7] did not take into account any age difference. Those samples recommend us to carry out deeper studies of dependencies of different ANS branches on geomagnetic activity.



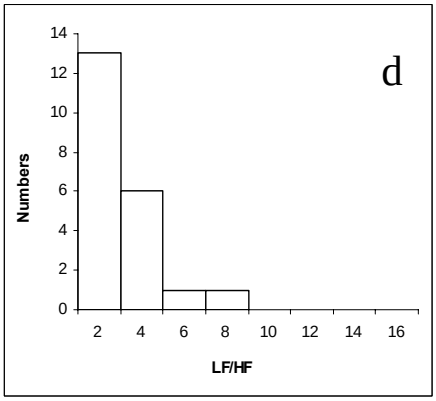
(PP), 56 y, LF/HF=1,03



(PP), 25 y, LF/HF=0,88



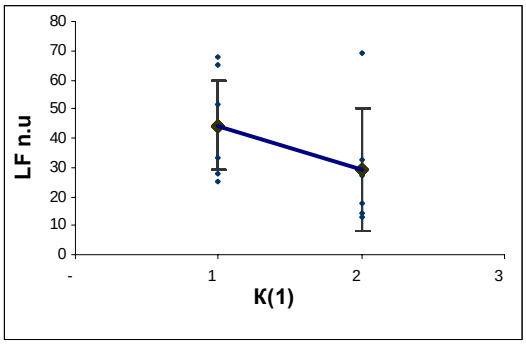
(SP), 49 y, LF/HF=3,49

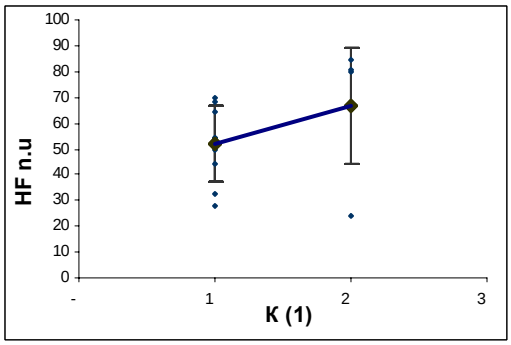


(SP), 23y, LF/HF=2,09

Figure 2 (a,b,c,d). Histograms of (LF/HF) relationship of sympathetic (a,b) and parasympathetic (c,d) people.

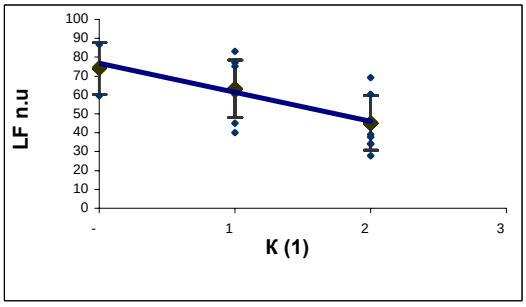
Typical distribution of LF/Hf coefficient for tested people of different age is represented in Figure 3. One can see that average balance coefficient for PP (top side of Figure 2) is about or smaller than 1,0 and the number of events is characterized by a sharp peak at 0-2 values of LF/HF. On the other hand, the distribution of the number of events is rather smothering for SP (bottom side of Figure 2) and varies from 2 up to 8-12. Next Figure 3 demonstrates dependencies of LF and HF indices of four selected persons (the same as in Figure 2 of PP and 2 of SP) of different age on local K-index. All curves were constructed as statistical linear trends using a standard EXEL 6.0 software. It is possible to see the different ANS accentuation. But reaction of people about the same age does not sharply depend on their ANS accentuation. There are no contradictions between the results published before and the ones presented here because authors [7] did not take into account any age difference. Those samples recommend us to carry out deeper studies of dependencies of different ANS branches on geomagnetic activity.

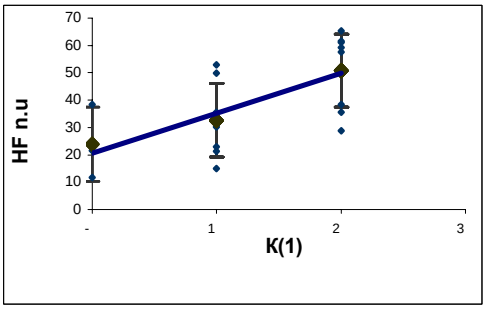




r=0,42 p=0,1 r=0,4 p=0,1

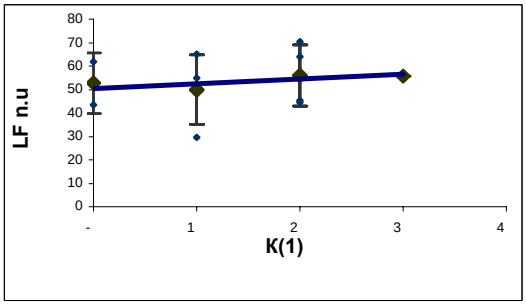
a) Parasympathetic 25y, LF/HF=0,88

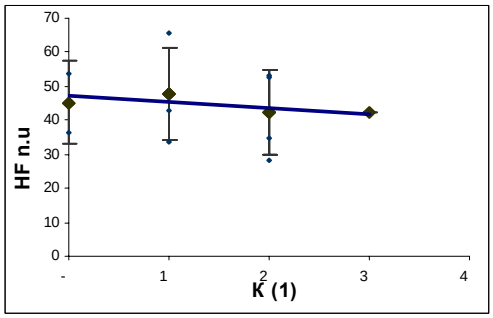




r=-0,63 p=0,001 r=0,64 p=0,001

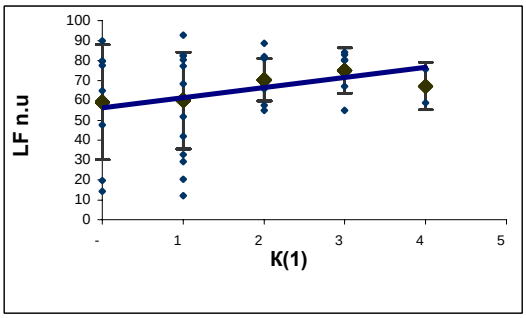
b) Sympathetic 23y, LF/HF=2,09

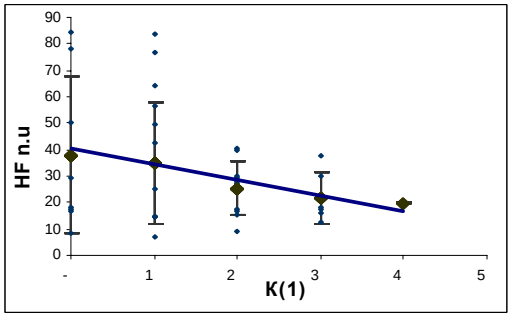




r=0,64 p=0,001 r=0,28 p=0,001

c) Parasympathetic 56y, LF/HF=1,03





r=0,28 p=0,1 r=-0,31 p=0,05

d) Sympathetic 49y, LF/HF=3,49

Figure 3 Dependencies of HF and LF parameters of different age tested people.
r - is correlation coefficient, p - significance level.

Conclusion

The results show that geomagnetic field variation and HRV parameters of people have valid correlation. This is not possible to stay that geomagnetic variation impact influence to human organism directly because the mechanism of this impact is not yet discovered. In any case we can use geomagnetic field variation as indicator or marker of influence of Heliogeophysical Disturbances on Human Health. There is necessary to point out that relationship between geomagnetic fields variations and HRV parameters is rather personal and varied in amplitude and direction for individual in dependence of age and ANS accentuation first of all.

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References

Chyzhevsky. A 1973, Zemnoye ekho solnechich bur Moscow, Mysl, 273p, in Russian.

Belisheva N. Et al 1995, Qualitative and quantitative evaluation at effects of geomagnetic field variations on the human brain, Biophysics, 40 (5)p., 1004-1007.

Chernouss S., Kuznetsova M., Fedorenko Yu., Vlassova E., Vinogradov A., 1999, Experimental possibilities for evaluation of influence of geophysical environment on human health in the Arctic Antropogenius impact on nature of the North and it's ecological consequences. INEP KNS RAS Apatity, pp 158-171 (in Russian)

Baevsky R.M. 1970. Physiological measurements in space and problem of their automatization. (Moscow, Nauka) 260 p. In Russian.

Pivovarov V, 1997, Kardioanalizator VR, physiological substantiation, St.-Petersburg, INTOKS, 20 pp. (in Russian)

Heart Rate Variability: Standards of measurements, physiological interpretation and clinical use, 1996, Et. Heart Y 17.p. 354-381.

Vlassova E., Chernouss S., Rintamaki H. The Roul of Autonomic Nervous System in individual response to meteorological and geophysical factors. Proceedings of the International Congress Center, Sydney, Australia, November 8-12,p. 178.