



Cosmic ray intensity variations and geomagnetic disturbances on human physiological state of aviators

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Abstract

Over the last few years researches have resulted to the wide acceptance from the scientific community that geomagnetic disturbances and cosmic ray variations are related to the condition of the human physiological state. In this study medical data regarding 4018 Slovak aviators were analyzed in relation to daily variations of geomagnetic activity and cosmic ray intensity. Specifically daily data concerning mean values of heart rate, which were registered during the medical examinations of the Slovak aviators, were related to daily variations of cosmic ray intensity, as measured by the Neutron Monitor Station on Lomnický štít (<http://neutronmonitor.ta3.sk/realtime.php3>) and the high resolution neutron monitor database (<http://www.nmdb.eu>) and daily variations of Dst and Ap geomagnetic indices. This particular study refers to the time period of January 1, 1994 until December 31, 2002. Statistical methods were applied to establish a statistical significance of the effect of geomagnetic activity levels and cosmic ray intensity variations on the aforementioned physiological parameters for the whole group. The Pearson r - coefficients were calculated and the Analysis of Variance (ANOVA) method was applied to establish the statistical significance levels (p -values) of the effect of geomagnetic activity and cosmic ray intensity variations on heart rate up to three days before and three days after the respective events. Results show that there is an underlying effect of geomagnetic activity and cosmic ray intensity variations on the cardiovascular functionality.

Introduction

Geomagnetic activity (GMA) and cosmic ray intensity (CRI) variations can influence not only the performance and reliability of space – borne or ground – based technological systems but also human life. Even though this scientific field concerning the responses of the human organism to CRI variations and GMA is relatively new, many interesting studies have been carried out with remarkable results (Stoupelet et al., 2007, Dimitrova et al., 2009).

Data and Method

The heart rate (HR) measurements refer to a group of 4018 Slovak aviators and were taken during their periodical medical checks at ground level. The group consisted only of men, age from 18 to 60 years, all in good health. Daily mean values of HR (beats/min) in rest (without load) (HRR), HR in 1st degree of load (HRFDL - sitting on a stationary bike and peddling at a power of 50 - 100 Watts), HR in 2nd degree of load (HRSDDL - sitting on a stationary bike and peddling at a power of 100 - 150 Watts), maximum HR achieved by load (HRMAX - sitting on a stationary bike and peddling at maximum power) were registered. The data refer to the time period from January 1, 1994 until December 31, 2002.

Pressure corrected daily data of the hadronic component of the CRI were obtained from Lomnický štít Neutron Monitor (SNM-15) of the Department of Space Physics, Institute of Experimental Physics, Košice, Slovakia. This station is located 2634 m above sea level and detects particles with a cut – off rigidity of 3.84 GV. It has been operational since December 1981 providing high quality data (archive, current data) through the internet in digital form (<http://neutronmonitor.ta3.sk/>).

Geomagnetic index Dst data were obtained from the World Data Centre for Geomagnetism, Kyoto (<http://swdcdwww.kugi.kyoto-u.ac.jp/>). Ap-index data were obtained from Space Weather Prediction Centre at NOAA, Boulder, (http://www.swpc.noaa.gov/fppmenu/indices/old_indices.html). GMA was divided into five levels (I0, I, II, III, IV) according to Dst-index and Ap-index. CR activity was divided into six levels (-3, -2, -1, 0, +1, +2) according to CRI.

Method – Statistical Method of ANOVA

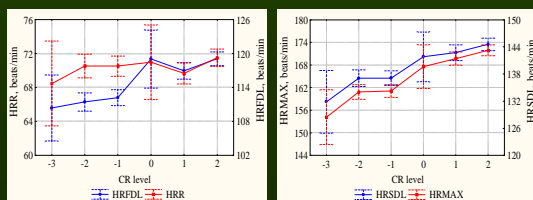
The statistical method the *ANALYSIS OF VARIANCE* (ANOVA), (statistical package STATISTICA (ver.6, StatSoft Inc., 2001), was applied to establish a statistical significance levels (p) of the effect of GMA levels and CRI variations on the HR. The effect of geomagnetic and CRI variations up to three days before and after the respective events (geomagnetic storms' developments and CRI decreases and increases) on the examined parameter HR was also investigated by the help of ANOVA. p – values were calculated for the days before (+), during (0) and after (-) geomagnetic storms and CRI variations.

Correlation coefficients between GMA and CRI parameters and physiological parameters under examination

	Ap	Ap level	Dst	Dst level	CR%	CR% level
HRR	-0.0389 $p = 0.174$	-0.0585* $p = 0.041$	0.0681* $p = 0.017$	-0.0591* $p = 0.039$	0.0325 $p = 0.257$	0.0288 $p = 0.315$
HRFDL	-0.0368 $p = 0.199$	-0.0545 $p = 0.057$	0.0804* $p = 0.005$	-0.0695* $p = 0.015$	0.2480* $p = 0.000$	0.2470* $p = 0.000$
HRSDDL	-0.0665* $p = 0.020$	-0.0732* $p = 0.011$	0.0987* $p = 0.001$	-0.0959* $p = 0.001$	0.2324* $p = 0.000$	0.2343* $p = 0.000$
HRMAX	-0.0637* $p = 0.026$	-0.0568* $p = 0.047$	0.0903* $p = 0.002$	-0.0721* $p = 0.012$	0.3140* $p = 0.000$	0.3245* $p = 0.000$

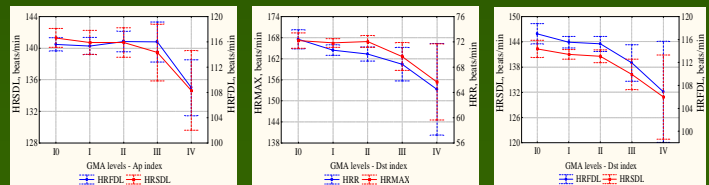
(Results marked with $*$ are statistically significant)

CRI decreases are associated to HR decrease



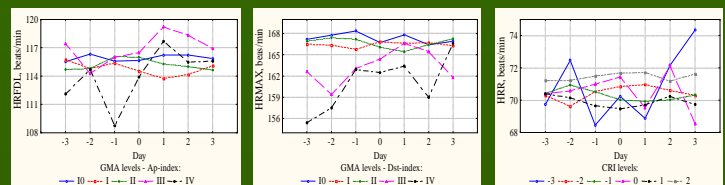
CRI effect, estimated by CRI, on HR measurements. Vertical bars in the figures denote 0.95 confidence intervals.

Higher GMA levels (GMA increase, i.e. Ap - index values increase and Dst - index values decrease) are associated to HR decrease



GMA effect, estimated by Ap- and Dst- index, on HR measurements. Vertical bars in the figures denote 0.95 confidence intervals.

HR parameters vary significantly on the days before, during and after geomagnetic storms with high intensity and large CRI decreases



GMA and CRI effect, estimated by Ap-index, Dst-index and CR decreases on HR before (+), during (0) and after (-) geomagnetic storms and CRI variations.

Conclusions

A series of recent studies prove that solar and geomagnetic conditions may be responsible for a number of responses of the human organism and may be connected to many diseases, mostly cardiovascular diseases and diseases of the nervous system, especially strokes, myocardial infarctions, etc. (Dzvonik et al., 2006, Dimitrova et al., 2009, Papailiou et al., 2009, Stoupelet et al., 2007). This study focuses on the possible relation between GMA and CR activity and human cardiologic parameters. HR variations have been analysed in regard to CRI decreases and Ap- and Dst- indices variations. The most interesting results of this study are :

- ✦ High GMA levels (GMA increase, i.e. Ap-index values increase and Dst-index values decrease) and CRI decrease are associated to HR decrease. HRR, HRFDL, HRSDDL and HRMAX take their minimum value for level IV for Ap-index classification and Dst-index classification as well as for CR level -3 (strongest decreases in CRI).
- ✦ HRR, HRFDL, HRSDDL and HRMAX vary significantly on the days before, during and after increased GMA (levels III and IV according to the Ap-index and Dst-index classification) and CRI decreases (levels -3, -2, -1 according to the CRI classification).
- ✦ HRR, HRFDL, HRSDDL and HRMAX had peak values on the days before (+3, +2, +1), during (0) and after (-1, -2, -3) geomagnetic storms regarding Ap-index classification.
- ✦ Values of HRMAX in relation to levels I0, I and II of the Dst-index classification and levels +1 and +2 of the CRI classification are higher in comparison to the values concerning the rest of the levels. The same effect is, also, observed in HRSDDL and CRI levels 0, +1 and +2.

The most interesting result is that HR variations appear to be connected to geomagnetic disturbances and CRI variations. The effects are more interesting for high levels of GMA (when geomagnetic storms occur) and large CRI decreases. However, because the possible space weather conditions influence on human health is a rather sensitive subject, further research is required.

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