Geo-Effective Heliophysical Variations and Human Physiological State

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A group of 86 volunteers was examined on each working day in autumn 2001 and in spring 2002. These periods were chosen because of maximal expected geomagnetic activity. There were 26 persons in the group on a drug treatment, mainly because of hypertension. Systolic and diastolic blood pressure and heart rate were registered. Pulse pressure was calculated. Data about subjective psycho-physiological complaints of the persons examined were also gathered. Altogether 2799 recordings were obtained and analyzed. MANOVA was employed to check the significance of the influence of three factors on the physiological parameters under consideration. The factors were as follows: 1) geomagnetic activity estimated by H-component of the local geomagnetic field and divided into five levels; 2) gender – males and females; 3) presence of medication. Post hoc analysis was performed to elicit the significance of differences in the factors' levels. The average arterial blood pressure, pulse pressure and the percentage of the persons in the group with subjective psycho-physiological complaints were found to increase significantly with the increase of geomagnetic activity. The maximal increment of systolic and diastolic blood pressure was 10-11% and for pulse pressure 13.6%. Analyses revealed that females and persons on a medication were more sensitive to the increase of geomagnetic activity than respectively males and persons with no medication.

Introduction

A lot of investigations confirm that environmental factors influence essentially on human health, physiological status and self-confidence. A number of scientific papers reveal that cardiovascular, blood vessel, nervous and other functional systems react under geophysical factors changes [1 - 4]. Although there are still contradictions in the field because of the lack of plausible mechanisms clarifying the mechanisms of influence of solar activity (SA) on biological processes on one hand and on the other hand there are some inconsistent results and there are no systematical investigations.

During the last years we have studied the influence of changes in geomagnetic activity (GMA) by using different indices (such as Dst-, Ap-, Kp-indices) on human physiological and psycho-physiological parameters. Here we present results obtained from investigations of influence of changes in the amplitude of horizontal H-component of the local geomagnetic field (GMF) on the arterial blood pressure (ABP), pulse pressure (PP), heart rate (HR) and some subjective psycho-physiological complaints (SPPC).

Materials and Methods

The experiment was performed in Sofia city (Latitude: 42°43' North, Longitude: 23°20' East). Data were obtained in 86 healthy volunteers (33 males and 53 females) with an average age of 47.8±11.9 years. They were healthy persons working at different Institutes of the Bulgarian Academy of Sciences. 26 persons of them were on a drug treatment, which in most instances was hypertensive therapy.

Recording of physiological parameters was performed on every working day from 1 October 2001 to 9 November 2001 and from 8 April 2002 to 28 May 2002. These periods were chosen because of the high probability for geo-effective solar storms during the autumn and spring. Observation periods were in years of maximal SA.

Systolic blood pressure (SBP), diastolic blood pressure (DBP) and HR were measured. PP was calculated (it is algebraic difference between SBP and DBP). ABP was registered by sphygmomanometric method to the single millimetre of Hg. HR was palpatorically measured over arteria radialis as beats per minute and by counting for a full minute.

Data for some subjective psycho-physiological complaints (SPPC) were also collected. Volunteers filled in a questionnaire with three groups of questions: one concerned complaints related to the common functional state (general condition, working ability, sleep disturbances, weakness, absent-mindedness); another concerned cardiovascular system (heart thumping, arrhythmia, tachycardia, extra systoles); and a third concerned nervous system (headache, dizziness, vertigo, nausea).

The same person performed the measurements at one and the same daytime for each volunteer. Altogether 2799 registrations for each of the physiological parameters under consideration were obtained for both periods of examinations.

Volunteers and the person who performed the measurements were blinded to the degree of GMA. Data about local GMF variations were obtained after the periods of examinations from the nearest geomagnetic observatory (Bulgarian Geomagnetic Observatory situated at Panagjurishte, Sofia region).

Three-factor analysis of variance (MANOVA) was applied. Impact of the following factors on the physiological parameters under consideration was studied: 1) GMA, which was divided into 5 levels; 2) gender – persons were divided into males and females; 3) medication – persons were divided into persons taking medicaments and persons not taking medicaments.

Post-hoc analysis (Neman-Keuls test) was also used to establish the statistical significance of the differences between the average values of the measured physiological parameters in the separate factors levels.

GMA was divided into 5 levels according to the amplitude (difference between maximal and minimal value) of H-component of local GMF.

The respective values and the corresponding names for the five levels are presented in Table I. The number of the days when the corresponding GMA levels were realized during examination periods is also shown in Table I.

Fig. 1 shows daily amplitude of H-component of local GMF during both periods when examinations were performed.

TABLE 1

GMA Levels

GMA level	1 calm GMA	2 weak storm	3 moderate storm	4 major storm	5 severe storm
H, nT	H<70	70÷120	120÷200	200÷320	H≥320
Days	62	18	8	2	1

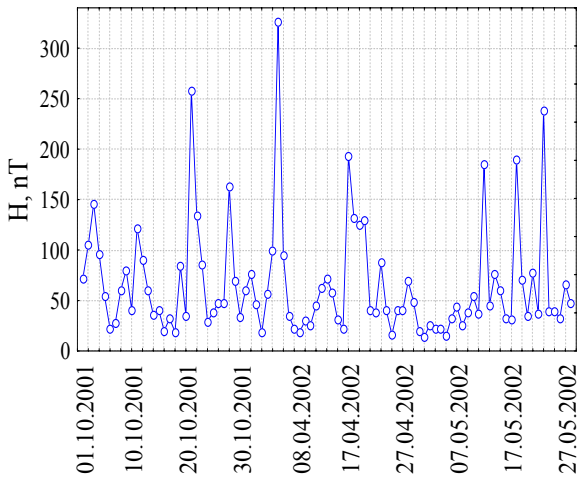

Fig. 1. Local (H, nT) GMA variations during examination periods.

Results

Three-factor analysis of variance was performed to investigate the influence of the local GMA on the whole group as well as on both genders and on the persons taking and persons not taking medicaments. Influence of some of the factors and interaction effects for the factors on the physiological parameters examined turned out to be statistically significant at $p<0.05$ and others revealed a trend to influence at $p<0.1$.

Table 2 shows significance levels *p* of main effect and interaction effect for the factors investigated on the physiological parameters. It is seen that the main effect for local GMA (H-component of local GMF) on SBP, DBP, PP and SPPC was statistically significant. Main effect for the factor gender was statistically significant for all of the physiological parameters examined, i.e. males' and females' values were significantly different in principle. It also concerned the factor medication except its influence on SPPC. It is seen from Table 2 that there was a statistically significant influence of the interaction effect for the factors GMA and medication on PP. It means that PP of the persons taking medicaments reacted in a significantly different way at GMA increase in comparison with PP of the persons not taking medicaments.

TABLE 2

MANOVA table for significance levels of the main effect and interaction effects for the factors investigated (Local GMA, Gender, Medication) on the physiological parameters examined

Effect (main and interaction effect for the factors)	*p*				
	SBP	DBP	PP	HR	SPPC
GMA	0.000*	0.000*	0.001*	0.338	0.000*
Gender	0.000*	0.000*	0.004*	0.002*	0.000*
Medication	0.000*	0.000*	0.000*	0.000*	0.348
Gender*Med.	0.961	0.199	0.104	0.865	0.138
GMA*Gender	0.8	0.772	0.735	0.647	0.274
GMA*Med.	0.367	0.995	0.036*	0.947	0.153
GMA*Gender*Med	0.859	0.866	0.9	0.945	0.093

Main effect for local GMA on SBP, DBP, PP and SPPC was statistically significant (Table 2). Average values of SBP and DBP of the group increased at local GMA increment (Fig. 2). Maximal increase was significant – for SBP 11.2% and for DBP 10.2%. Post hoc analysis revealed that ABP increased significantly at severe local geomagnetic storms and DBP still at weak local storms. In addition a significant increase of PP at severe storms was also established and this change reached 13.6% (Fig. 3). Percentage of the persons in the group with SPPC increased in a similar way as ABP at local GMA increment and during severe local geomagnetic storms reached a significant increase and almost 1/3 of the persons examined reported SPPC (Fig. 4). Significant change in HR of the group examined under local GMA variations was not established. The largest changes in HR were 2.2% (Fig. 3).

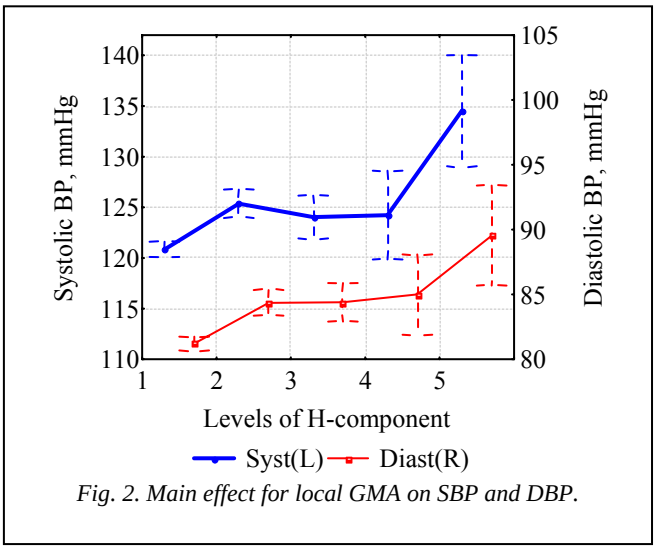

Fig. 2. Main effect for local GMA on SBP and DBP.

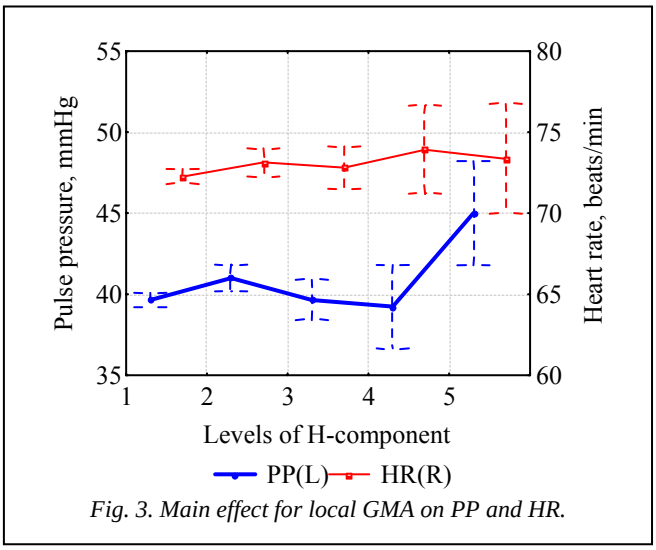

Fig. 3. Main effect for local GMA on PP and HR.

Although the interaction effect for factors GMA and gender on the physiological parameters examined was not significant (Table 2), it was established by Post hoc analysis that females' physiological parameters were more sensitive under GMF intensity increase than males' parameters. Both genders increased significantly ABP during severe geomagnetic storms but the most expressed reaction was for females' SBP. In addition a significant increase only for females' PP was

established at severe storms and it should be noted that this change reached 21.6% (Fig. 5). Only percentage of females with SPPC increased significantly under these conditions and covered almost half of them (Fig. 6).

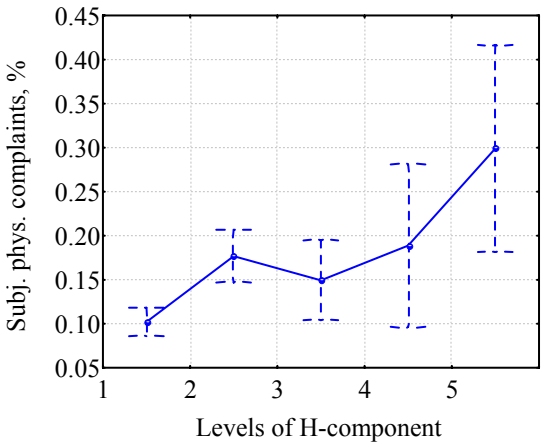

Fig. 4. Main effect for local GMA on SPPC.

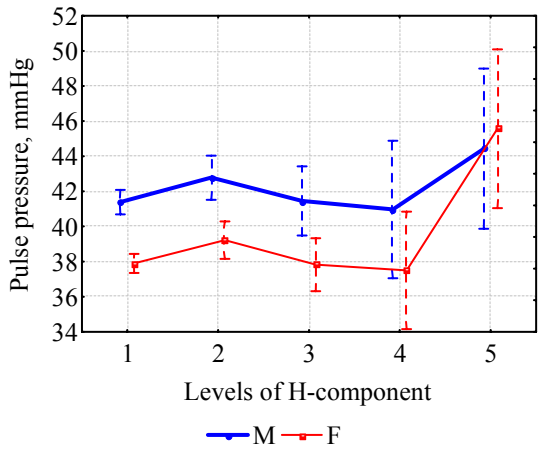

Fig. 5. Two-way interaction effect for factors local GMA and gender on PP.

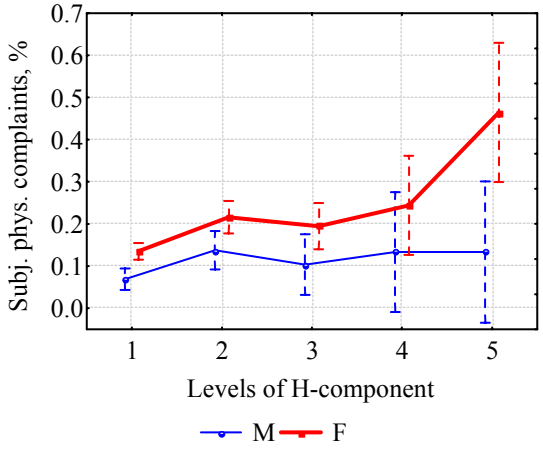

Fig. 6. Two-way interaction effect for factors local GMA and gender on SPPC.

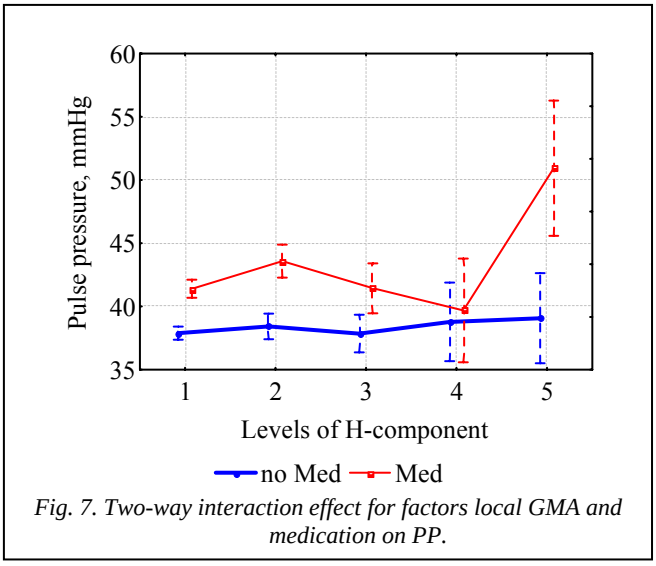

Fig. 7. Two-way interaction effect for factors local GMA and medication on PP.

Interaction for factors GMA and medication influenced significantly only on PP (Table II, Fig. 7) and the results revealed that PP only for the persons on a medication increased significantly during severe storms and variation reached 28.2%. It was established that both subgroups increased significantly ABP at severe storms but the most expressed reaction was for SBP of the persons taking medicaments. Almost 1/3 from both subgroups reported SPPC during severe storms.

Post hoc analyses for three-way interaction effects for the factors investigated supported the hypothesis that physiological parameters of the persons on a medication (both males and females) were more sensitive under local GMA changes – they increased significantly SBP and PP at severe local storms. However regarding psycho-physiological reaction it concerned females not taking medicaments.

Conclusions and Discussion

ABP of the group examined increased with GMA increase. The fact that the increment of SBP and DBP reached 10-11% deserves attention from a medical point of view. PP also increased significantly during severe storms and the change reached 13.6%. Besides it the percentage of the persons in the group with SPPC also increased and almost 1/3 from the persons examined reported SPPC during severe storms.

It was obtained that probably females' physiological parameters were more sensitive to GMA variations than males'. Both genders increased significantly ABP during severe local geomagnetic storms but the most expressed reaction was for females' SBP. In addition a significant increase for PP (21.6%) and SPPC (46.5%) at severe storms was revealed only for females.

Analyses performed revealed that persons on a medication were probably more sensitive to GMA changes than persons with no medication. Both subgroups increased significantly ABP during severe storms but the most expressed reaction was for SBP of the persons on a medication. This subgroup also increased PP under these conditions (28.2%).

Post hoc analyses for the three-factor interactions confirmed that physiological parameters of the persons taking medicaments were more sensitive under local GMA changes since they increased significantly SBP and PP during severe local geomagnetic storms.

Influence of some meteorological elements (atmospheric pressure, air temperature, relative humidity) on the physiological parameters examined was investigated too. Influence of some of meteorological elements turned out to be statistically significant but the changes of the physiological parameters were not as biologically significant as they were under GMA influence [5]. It is consistent with the results obtained by other authors [1, 6, 7].

The results obtained prove the necessity and usefulness to study helio-biological interactions. It would help for timely applying a prophylactic measures (pharmacological, regime, preventive) to avert unfavorable physiological reactions of sensitive and unstable persons. In general the relationship between SA and human physiological and psychological state needs still more significant endeavors and deserves attention as a possibility to aid the struggle for a better health.

Acknowledgment

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