

Geomagnetic Indices Variations and Human Physiology

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Abstract. A group of 86 volunteers was examined on each working day in autumn 2001 and in spring 2002. Systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were registered. Pulse pressure (PP) was calculated. Data about subjective psycho-physiological complaints (SPPC) were also gathered. Altogether 2799 recordings were obtained. ANOVA was employed to check the significance of influence of daily amplitude of H-component of local geomagnetic field, daily planetary Ap-index and hourly planetary Dst-index on the physiological parameters examined. *Post hoc* analysis was performed to elicit the significance of differences in the factors' levels. Average values of SBP, DBP, PP and SPPC of the group were found to increase statistically significantly and biologically considerably with the increase of geomagnetic indices.

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Introduction

The relationship between geophysical factors and physiological and psychological state was treated in Persinger's review [1] where more than 95 western authors were considered and in Zhadin's review [2] where the results of investigations of about 170 Russian scientists who have been working in the field during the last 20-30 years were generalized. Although of these evidence there are still contradictions and skepticism in the field. There are not convincing influence mechanisms and additionally there are investigations which do not establish relationship between geomagnetic activity (GMA) and human health [3, 4]. That is why some scientists have doubts about relation between geomagnetic disturbances and human functional state. At the same time it is rightly pointed out that anthropogenic electromagnetic fields (EMF) often exceed the intensity of the severe geomagnetic storms. Why do not they influence and the weak geomagnetic field (GMF) variations influence human physiology? That is a reasonable argument as well as it is a truth that the influence of artificial EMF is also not studied. It is supposed that the natural EMF has information and not energetic influence on biological systems. It means that the answer should be sought in EMF parameters, which can have the strongest effect on biosystems (frequency, velocity variation and other spectral characteristics), in the level this influence carries into effect (molecular, cellular or organismal), in the critical thresholds of EMF influence according to different conditions (ill or healthy organism) and in the nature of EMF influence (chemical, receptor, etc.).

Having in mind inconsistent results in the field of medico-biological effects of solar activity (SA) and our preliminary observations and results we performed planned experiment to establish whether GMA changes influence on human physiological and psycho-physiological status.

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. Recording of physiological parameters was performed on every working day during the autumn and spring in years of maximal SA (from 1 October 2001 to 9 November 2001 and from 8 April 2002 to 28 May 2002).

Systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured. Pulse pressure (PP) was calculated (PP is algebraic difference between SBP and DBP). Arterial blood pressure (ABP) was registered by sphygmomanometric method to the single millimeter of Hg because of the required accuracy for such investigations. 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 the third concerned nervous system (headache, dizziness, vertigo, nausea).

The same person performed the measurements at one and the same daytime for each person. In this way the subjective error in result of different ear threshold when two persons perform measurements and daily variations of ABP were avoided.

Registrations were performed at the offices of the individuals. It assumed that the examined persons were under similar conditions during each of the measurements. If the examined persons reported some personal troubles and respectively their physiological parameters changed as a result of these, their

measurements were not considered. When different from regular values for some person were observed without an objective reason, then multiple measurements for that person were made within half an hour and they were averaged. Excluding individuals' registrations out of the norm related to known factors (on the personal information basis) and performing every day measurements of a large group of persons for a long period of time under the same conditions and during the same time decrease to a certain extent the error related to the social life environment. Some of the examined persons could not be found daily at the appointed time and then they were left out of data for the relevant day. 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 (GMOP), Sofia region). Data about planetary GMA (Kp-, Ap- and Dst-indices) were got from Internet (World Data Center for Geomagnetism, Kyoto).

GMA was divided into five levels according to the accepted limits for local [5] and planetary GMA [<http://www.stil.bas.bg>; <http://www oulu.fi/~spaceweb/textbook/>]. The five levels of the three GMA indices are presented in Tables 1 – 3. Tables 1 and 2 show also the number of days during examination periods when the respective GMA levels were realized. Table 3 shows the number of physiological parameters' measurements for the five Dst-index levels since it is an hourly and not daily planetary geomagnetic index.

TABLE 1

Levels of H-component of local GMF

H level	1	2	3	4	5
H, nT	H<70	70≤H<120	120≤H<200	200≤H<320	H≥320
Days	62	18	8	2	1

TABLE 2

Ap-index levels

Ap level	1	2	3	4	5
Ap value	Ap<15	15≤Ap<30	30≤Ap<50	50≤Ap<100	Ap≥100
Days	61	16	4	9	1

TABLE 3

Dst-index levels

Dst level	1	2	3	4	5
Dst, nT	Dst>-20	-50<Dst≤-20	-100<Dst≤-50	-150<Dst≤-100	Dst≤-150
Meas.	1819	544	290	104	42

ANOVA (*analysis of variance*) method was performed to establish statistical significance of the influence of GMA indices on the physiological parameters of the group examined. A *Post-hoc* analysis (*Newman-Keuls test*) was also used to establish statistical

significance of the differences between the average values of the measured physiological parameters at the separate factors levels.

Results

Significance levels p obtained from ANOVAs performed for the influence of geomagnetic indices on the physiological parameters are presented in Table 4.

TABLE 4

Significance level of geomagnetic factors influence on the physiological parameters under ANOVA analyses

Factor	p				
	SBP	DBP	PP	HR	SPPC
H	0.000*	0.000*	0.004*	0.601	0.000*
Ap	0.000*	0.000*	0.054	0.811	0.000*
Dst	0.000*	0.000*	0.003*	0.719	—

Table 4 shows that significant influence was established for all GMA indices under consideration on SBP and DBP. Local GMA and Dst-index influenced significantly also on PP and there was a trend for influence of planetary GMA estimated by Ap-index on this physiological parameter. It was not obtained a significant change in HR under influence of geomagnetic factors. SPPC were significantly influenced from both local and planetary GMA, estimated by Ap-index. The influence of Dst-index on SPPC was not examined since it is an hourly geomagnetic index and SPPC were reported for the day.

The following changes in the physiological parameters were established at the detailed results' analyzing.

1. Influence of local GMA (daily amplitude of H-component of local GMF)

Fig. 1a shows the mean values of SBP and DBP of the group examined under changes of local GMA level, which influenced statistically significantly SBP and DBP as it was mentioned above (Table 4). Confidential intervals at 95% confidence probability of the mean values of SBP and DBP for the different GMA levels are also shown in the figure. It is seen that SBP and DBP increased at 2nd GMA level (weak local geomagnetic storms), kept almost the same values at 3rd and 4th level (moderate and major storms) and sharply increased at 5th level (severe storms). The maximal range of changes (from 1st to 5th level) for SBP was 11% and for DBP 10.9%. *Post hoc* analysis applied revealed that SBP and DBP increased significantly at 5th local GMA level in comparison to all of the other levels and DBP increased significantly also at 4th level compared to 1st level. These results show that ABP increased with the increase of local GMF intensity and ABP was statistically significantly higher during severe geomagnetic storms ($H\geq 320\text{nT}$) in comparison with the other local GMA levels ($H<320\text{nT}$). DBP increased significantly still at major local geomagnetic storms ($H\geq 200\text{nT}$) in comparison to the values at $H<70\text{nT}$.

Variations of PP and HR under local GMA changes are presented in Fig. 1b. PP was statistically significantly influenced and HR was not significantly influenced

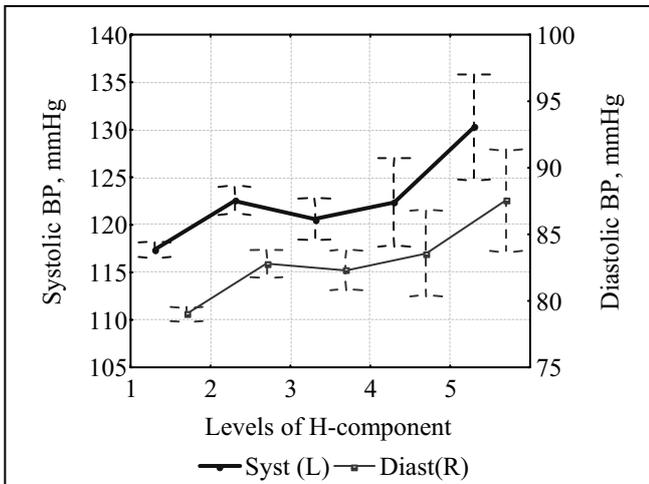


Fig. 1a. Influence of H-component on SBP and DBP.

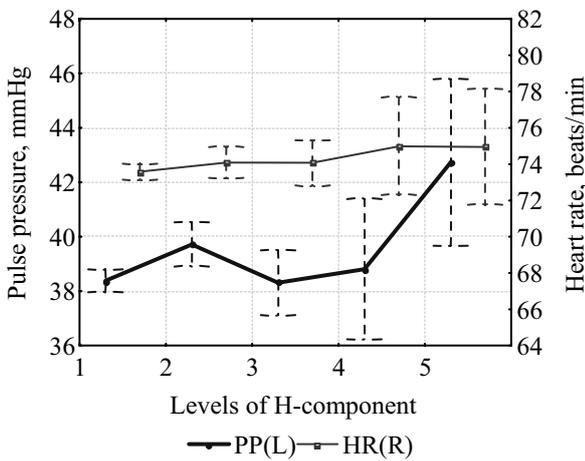


Fig. 1b. Influence of H-component on PP and HR.

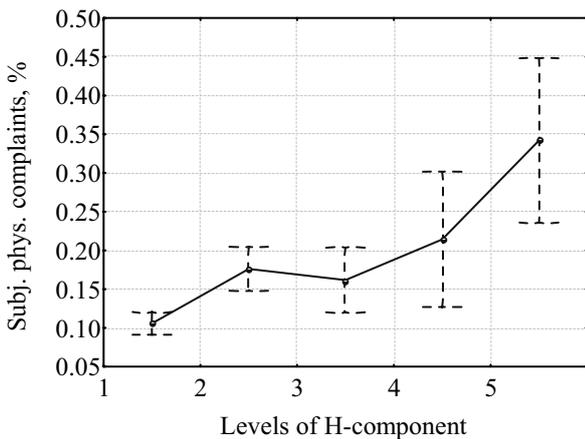


Fig. 1c. Influence of H-component on SPPC.

(Table 4). It is noticed that PP also increased expressively at severe geomagnetic storms and the maximal range of changes was 11.5%. It was established by *Post hoc* analysis that PP was statistically significantly higher at severe storms than PP at H<320nT. It is observed in the

figure an increase of HR at local GMF intensity increment but the range of changes was only 1.9% and these changes were not significant (Table 4).

Fig. 1c shows the influence of local GMA on the percentage of the persons in the group examined with SPPC, which was statistically significant (Table 4). It is seen that the percentage investigated increased with the growth of local GMA intensity and during severe geomagnetic storms more than 1/3 of the examined persons reported SPPC. *Post hoc* analysis revealed that then percentage significantly differed from the percentage of the persons with complaints at H<320nT.

2. Ap-index influence

Ap-index influenced statistically significantly on ABP and SPPC and there was a trend to influence on PP (Table 4). Physiological parameters examined increased significantly with the planetary GMA increment, assessed by Ap-index. Maximal range of changes of ABP (Fig. 2) and PP in this case was also about 11% as it was for local GMA. Percentage of the persons with SPPC during severe storms covered also more than 1/3 from the examined persons. ABP, PP and percentage of the persons with complaints, increased significantly at severe storms in comparison to the other planetary GMA levels as it was for local GMA. However it was observed that percentage of the persons with complaints at moderate storms was significantly larger than the percentage at major planetary storms and Ap<15.

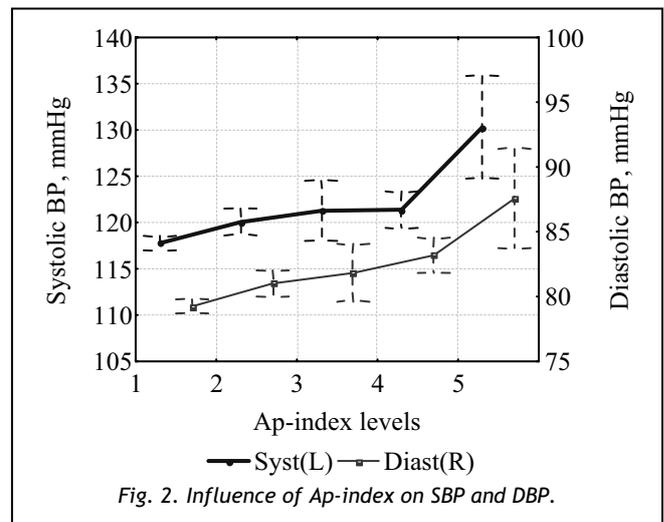


Fig. 2. Influence of Ap-index on SBP and DBP.

3. Dst-index influence

Dst-index influence on ABP and PP was statistically significant (Table 4). The changes of SBP and DBP under Dst-index variations are shown in Fig. 3. Dst-index values decrease was related to an increase of physiological parameters and the range of changes of ABP and PP in this case was again about 11%. ABP and PP were again significantly increased during severe storms in comparison to the other planetary geomagnetic levels estimated by Dst-index but there was significant increase of ABP still at moderate storms (Dst≤-50nT) in comparison with ABP values at Dst>-20nT.

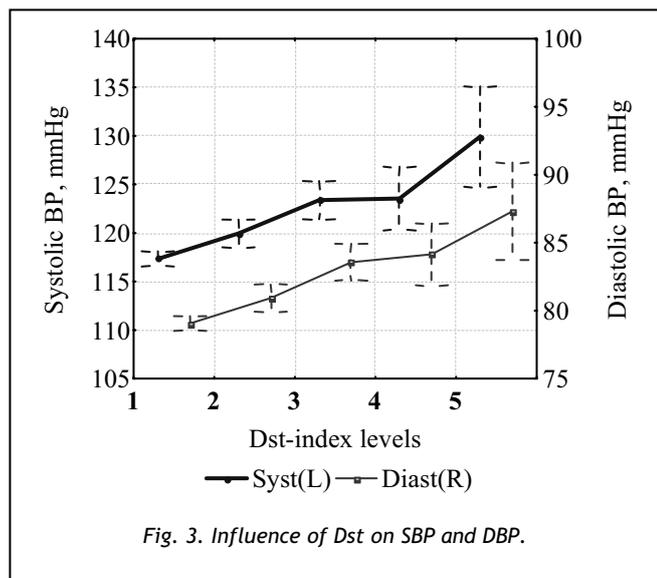


Fig. 3. Influence of Dst on SBP and DBP.

Discussion of the Results

The results exposed reveal that for such investigations at our latitudes planetary geomagnetic indices can also be used. It was obtained that the influence of all geomagnetic indices under consideration was related with increase of ABP and PP up to 11% as well as 34% from the examined persons reported SPPC during severe geomagnetic storms.

These results showed a higher sensitivity of ABP to Dst-index variations – there were significant changes in ABP still at moderate geomagnetic storms according to Dst data while in respect to daily local and planetary GMA, ABP reacted significantly at severe geomagnetic storms and DBP also at major local storms.

It was obtained a significant increase for PP at severe storms according to all of geomagnetic indices investigated.

SPPC increased significantly during severe local and planetary geomagnetic storms as well as during moderate planetary storms.

Results presented were obtained by using contemporary statistical methods and on the basis of planned experiment with a sizable database. The measurement of each person at one and the same daytime as well as collecting a large number of data for each of the physiological parameters – a large group of persons within several months at which it is most probable geomagnetic storms to be developed (autumn and fall of years of maximal solar activity) increase reliability of the results obtained. That is a period shortly enough by one hand lasting physiological changes to occur (in a sense of aging, pathological) and on the other hand it is a large enough period a significant database with a large number of registrations to be obtained. That is why the results obtained are reliable and they enhance the importance of other similar investigations which are retrospective – analyzing of average values of ABP and HR of persons for a period of several years or of different group persons [6, 7]. They indicate that GMA increase influence on physiological processes adjusting. There are different external and

individual factors which can influence on ABP but in a case of investigation of a large number everyday registrations of a large group of persons and when statistically significant variations in ABP are obtained, which coincide with the changes in a definite external factor, then it can be assumed that this factor has a prevailing role for the variations in ABP.

Changes in ABP can be regarded as a kind of organism compensatory reaction as a consequence of GMA increase. However SPPC increment reveals that although of the attempts to compensate, a functional deficit of separate systems starts and it is shown in different subjective complaints. The increase of ABP and PP with 10-11% in combination with SPPC covering about 30% from the examined persons are facts which not only should be neglected but deserve attention from a medical point of view and enhance biological, clinical and social importance of the influences examined.

The results obtained from the investigations performed are one more proof that human physiological status could be influenced by solar variations and related to them geomagnetic changes. They indicate that persons, without considering their health condition, could be sensitive to geomagnetic variations and their self-confidence, working ability and health status could be attacked. That problem is of a great importance for the sick and old persons, emotionally and physically unstable, physically overloaded and persons under stress. Influence of geophysical factors on emotional status and working ability of the healthy persons gives a social-economical importance of the problem. Surely more investigations are needed to precise those geomagnetic factors features which most strongly and permanently correlate with human physiology and pathology parameters.

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