Annual Research & Review in Biology
9(1): 1-11, 2016, Article no.ARRB.21656
ISSN: 2347-565X, NLM ID: 101632869

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Estimation of Stability of Arterial Pressure and Pulse at Changes of Geomagnetic Data and Atmospheric Pressure

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Authors' contributions

This work was carried out in collaboration between all authors. Author OI designed the study, wrote the protocol and interpreted the data. Author YK anchored the field study, gathered the initial data and performed preliminary data analysis. Methods of analysis of monitoring data and environmental conditions are offered by author IS. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARRB/2016/21656
Editor(s):
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Complete Peer review History: http://sciencedomain.org/review-history/12397

Original Research Article

Received 27th August 2015
Accepted 4th November 2015
Published 23rd November 2015

ABSTRACT

This work analyses annual blocks of daily observations of pulse with arterial blood pressure (ABP) and interrelation between them. Dynamics of morning and evening parameters is compared, behavior of atmospheric pressure and geomagnetic activity is correlated. Pulse and arterial blood pressure are evaluated during periods of more active behavior of patient (expeditions, business trips, holidays, etc), as well as during moments of considerable deviations of atmospheric pressure

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from annual average value. Regular (in the morning after sleep and in the evening) observations of heart rate (HR), systolic arterial blood pressure (SABP) and diastolic arterial blood pressure (DABP) are used. These observations are conducted by the patient (man with 2 step and 2 stage hypertensive disease, 1940 year of birth) within the program of ABP self-control. Values of geomagnetic activity and atmospheric pressure, drawn in for correlation, are tied to patient's place of residence (Troitsk, Moscow). This study is based upon series reflecting in time dynamics of correlation coefficients, which were received during simultaneous scanning of characteristics under study. Such series of correlation coefficients of medical parameters, analogue of degree of organism coordination are taken as the basis and compared with changes of environmental parameters. The suggested approach made it possible to single out situations, at which interrelations of pulse and ABP may be compared with concrete environmental conditions. A number of differences in characteristics of morning and evening series of monitoring may be tied with rapid relaxation of organism during night from rhythmical activity and enhanced sensitivity of organism in the morning to background effect. The considered material has confirmed effectiveness of self-control of ABP for its control and during selection, if necessary, of antihypertensive drug, which ensures normal patient's vital activity.

Keywords: Arterial blood pressure; pulse; geomagnetic data; atmospheric pressure; spectral analysis.

1. INTRODUCTION

One of co-authors of this work is keeping a diary of ABP self-control from 1997 under observation of a doctor, parameters of which are used in this publication. Self-control of ABP at home is very useful. It makes it possible for a doctor to give a more exact estimation of the true ABP level and administer proper antihypertensive medicines for long-term treatment of patients with hypertension. Possibility of active participation of the patient in treatment of arterial hypertension forms motivation and increases treatment compliance, which is an integral part of accomplishment of programs of primary and secondary prophylaxis of cardiovascular and cerebrovascular complications. Such approach enables to maintain stable ABP and efficiently control it. Observations concern the elderly man with mild hypertension who independently in home conditions kept the diary of the patient. The measurements were carried out tonometer OMRON M10-1T on the average readings from three measurements. Periodically the data were shown to the cardiologist to adjust the therapy. The standard method of hypotensive therapy was applied: An effective drug and its effective dose was selected. The antihypertensive medicine was taken once daily in the morning after measurements. For example in 2000 were accepted Betalok (Betalok's dose of 100 mg.) with Kristepin and Sektral (Sektral's dose of 200 mg.) with Kristepin. Antihypertensive drugs are taken 121 times, the average pause in the drugs use is equal to two days. The present paper is based on self-control data. In previous publications of the authors [1,2] general evaluation of these observations for more than 13 years is given, statistic characteristics of series are provided and stabilizing role of rhythmical activity is underlined. Distinctions of spectra of morning and evening series of self-control are specially pointed out. Spectral harmonic with period of 7 days is specific for evening series. "Moon" period in ~27.35 days is manifested in morning series. Seasonal variations of pulse and ABP are singled out. We will note that reasonable results are received in the analysis of indications of one patient. The given work continues these studies. Year of 2000 is chosen for the analysis as the year containing detailed comments of moments of increased activity of patient (expeditions, business trips, holidays, etc) and heart rate, ABP is assessed during these periods. Comparison is provided of correlation relationship of monitoring parameters with the data of atmospheric pressure P and magnetic H, D, Z – variations (IZMIRAN, 2000 y.). Emphasis is placed on dynamics of regular manifestations of background effect, which makes it possible to correlate long-term time intervals.

Studies for influence of space geophysical factors upon biomedical characteristics of human being are actively conducted from mid last century. The foundations are laid down (F. Hulberg and his colleagues) for such spheres as chronobiology and chronomedicine [3–10]. Organism's sensitivity to various forms of environment is modulated by biological rhythms. When adaptation properties of organism are diminished, its sensitivity to impact of environment increases, including change of geophysical parameters. In majority of studies parameters, characterizing space geophysical processes (indexes of geomagnetic activity Кр and Ap are usually used), are correlated with statistics of emergency calls, data of resuscitation departments and observations in profile departments of hospitals [11–21]. Actually, disturbance of physical factors, which are associated in time with medical manifestations, are under study.

In our case, we investigate the influence of external factors on stable indications, which are obtained within the program of self-control of the patient. Authors agree that it is single experiment and it can't be extrapolated on all persons.

2. INITIAL DATA AND THEIR OVERALL ESTIMATION

At the given moment the program of ABP self-control is being conducted for over 17 years. The year of 2000 was chosen for the analysis as the year containing detailed comments. Observation data are correlated with atmospheric pressure and geomagnetic activity (H, D, Z variations of a magnetic field). Values of SABP, DABP and atmospheric pressure P were registered in mm Hg, heart rate (HR) – in number of beats per minute. H, D, Z-amplitudes are given in nanotesla. For sake of convenience series of monitoring and atmospheric pressure are preliminarily given to commeasurable scale, i.e. after subtraction of annual average values (Mean), standardization was made on root-mean-square deviation (σ ½), corresponding values of which are given below. Change of standardized value per unit is equivalent to its change by corresponding σ½.

2.1 Self-Control Series and Atmospheric Pressure

Review of morning and evening monitoring data for 2000, taken as a basis for the work, is given in the Fig. 1. For correlation with them drawn in are six-hour readings of atmospheric pressure [22], corresponding cuts of which at 0, 6, 12 and 18 hours are shown in the Fig. 2 for 2000. Axis OX in both figures corresponds to days of year. Red marker registers moments of increased activity of patient, all together 25 days. Days, when atmospheric pressure deviated from annual average value by more than 2 units (in terms of size │dP│ ≥ 15 Hg. mm.), are also related to single out events and marked with blue marker in the Fig. 1. 13 days fell within reduced pressure out of 24 days for morning cut of atmospheric pressure, 10 days proved to be with reduced pressure out of 20 days for evening cut. In addition to mentioned events one can single out several periods in atmospheric pressure, which show nature of its behavior. Period T1 from 20th day to 90th day is growth of P from very low pressure to high pressure with separate pressure differentials. Further, up to 240th day period T2 – pressure varies round annual average value. Period T3 from 240th day up to 290th day – P increases up to very high pressure. From 335th day and to the end of year pressure drops from very high value down to low pressure – period T4. It is well known that not only the value of atmospheric pressure, but also rate of its measurement affects patient's health [23]. It is problematic to assess impact of the latter because of daily character of data of our monitoring.

2.2 Variations of Magnetic Field

Minute data of H, D, Z variations of magnetic field (**D –** the intensity along a magnetic meridian, **H –** the horizontal intensity perpendicular **D** and the vertical intensity **Z**) are also drawn in the work for 2000 [24]. Basic spectral components of these variations are equal to 24, 12, 8 and 6 hours, values of their spectral amplitudes are given in the Fig. 3a. Moon (27.3 d.) and triple moon period with spectral amplitudes by 30 times less than with daily harmonics are singled out in the range of long period (Fig. 3b). The axis of frequencies in both figures corresponds to reverse days. To correlate dynamics of magnetic field behavior with daily data of monitoring, it is reasonable to rest upon daily harmonics of magnetic field variations. After their singling out and use of Gilbert's transformation [25], we shall receive amplitudes (envelop curves) of daily

Table 1. Average annual values HR, ABP, P and their square root of the dispersion

	HR morning/ evening	SABP morning/ evening	DABP morning/ evening	P (Hg. mm) morning/ evening
Mean	58.2 / 61.3	122.3 / 119.6	82.2 / 79.1	743.47 / 743.32
σ ½	4.2 / 5.7	6.9 / 9.5	3.8 / 5.4	7.35 / 7.30

harmonics as function of time. Annual dynamics of these amplitudes for components H, D, Z is shown in the Fig. 3c, where days of year are laid across axis OX, and values of amplitudes are given in nanotesla. The received representation is convenient during further analysis.

3. DYNAMICS OF SELF-CONTROL SERIES AND BEHAVIOR OF P AND GEOMAGNETIC ACTIVITY

3.1 The Marked-out (Celebrated) Events

The Table 2 provides average characteristics of medical parameters during singled out periods. Fluctuations of heart rate, SABP and DABP are clearly seen during period of increased activity: in the morning pulse increases on the average by 7 ≈ 1.55×4.2 beats a minute, SABP and DABP – by 8 (≈1.1×6.9) and 4 (≈1.06×3.8) mm Hg, respectively. Also evening readings increase on the average during this period – heart rate by 5 ≈ 0.8×5.7 beats a minute, SABP and DABP by 10 (≈1.02×9.5) and 5 (0.98×5.4) mm Hg, respectively.

From received evaluations, taking into account difference of morning and evening annual average values of medical parameters, adjustment of morning and evening readings of heart rate, SABP and DABP follows during periods of increased activity. Moments with singled out atmospheric pressure in numerical characteristics are manifested less obviously. Only in evening data increase of SABP and DABP is singled out at increased atmospheric pressure. But coincidence of signs of disturbance of morning values of heart rate, SABP and DABP with sign of disturbance of atmospheric pressure (for "**+**" italic type is marked and for "**-**"in Table 2. is underlined) should be noticed.

3.2 Coherence of Characteristics of Self-control and Background Parameters

Differences of relative behavior of heart rate and SABP in different periods are appreciable even during visual assessment. To describe degree of coordination of organism and correlation with background characteristics, it is reasonable to use time dependence of linear correlation coefficients of medical parameters. Linear correlation coefficient is calculated at time interval *dT* for respective fragments of series A and B. Scanning interval *dT* over time axis and finding correlation coefficient at every moment of time, we will receive time dynamics of this coefficient. At such approach all variety of situations is displayed on interval of values [-1; +1] and is of assessment character of organism, but time dynamics of correlation coefficients and degree of their smoothness make it possible to compare behavior of background values of atmospheric pressure and magnetic field variations. Result of calculations at scanning interval *dT* = 9 days is represented in the Fig. 4. for morning and evening data, where: K1 – correlation coefficient dynamics between heart rate and SABP; K2 – correlations between heart rate and DABP; K3(t) – between SABP and DABP.

It is clear that characters of ties with morning and with evening parameters are quite different, though there are some coincidences. Presence of week component in spectrum of evening series of monitoring and its absence in spectrum of morning series have been already noticed [1,2], but moon period has been clearly manifested in spectra of morning series of monitoring, which is not available in the evening spectra. Let us consider in more details morning correlation series, represented in the Fig. 4a, which are free from influence of physical activity and administered drug. Relationship of pulse and arterial blood pressure is most interesting. Intervals T1 ÷ T4, reflecting behavior of atmospheric pressure, are applied underneath with grey marking. Periods T1, T3 and T4, characterizing change of atmospheric pressure, fell well in the regions of K1 and K2 with clear cut trends. There is also no monotonicity in relationship of heart rate with SABP and DABP on interval T2, when atmospheric pressure varies round annual average value. Further on, local negative minimums from the left and from the right from 100th day and 200th day attract attention, when pulse varies in antiphase with arterial pressure. Correlating with amplitudes of daily harmonics of magnetic field, we see that these moments are also singled out there. Dynamics of evening correlation series, which has absolutely different character because of effect of rhythmical activity during day, is represented in the Fig. 4b. Let us compare statistic characteristics of morning and evening correlation series. Assessments of these series are given in the Table 3. with the mean, square root of the dispersion (σ½), excess (Kurtosis's factor – a measure of the concentration of a distribution about its mean, kurtosis) and asymmetry (skewness – a measure of the symmetry of a distribution about its mean) [26].

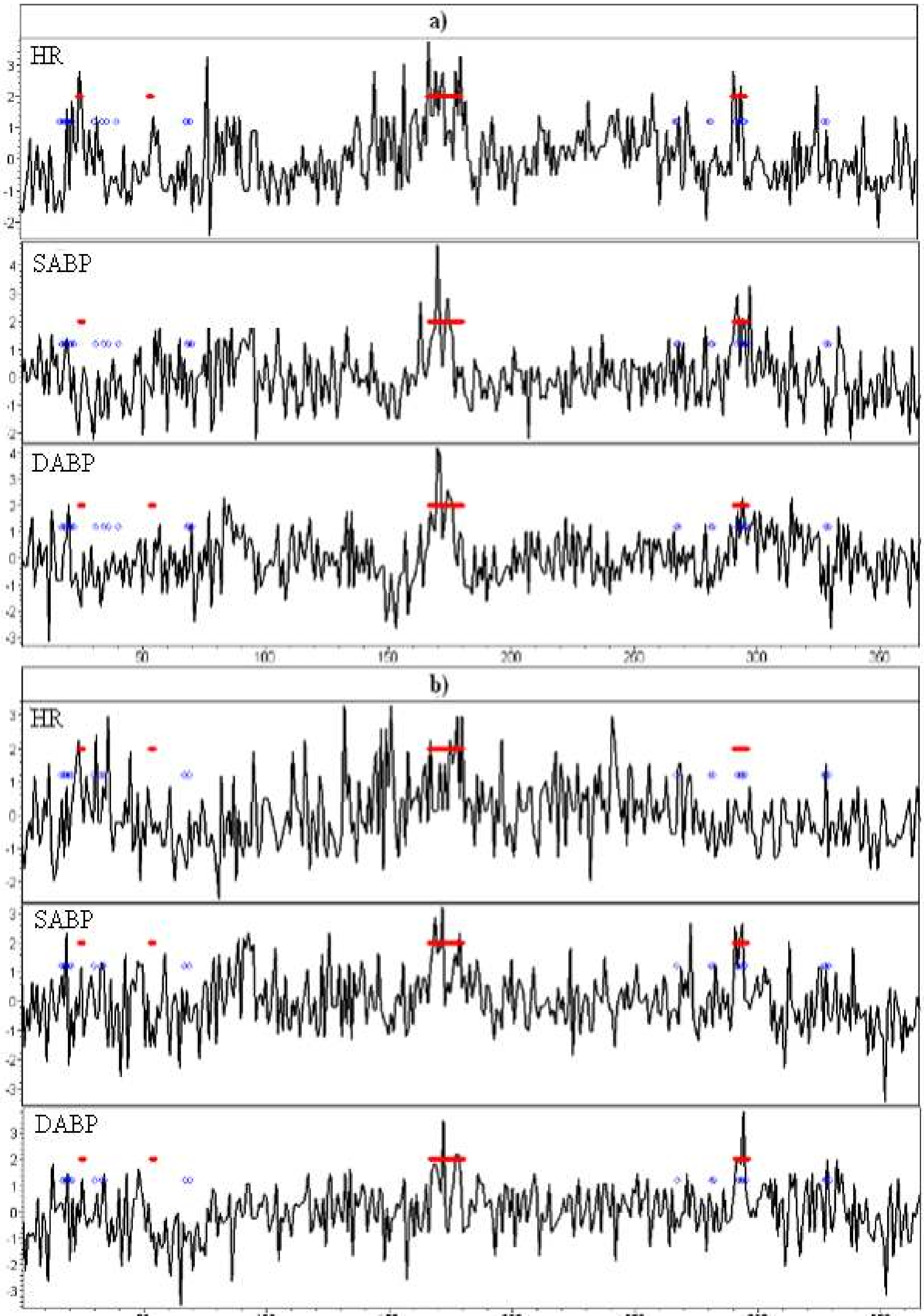

Fig. 1. Review of monitoring data: a) – morning; b) – evening. Axis OX -- days of the year

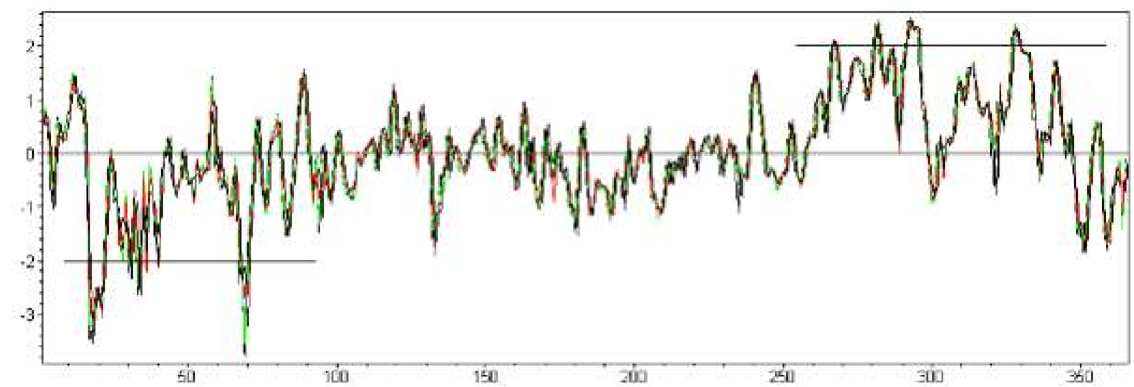

Fig. 2. Atmospheric pressure (IZMIRAN, 2000). Axis OX -- days of the year

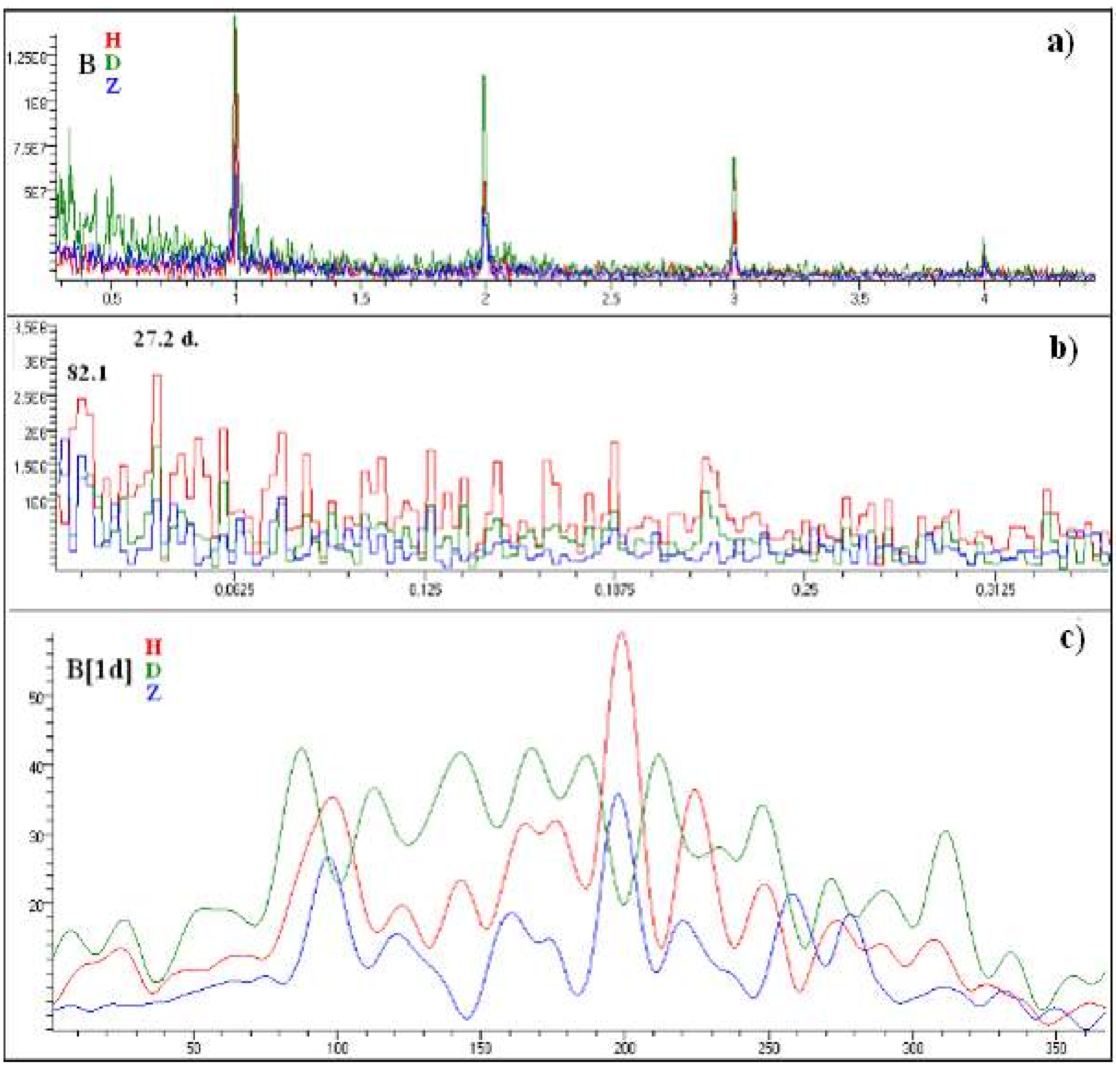

Fig. 3. Variations of magnetic field (H, D, Z – components, IZMIRAN, 2000). a), b) – The spectral components; axis OX – inverse day, c) Daily amplitudes of magnetic components in nanotesla; axis OX -- days of the year

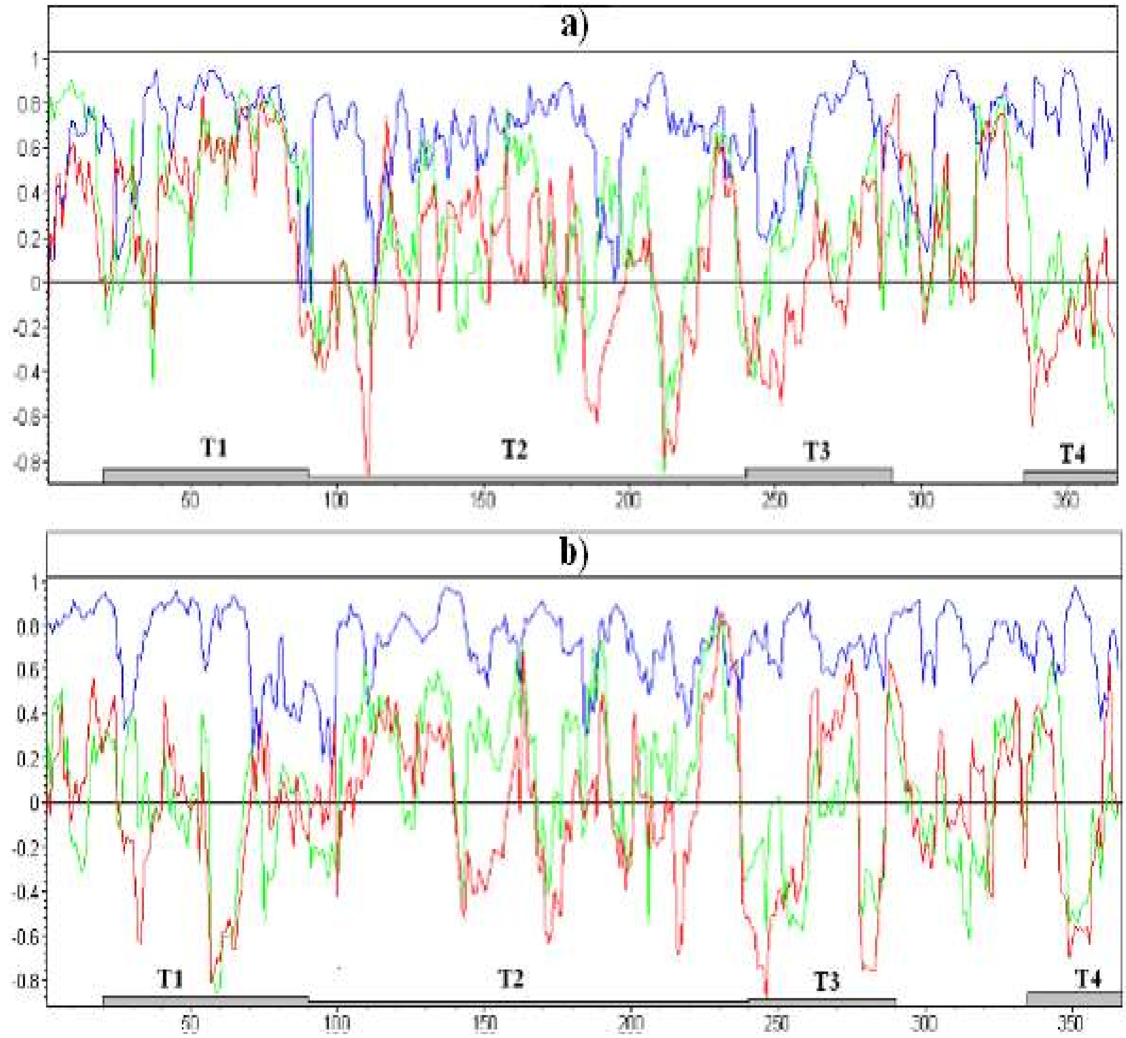

Fig. 4. Correlation series: a) – morning; b) – evening

----- K1(t); ----- K2(t); ----- K3(t). Axis OX -- days of the year

Mean values of correlation series of heart rate with SABP and DABP for evening data are actually equal to zero or less, than with morning data, when organism is more sensitive for environmental load, and physical activity did not “wash off” this influence.

Corresponding values of dispersions, characterizing relationship of pulse and arterial pressure, are comparable. Relationship between SABP and DABP are considerably closer, and in the evening they are intensified more when dispersion decreases.

Histograms, given in the Fig. 5, provide vivid comparison of characteristics of monitoring correlation series. Manifestation of the second maximum in morning histogram K1 reflects influence of environmental conditions on the organism, mentioned above. And greater degree of symmetry in the evening than in the morning for K1 and increased monotonicity of evening histogram may be bounded with stabilizing effect of rhythmical loads.

Let us add that the used methods enable to make analysis in terms of “averaged characteristics” and do not lay claim for correlation of relationship of scale of three and less days. At the conclusion, the Fig. 6. gives review of morning correlation series for scanning intervals dT at 5 and 13 days. All properties registered above are retained despite natural difference in degree of smoothness of these representations.

Table 2. Average characteristics of monitoring parameters during singled out periods

	Number of days morning / evening	HR morning / evening	SABP morning / evening	DABP morning / evening
mean (active period)	25 / 25	1.55 / 0.80	1.10 / 1.02	1.06 / 0.98
mean (dP ≥ +2)	11 / 10	***0.38*** / -0.14	***0.40*** / 0.47	***0.30*** / 0.91
mean (dP ≤ -2)	13 / 10	-0.27 / -0.14	-0.24 / 0.20	-0.22 / 0.00

Table 3. Statistical characteristics of correlation series

	Mean morning / evening	σ ½ morning / evening	Kurtosis morning / evening	Skewness morning / evening
Corr (HR&SBP)	0.135 / -0.014	0.367 / 0.357	2.38 / 2.46	-0.187 / -0.164
Corr (HR&DBP)	0.245 / 0.057	0.349 / 0.335	2.33 / 2.55	-0.140 / -0.183
Corr (SBP&DBP)	0.654 / 0.721	0.219 / 0.161	3.83 / 3.46	-1.126 / -0.903

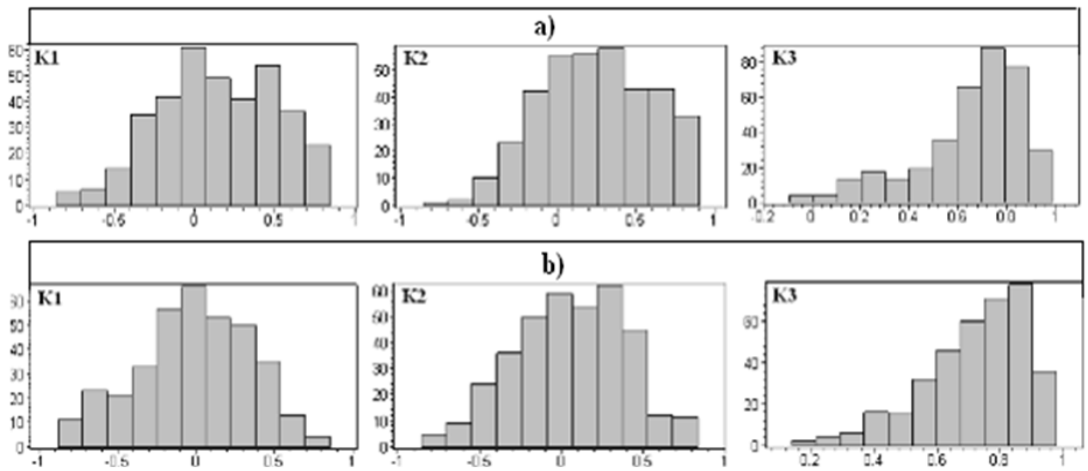

Fig. 5. Histograms of correlation series: a) – morning; b) – evening

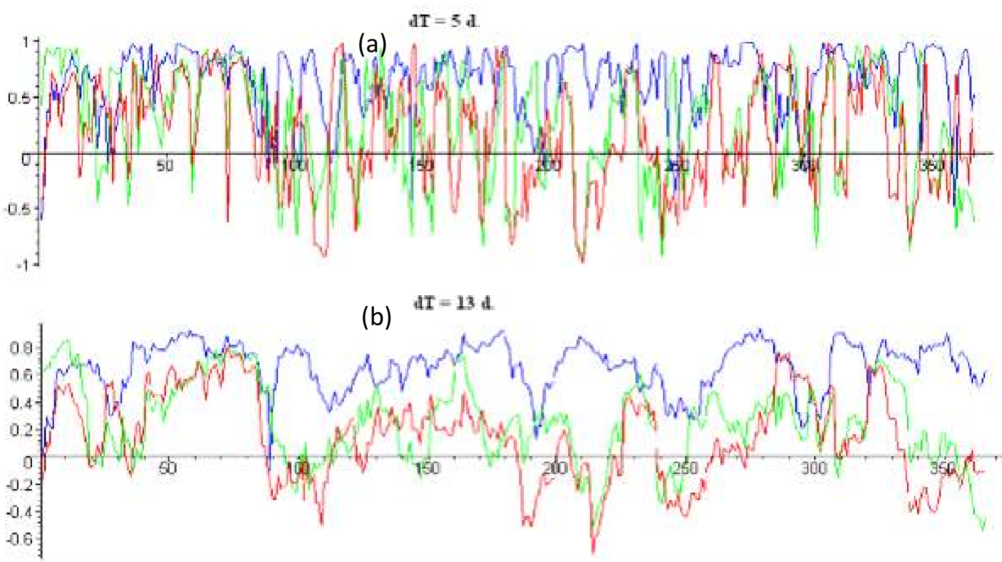

Fig. 6. Morning correlation series: a) dT = 5 days; b) dT = 13 days
----- K1(t); ----- K2(t); ----- K3(t). Axis OX -- days of the year

4. RESULTS

Our analysis enabled to single out a number of situations, when relationship of heart rate with ABP may be correlated with environmental conditions, and to evaluate changes of pulse and ABP during active periods of patient's behavior:

- During active period pulse and ABP are increasing and their morning readings are closing in with evening ones;
- During days with low or high atmospheric pressure variations of ABP and heart rate are manifested less obviously, but sign of variations of morning values of pulse and ABP coincides with sign of variations of atmospheric pressure;
- Time periods of atmospheric pressure, reflecting character of its behavior, and regions with clear cut trends with the series, characterizing relationship of morning readings of heart rate and ABP, are well mated;
- Maximums (at 100^{th} and 200^{th} days) of daily amplitudes of H, D, Z components and their fronts are laid on the periods, when morning readings of heart rate and ABP have been varied in antiphase most evidently;
- With series, characterizing relationship of evening readings of heart rate and ABP, histograms are more balanced and there is no distinct relationship of these series with periods T1 ÷ T4 of atmospheric pressure and maximums of daily amplitudes of H, D, Z components.

5. CONCLUSIONS

It is assumed that there is no clear functional relationship between value of ABP and pulse. Pulsus parvus absolutely does not imply reduced level of arterial blood pressure. Respectively and vice versa, at pulsus magnus, pressure may be not only normal, but in some cases reduced (for example, during myocardial infarction, cardiac insufficiency), since high rate of heart contraction does not leave heart time to have time to collect sufficient amount of blood and such work will be inefficient. Pressure buildup is possible at infrequent pulse, caused by different forms of blocks. Conditions also exist, at which both ABP and pulse may be increased. For instance, it is encountered in physiological state during physical activity, psycho-emotional overexcitation; during different diseases – for example, hyperkinetic type of vegetovascular dystonia, thyrotoxicosis. Reduction of ABP and slow down of pulse are observed during sleep. This is also characteristic for sportsmen, with whom these two parameters are clearly connected as a result of long trainings, which is not peculiar to ordinary people.

Proposed approach and results of our analysis make it possible to single out a number of situations, when relationship of heart rate and ABP may be correlated with environmental conditions at considerable time intervals. It is important to emphasize difference “morning-evening” of not readings themselves, but also relationship of these readings in the morning and in the evening. Enhanced sensitivity of organism during morning hours (absence of week component and manifestation of moon period in morning series of self-control), registered earlier, is also confirmed during assessment of influence of atmospheric pressure and magnetic field variations. Greater susceptibility to environmental conditions during night and morning hours is possible for patients with weakened heart activity and during absence of self-control. It is necessary to expect intensification of influence of geomagnetic situation on heart rate and ABP at high (polar) latitudes during period “night – morning” because of increased level of magnetic variations.

In spite of solitary cases of long-term and regularly held medical examinations the investigations are of a real interest. Dynamics of correlation series characterizes a condition of an organism. The authors hope that this approach increases the objectivity of research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Isaikina OJ, Kuksa JI, Shibaev IG. Estimation and comparison of long-term dynamics arterial pressure and pulse with solar and atmospheric parameters. Proceedings of Fifteenth All-Russian annual conference on Sun physics "Solar and Solar - terrestrial physics – 2011", Pulkovo Observatory, Saint Petersburg, Russia, 03 — 07 October. 2011;375–378. (in Russian)

2. Isaikina OJ, Kuksa JI, Shibaev IG. Analyses of characteristics of long-term monitoring of arterial pressure and pulse. Journal of Environmental Science and Engineering. 2012;1(9(B)):1064-1073.
3. Barnothy MF. Biological effects of magnetic fields. NY: Plenum Press; 1964.
4. Halberg F, Engeli M, Hamburger C, Hillman D. Spectral resolution of low-frequency, small-amplitude rhythms in excreted 17-ketosteroid: Probable androgen induced circaseptan desychronization. Acta Endocrinol. (Kbh). 1965;50(Suppl. 103):5-54.
5. Stoupel E. Forecasting in cardiology. NY, Toronto, Jerusalem: John Wiley & Sons, Israel University Press. 1976;141.
6. Roederer JG. Tearing down disciplinary barriers. Eos, Transactions, Amer. Geoph. Union. 1985;66:681,684–685.
7. Halberg F, Breus TK, Cornelissen G, Bingham C, Hillman DC, Rigatuso J, Delmore P, Bakken E. (International Womb-to-Tomb Chronome Initiative Group). Chronobiology in space: Keynote of the 37th Ann. Mtg. Japan Soc. for Aerospace and Environmental Medicine, Nagoya, Japan, November 8 – 9, 1991. University of Minnesota / Medtromic Chronobiology Seminar Ser. December. 1991;1:21.
8. Roederer JG. Are magnetic storms hazardous to your health? // Eos, Transactions, Amer. Geoph. Union. 1995;76:441,444–445.
9. Breus T, Cornelissen G, Halberg F, Levitin AE. Temporal associations of life with solar and geophysical activity. Annales Geophysicae. 1995;13:1211–1222.
10. Oraevski VN, Breus TK, Baevski RM, Rapoport SI, Petrov VM, Barsukova ZhV. Effect of geomagnetic activity on the functional status of the body. Biofizika. 1998;43(5):819–826.
11. Burch JB, Reif JS, Yost MG. Geomagnetic disturbances are associated with reduced nocturnal excretion of a melatonin metabolite in humans. Neuroscience Letters. 1999;266(3):209–212.
12. Stoupel E. Effect of geomagnetic activity on cardiovascular parameters. J. Clinical and Basic Cardiology. 1999;2:34–40.
13. Cornelissen G, Halberg F, Breus T, Syutkina EV, Baevsky R, Weydahl A, Watanabe Y, Otsuka K, Siegelova J, Fiser B, Bakken EE. Non-photic solar associations of heart rate variability and myocardial infarction. J. Atmospheric and Terrestrial Physics. 2002;64:707–720.
14. Singh RB, Cornelissen G, Siegelova J, Homolka P, Hulberg F. About half-weekly (circasemiseptan) patten of blood pressure and heart rate in men and women of India. Scripta Medica (Brno). 2002;75:125–128.
15. Palmer SJ, Rycroft MJ, Cermack M. Solar and geomagnetic activity, extremely low frequency magnetic and electric fields and human health at the Earth’s surface. Surveys in Geophysics. 2006;27:557–595.
16. Babayev E, Allahverdiyeva A. Effects of geomagnetic activity variations on the physiological and psychological state of functionally healthy humans: Some results of Azerbaijani studies. Advances in Space Research. 2007;40:1941–1951.
17. Hrushesky WJM, Sothern RB, Du-Quiton J, Quiton DFT, Rietveld W, Boon ME. Sunspot dynamics are reflected in human physiology and pathophysiology. Astrobiology. 2011;11:93–103.
18. Watanabe Y, Halberg F, Otsuka K, Cornelissen G. Physiological changes in relation to the 2011 East Japan earthquake. Proc. of the World forum “Natural cataclysms and global problems of the modern civilization”, Istanbul, Turkey, 19—21 September, 2011. London: SWB Intern. Publ. House. 2011;113—114.
19. Satoh M, Kikuya M, Ohkubo T, Imai Y. Acute and subacute effects of the great East Japan earthquake on home blood pressure values. Hypertension. 2011;58: 193—194. DOI:10.1161/HYPERTENSIONAHA.111.18477
20. Katsavrias Ch, Preka-Papadema P, Moussas X, Apostolou Th, Theodoropoulou A, Papadima Th. Helio-geomagnetic activity influence on cardiologic cases. J. Advances in Space Research; 2012.
21. Mulligan BP, Persinger MA. Expiremental simulation of the effects of sudden increases in geomagnetic activity upon quantitative measures of human brain activity: Validation of correlational studies. Neurosci. Lett. 2012;516(1):54–56.
22. Available:http://cr0.izmiran.ru/mosc/main.htm
23. Ioannidou SP, Papailiou M, Mavromichalaki H, Apostolou Th, Paravolidakis K. Kouremeti M, Rentifis L, Simantirakis E, Xystouris G. Impact of

cosmic ray intensity and geomagnetic activity on human heart rate. Proceedings of the International Conference: SWH, Space Research Institute, Moscow, Russia, June 4–8, 2012. 2013;2:683–694.
24. Available:ftp://ftp.iki.rssi.ru/magbase/database/
25. Bendant J, Pirsol A. Random data. Analysis and Measurement Procedures, John Wiley & Sons, Inc., NY; 1986.
26. Stuart A, Ord K. Kendall's Advanced Theory of Statistics. Vol. 1: Distribution Theory, 6th ed. London: Edward Arnold; 1998.

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