Biochemical Parameters of Human Health Monitored in Season of Low and High Solar Activity

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*Abstract***— In work (Dzvonik et all, Studia psychologica, 48, 4, 273-292, 2006) was monitored possible connectivity of space weather and some parameters of mental performance and health in aviation personnel. In next study we analysed the distributions of some physiological and biochemical parameters monitored in Air Force Military hospital Košice during season of low and high solar activity. Statistical tests shows significant differences of high density level cholesterol distribution, haemoglobin content distribution, erythrocytes distribution and erythrocytes sedimentation distribution in these two data samples. The results are discussed in comparison with similar empirical determined connectivity of other authors.**

1. Introduction

SPACE weather includes a many effects which are affected by physical processes on surface of the sun, within interplanetary environment, magnetosphere, ionosphere and atmosphere and have adverse effects on technological systems not only at the satellites, but also at the aircrafts and surface of the earth as well as on the live structures including people. Effects of space weather on health and mental state of people are topics of research for long time. Very important effect of space weather on human life and health are those on different biological and physiological systems.

The effect of solar activity and geomagnetic activity on human homeostasis has been object of research for long time period. Monthly incidence of mortality (positive and negative) correlates with solar activity and has negative correlation with space proton flow (>90 MeV) [1]. During geomagnetically quiet days the heart rate and the cosmic ray intensity variations are positively correlated [4]. Clinical blood analyses of tested patients provided interesting results – blood viscosity (sedimentation) rapidly increases during geomagnetic storms (in some cases nearly two times), erythrocytes are more adhesive, blood flow is slower. It seems to be probable that geomagnetic storms have affection on increasing of cardio-vascular system diseases [3].

We focused on statistic relation between some long-time monitored space weather parameters (as a type of environment load) and biochemical data obtained from selection and periodic medical-psychological investigations of Slovak aviation personnel through the years 1994-2004.

2. Data and Methods

Two types of data files were used for purpose of the analysis: medical data and parameters of space weather.

A. Biochemical data

The data were processed from medical examinations of 4018 Slovak aviators. Many of them were examined again but in different time periods hence the number of subjects can vary in dependence on it. All subjects were men of age 18-60 years.

TABLE I
BIOCHEMICAL PARAMETERS

Parameter	Legend
FW	Erythrocytes sedimentation (parts/hour)
HB	Heamoglobin content (g/dl)
HTK	Heamatocrit (% ratio of constant blood elements to plasma volume)
ERY	Number of erythrocytes (T/l)
LE	Number of leukocytes (G/l)
GLYK	Glycogen level in blood (mmol/l)
CHOLCEL	Total cholesterol in serum (mmol/l)
TRIGLYC	Triglyceride content in serum (mmol/l)
HDLCHOL	High density level cholesterol (mmol/l)
UREA	Urea content in serum (mmol/l)
KREATIN	Creatinine content in serum (μmol/l)
KYS_MOC	Uric acid content in serum (μmol/l)
BIL_C	Bilirubin content in serum (μmol/l)
AST	Liver enzyme content AST (aspartat-amino-transpherase) (μkat/l)
ALT	Liver enzyme content ALT (alanin-amino-transpherase) (μkat/L)
MG	Magnesium content in blood (mmol/l)

Our research sample consisted of military and civil aircrews (e.g. pilots, board engineers and navigators) and military and civil air traffic controllers. All of them

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B. Monitored parameters of space weather

In this study we prepared the data from January 1994 to December 2004 and we separated them to several series.

In second series are geomagnetic activity data. They are described by index Dst taken from the page ftp://ftp.ngdc.noaa.gov and every hour characterize disturbance of geomagnetic field on low latitudes. Besides the three-hour-range Kp index is taken from the page OMNIWEB NASA http://nssdc.gsfc.nasa.gov/omniweb/, which describe disturbances of Earth magnetic field on middle latitudes.

TABLE II
SPACE WEATHER PARAMETERS

Parameter	Legend
B	Induction of interplanetary magnetic field module (nT - nanotesla)
PlasTemp	Plasma temperature (K –Kelvin)
PlaSp	Plasma speed (km/s)
ProDen	Proton density (cm^{-3})
Kp	The planetary three-hour-range index of global geomagnetic activity level, this is empirically determined index with 28 steps (highest activity is 9, lowest is 0, between are steps 0,0+,1-,1,1+,...,9)
R	Sunspot number, global character of solar activity,
Dst	(Disturbance Storm Time) equivalent equatorial magnetic disturbance indices (nT - nanotesla), specified from records of a worldwide array of low-latitude observatories
PrFl>1, PrF1>10, PrF1>60	The flux of high-energy protons from the Sun (they are very high during some of solar flares), number >1, >10, >60 specifies threshold energy in MeV (megaelectronvolt), they are fluxes (counts per 1 cm^2 during 1 sec)
Sol Flux	adio flux from the Sun measured on wave-length 10.7 cm.

As for physical parameters of interplanetary space we induct to the date basis hourly values about solar wind plasma (solar wind plasma temperature, its density, speed of flux), and the energetic proton flux too, which are not observable on surface of Earth and are monitored from satellites (protons with energy above 1, 10 and 60 MeV respectively) and are modulated by interplanetary magnetic field, which is in-frozen in plasma of solar wind propagating from Sun surface to interplanetary space.

For solar activity characteristics we appended basis with sunspot number and radio solar flux with wave-length 10.7 cm.

Observed parameters of space weather are present in Table II.

Because the data of solar, interplanetary and geomagnetic activity are characterized on different time scales the same problem was with the medical data mentioned in first part. It was necessary for comparison purpose to make a lot of works in connection with data arrangements.

The numbers of daily or hourly performed examinations were relatively low for simple correlation with space weather parameters. In the first part of the study we selected 2 intervals of season of low solar activity (March 1995 – July 1997) and high solar activity (April 1999 – December 2002). As for the criteria we used the solar activity and/or number of sunspots R (for solar minimum $R < 30$, for solar maximum $R > 75$), respectively.

The data were subsumed into 9-days intervals corresponding to 1/3 of solar rotation cycle. Obtained mean values were used for statistical tests and correlation between selected physical parameters and the data of medical examinations. Obtained results are shown in the tables and graphs.

3. RESULTS

Statistical tests shows (Student T-test, Mann-Whitney U-test), that values of some biochemical parameters are depending on season of examination (season of low solar activity or season of high solar activity) (Table III).

The diferences in values of some biochemical parameters in season of low and high solar activity are shown in histograms. The curved line plots Gaussian distribution. Heamoglobin content in blood is lower in season of low solar activity than in season of high solar activity (Fig. 1).Erythrocytes sedimentation and number of erythrocytes are lower in season of low solar activity too (Fig.2, Fig.3).However a level of total cholesterol in serum (CHOLCEL) does not show dependence on solar period (Tab. 2), level of high density cholesterol (HDLCHOL) show remarkable differences in different solar periods (Fig. 4).

4. CONCLUSION

Empirical analysis of relations between some parameters of space weather and medical data from examinations of aviation personnel indicates statistic significant differences in some parameters values. Number of erythrocytes, heamoglobin content, high density level cholesterol and erythrocytes sedimentation are lower during low solar activity as during high solar activity.

Obtained results could motivate a research of space weather effects on physiological or biochemical processes at cellular level. Interpretation of causes of found correlation in biochemical sphere of human physiology exceeds framework of this study.

TABLE III
TABLE OF DEPENDENCE TEST OF SELECTED PARAMETERS BY SEASON

Parameter	Mann-Whitney U-test by variable Season (1 – solar minimum, 2 - solar maximum) Marked tests are significant on level p < 0.05000								
	Order Sum Group 1	Order Sum. Group 2	U	Z	Level p	Z Adjust.	Level p	N Group 1	N Group 2
FW	*6430,5*	*18769,5*	*2059,50*	**-8,4361**	**0,000000**	**-8,4362**	**0,000000**	*93*	*131*
HB	*5768,0*	*19432,0*	*1397,00*	**-9,8223**	**0,000000**	**-9,8223**	**0,000000**	*93*	*131*
HTK	*7823,0*	*17377,0*	*3452,00*	**-5,5226**	**0,000000**	**-5,5226**	**0,000000**	*93*	*131*
ERY	*6697,5*	*18502,5*	*2326,50*	**-7,8775**	**0,000000**	**-7,8776**	**0,000000**	*93*	*131*
LE	*9824,0*	*15376,0*	*5453,00*	*-1,3359*	*0,181574*	*-1,3359*	*0,181569*	*93*	*131*
GLYK	*11663,0*	*13537,0*	*4891,00*	**2,5118**	**0,012012**	**2,5118**	**0,012012**	*93*	*131*
CHOLCEL	*10934,5*	*14265,5*	*5619,50*	*0,9876*	*0,323368*	*0,9876*	*0,323365*	*93*	*131*
GLYK	*12814,5*	*12385,5*	*3739,50*	**4,9211**	**0,000001**	**4,9211**	**0,000001**	*93*	*131*
HDLCHOL	*5312,0*	*19664,0*	*1034,00*	**-10,5247**	**0,000000**	**-10,5249**	**0,000000**	*92*	*131*
UREA	*10404,0*	*14572,0*	*5926,00*	*0,2108*	*0,833018*	*0,2108*	*0,833017*	*92*	*131*
KREATIN	*12387,0*	*12589,0*	*3943,00*	**4,3916**	**0,000011**	**4,3916**	**0,000011**	*92*	*131*
KYSMOC	*10359,5*	*14616,5*	*5970,50*	*0,1170*	*0,906851*	*0,1170*	*0,906851*	*92*	*131*
BILC	*9240,0*	*15960,0*	*4869,00*	**-2,5578**	**0,010533**	**-2,5578**	**0,010533**	*93*	*131*
AST	*10669,0*	*14531,0*	*5885,00*	*0,4321*	*0,665699*	*0,4321*	*0,665665*	*93*	*131*
ALT	*9014,0*	*16186,0*	*4643,00*	**-3,0307**	**0,002440**	**-3,0308**	**0,002439**	*93*	*131*
GGTP	*8350,0*	*16850,0*	*3979,00*	**-4,4200**	**0,000010**	**-4,4201**	**0,000010**	*93*	*131*
MG	*7211,5*	*11316,5*	*2670,50*	**3,6960**	**0,000219**	**3,6962**	**0,000219**	*61*	*131*

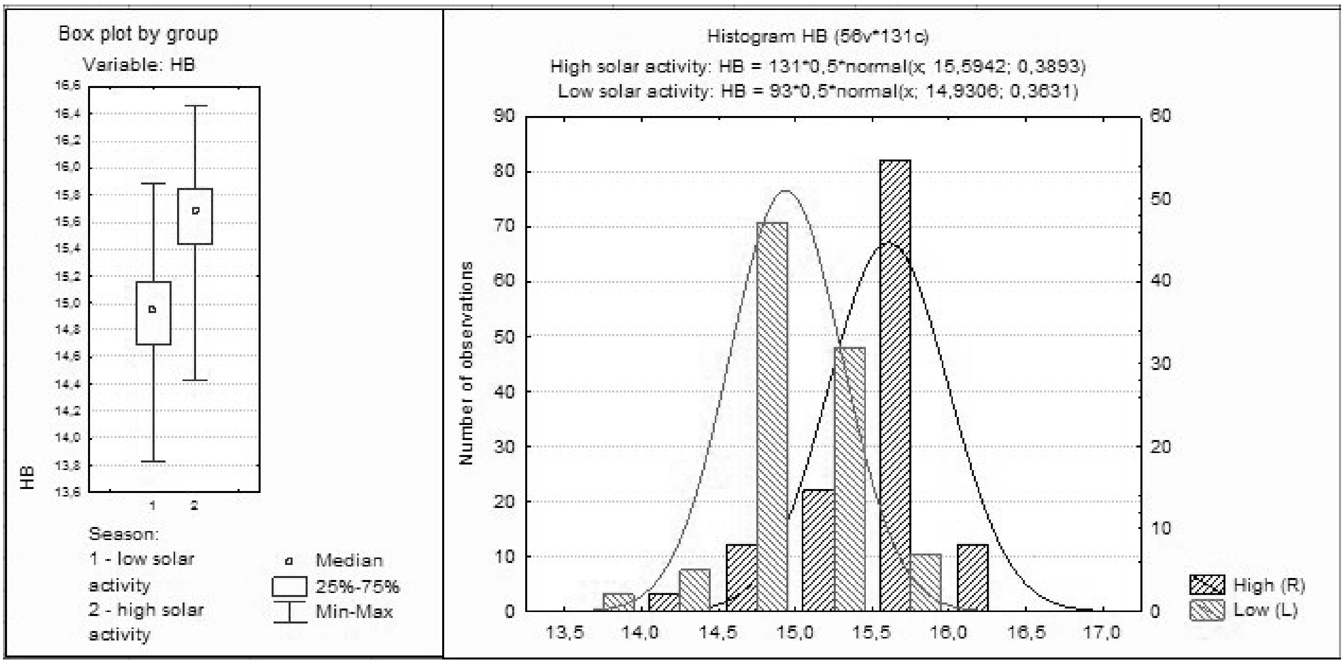

Fig. 1: Differences in heamoglobin content in blood in season of low and high solar activity
Season Low: Gaussian distribution, Chi-square = 7,22284, df = 4 , p = 0,12457
Season High: Gaussian distribution, Chi-square = 32,04379, df = 5 , p = 0,00001

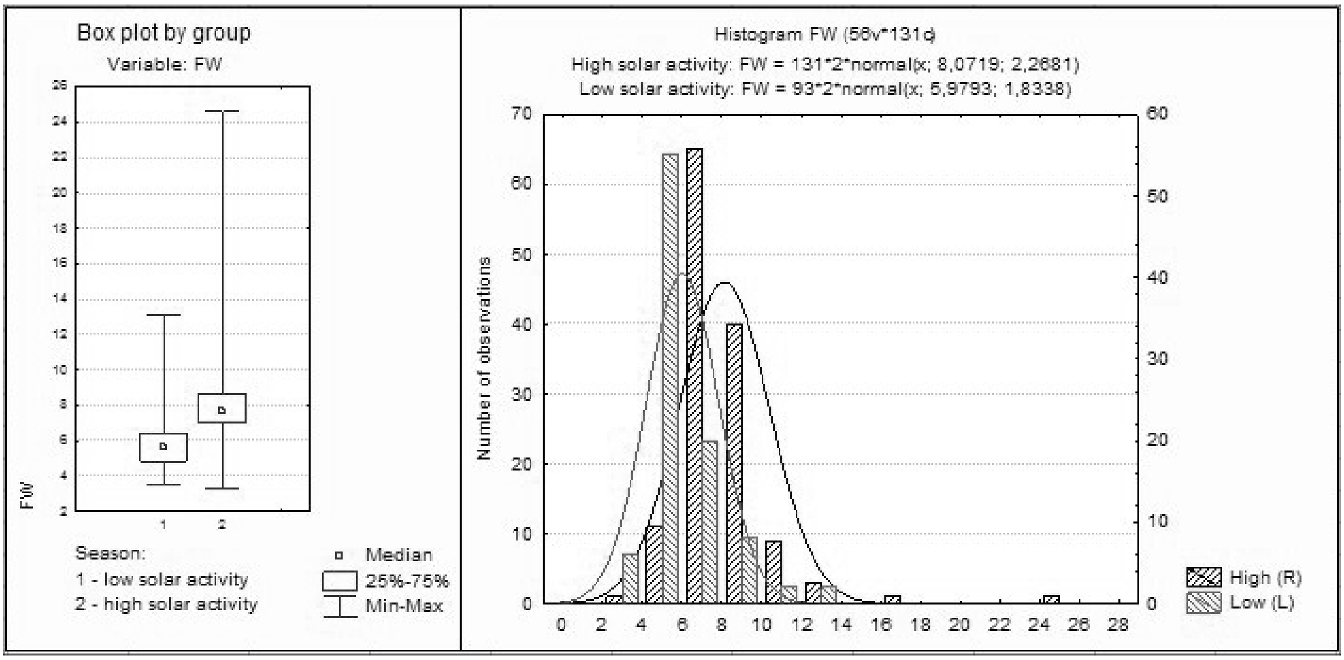

Fig. 2: Differences in values of erythrocytes sedimentation in periods of low and high solar activity
Season Low: Gaussian distribution, Chi-square = 25,53849, df = 3 , p = 0,00001
Season High: Gaussian distribution, Chi-square = 27,51102, df = 2 , p = 0,00000

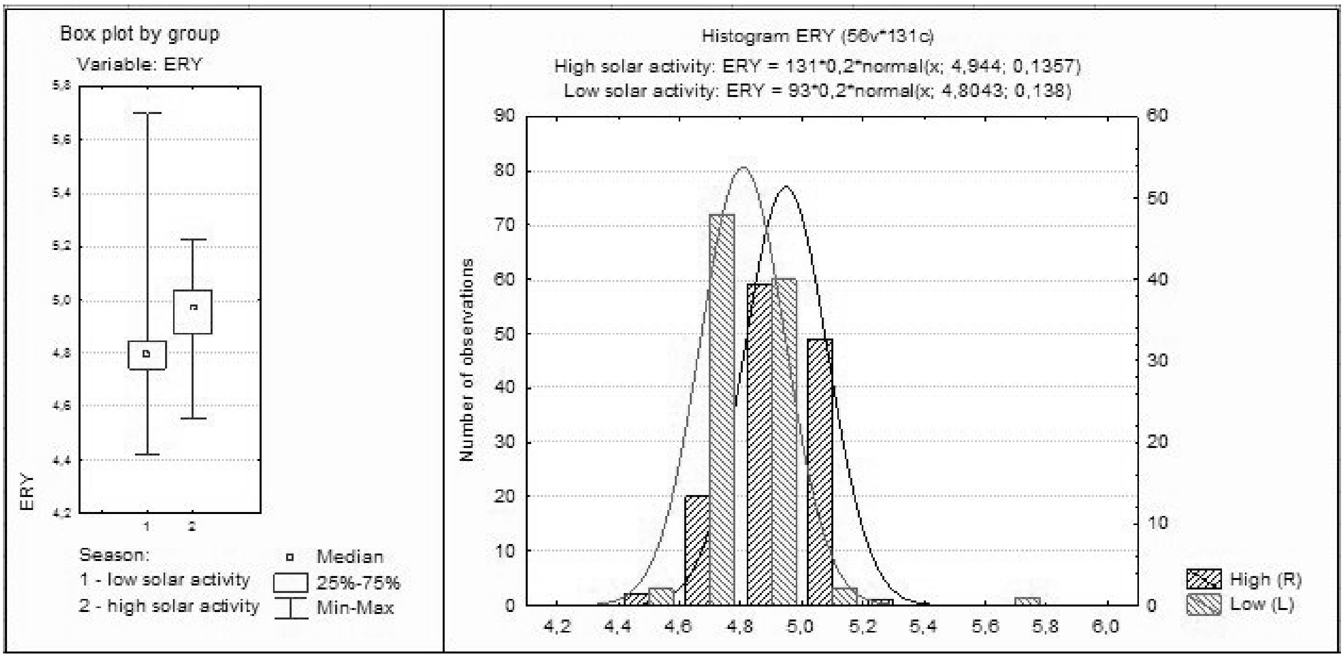

Fig. 3: Diffrences in number of erythrocytes in periods of low and high solar activity
Season Low: Gaussian distribution, Chi-square = 15,60913, df = 3 , p = 0,00136
Season High: Gaussian distribution, Chi-square = 10,21355, df = 2 , p = 0,00606

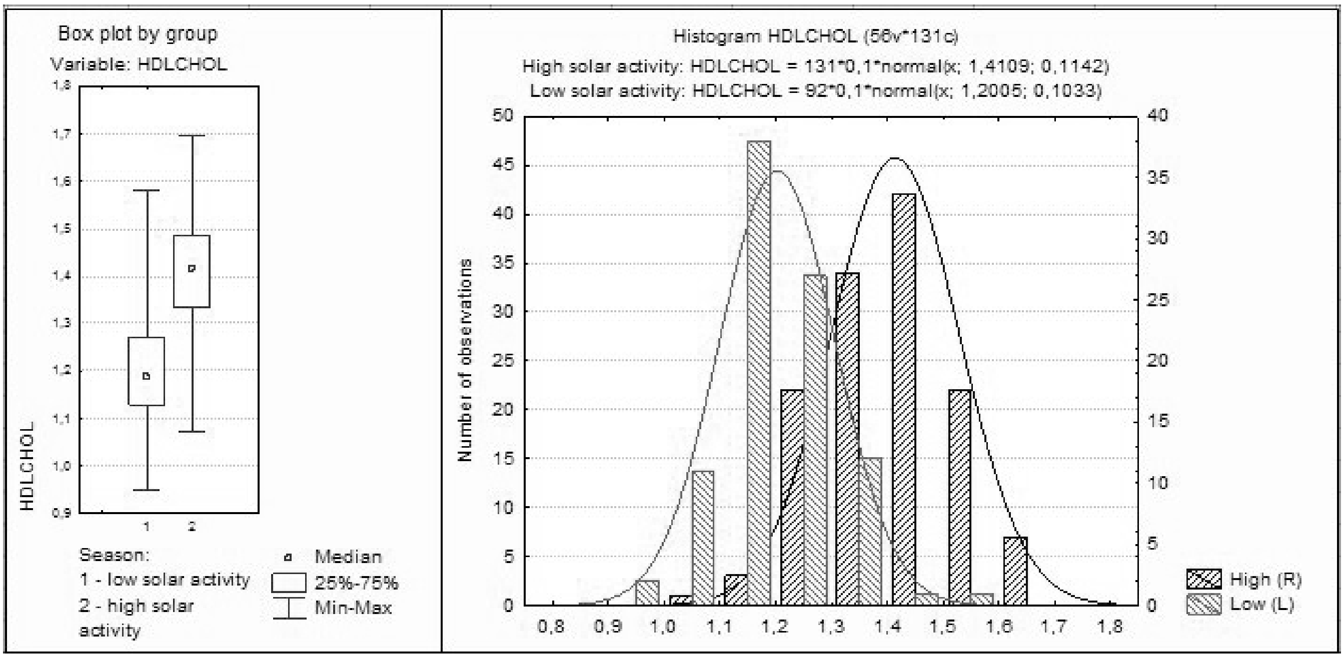

Fig. 4: Level of high density cholesterol in periods of low and high solar activity
Season Low: Gaussian distribution, Chi-square = 2,69474, df = 1 , p = 0,10068
Season High: Gaussian distribution, Chi-square = 1,50605, df = 2 , p = 0,4704

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REFERENCES

[1] E. Stoupel, J. Abramson, S. Domarkiene, M. Shimshoni, J. Sulkes, "Space proton flux and the temporal distribution of cardiovascular deaths", *International Journal of Biometeorology, 1997, 40, 2, 113-116*

[2] O. Dzvoník, J. Štetiarová, K. Kudela, P. Daxner, "A monitoring of space weather effects on some paramters of mental performance and health in aviation personnel ", *Studia Psychologica, 2006, 48, 4, 273-291*

[3] E. Stoupel, "Effect of geomagnetic activity on cardiovascular parameters ", *Journal of Clinical and Basic Cardiology, 1999, 2 (Issue 1), 34-40*

[4] M. Papailiou, H. Mavromichalaki, A. Vassilaki, K.M. Kelesidis, G.A. Mertzanos, B. Petropoulos, "Cosmic ray variation of solar origin in relation to human physiological state during the December 2006 solar extreme events ", *Journal of Advances in Space Research, 2008, doi: 10.1016/j.asr.2008.08.0*