

## INVESTIGATION OF HUMAN SENSITIVITY TOWARDS GEOMAGNETIC CHANGES

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**Key words:** *physiological parameters; solar activity; geomagnetic field*

**Abstract:** *Arterial blood pressure and heart rate of healthy volunteers in Sofia and cardiologic patients with anti-hypertension therapy in Moscow were examined. MANOVA was applied to check the significance of the effect of geomagnetic activity indices on the physiological parameters. Arterial blood pressure and pulse pressure were found to increase statistically significantly with the increase of geomagnetic activity level for the healthy patients. It was obtained significant increment of arterial blood pressure and heart rate for patients with cardio-vascular diseases. The results revealed a higher sensitivity to geomagnetic activity for females than males in both groups examined.*

### Introduction

Our teams have been studying medico-biological effects of solar activity during the last years. Our investigations revealed influence of geomagnetic activity (GMA) on human physiological and psycho-physiological state (Dimitrova et al., 2004; Breus and Rapoport, 2003). It was the reason to join our efforts and perform similar examinations at different latitudes and geographical regions. Results presented in that paper were obtained from a collaborative study between Solar-Terrestrial Influences Laboratory at the Bulgarian Academy of Sciences and Space Research Institute at the Russian Academy of Sciences.

### Material and methods

Data were obtained in 86 healthy volunteers examined in Sofia. Systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured. Pulse pressure (PP) was calculated (it is the algebraic difference of SBP and DBP). Recording of physiological parameters was performed on every working in the autumn of 2001 and in the spring of 2002 at one and the same day time for each person. Altogether 2799 registrations for each of the physiological parameters examined were gathered.

Analogical data were obtained in 33 patients with diagnose hypertension through 3-months arterial blood pressure (ABP) and HR monitoring in Cardiologic Clinic in Moscow during the period 2001-2003. Altogether 5694 registrations were collected. Patients were on a medication treatment. Registrations were performed twice per a day in series of several measurements in the morning and in the evening (interval between the measurements in each of the series was several minutes). The average values of ABP and HR were calculated for each measurement series.

Data about GMA (Ap-index and hourly Dst-index) were got from Internet (<http://swdcdb.kugi.kyoto-u.ac.jp/>). GMA was divided into five levels, which are shown in Table 1 and 2.

MANOVA (in the paper presented two-factorial analyses of variance) was performed to establish statistical significance of the influence of GMA indices on ABP and HR having in mind the gender of the persons in the groups examined.

**Table 1.** *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

**Table 2.** *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

## Results

### 1. MANOVA (two-factorial analysis of variance) for healthy persons examined in Sofia.

#### 1. 1. Factors hourly Dst-index and gender

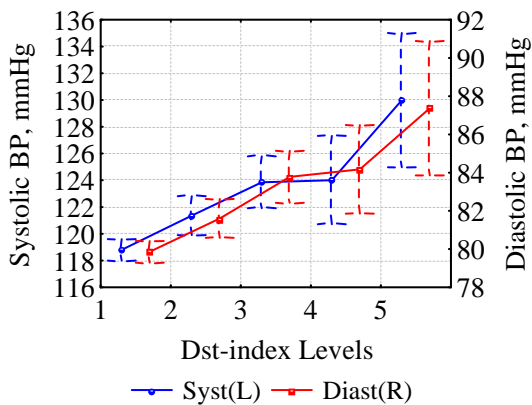
Table 3 shows significance levels  $p$  of main effect and interaction effect for the factors investigated (hourly Dst-index and gender) on the physiological parameters (SBP, DBP, PP and HR) of healthy persons examined in Sofia.

**Table 3.** Significance levels ( $p$ -values) of the main effect and interaction effect for the factors investigated (Gender and GMA, estimated by hourly Dst-index) on the physiological parameters of healthy persons registered in Sofia

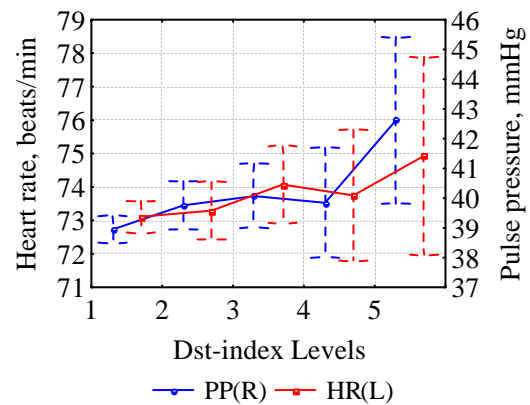
Effect (main and interaction effect for the factors)	$p$			
	SBP	DBP	PP	HR
Dst	0.000*	0.000*	0.024*	0.440
Gender	0.000*	0.001*	0.000*	0.001*
Dst*Gender	0.079	0.117	0.296	0.896

\* - statistically significant result

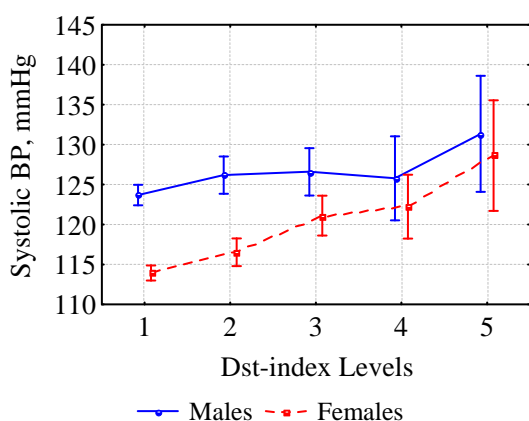
The main effect for Dst-index on SBP, DBP and PP was statistically significant (Table 3). The average value of ABP of the group increased with the decrease of Dst-index values (Fig. 1). The maximal growth for both SBP and DBP was 9.4%. PP also increased (Fig. 2) and the increment was 9.5%. HR of the group increased too (Fig. 2) but the values was not statistically significant (Table 3). The maximal range of changes of that physiological parameter for the group was only 2.5% (Fig. 2).



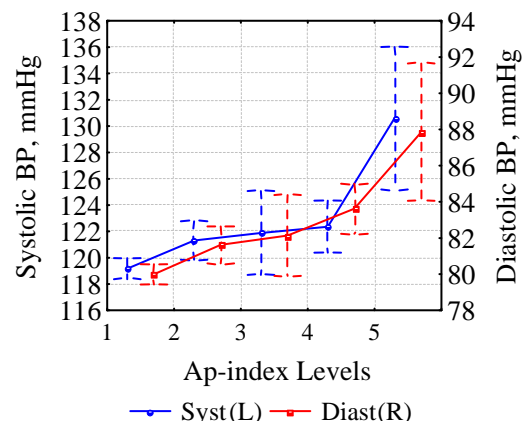
**Fig. 1.** Main effect for factor Dst-index on SBP and DBP



**Fig. 2.** Main effect for factor Dst-index on PP and HR



**Fig. 3.** Two-way interaction effect for factors Dst-index and gender on SBP



**Fig. 4.** Main effect for factor Ap-index on SBP and DBP

Two-way interaction effect for factors Dst-index and gender revealed a trend SBP and DBP of males and females to react in a different way at GMA increment (Table 3). It was established that females' SBP reacted more expressively to GMA increase than male's SBP. Females' SBP increased with 12.9% while male's SBP with 6.2% (Fig. 3). For DBP the respective values were 11.3% and 7.6%, for PP 16.3% and 3.3% and for HR 0.6% and 4.5%.

## 1. 2. Factors Ap-index and gender

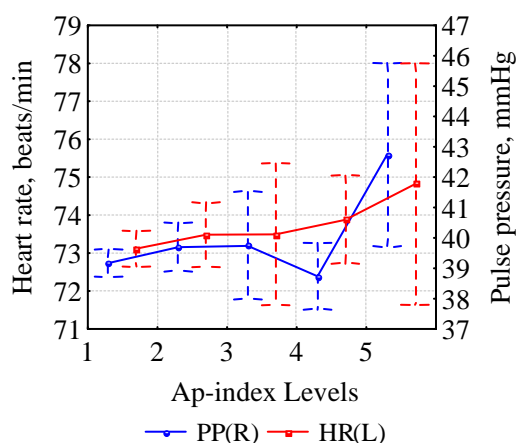
Table 4 shows significance levels  $p$  of main effect and interaction effect for the factors investigated (Ap-index and gender) on the physiological parameters (SBP, DBP, PP and HR) of healthy persons examined in Sofia.

**Table 4.** Significance levels ( $p$ -values) of the main effect and interaction effect for the factors investigated (Gender and GMA, estimated by Ap-index) on the physiological parameters of healthy persons registered in Sofia

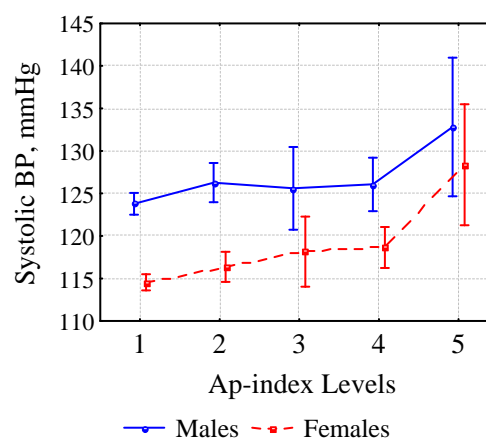
Effect (main and interaction effect for the factors)	$p$			
	SBP	DBP	PP	HR
Ap	0.000	0.000	0.112	0.623
Gender	0.000	0.000	0.000	0.000
Ap*Gender	0.738	0.845	0.555	0.911

\* - statistically significant result

The main effect for factor Ap-index on SBP and DBP of the group was statistically significant (Table 4). ABP of the group increased with the increment of GMA and the sharpest increase was during severe geomagnetic storms (Fig. 4). The maximal growth for SBP was 9.6% and for DBP 9.8%. PP increased with 9.1% at 5<sup>th</sup> GMA level in comparison with 1<sup>st</sup> GMA level (Fig. 5). Statistically significant change in HR of the group examined was not established under planetary GMA changes. HR increased with GMA increment but the largest variations of HR were only 2.3% (Fig. 5).



**Fig. 5.** Main effect for factor Ap-index on PP and HR



**Fig. 6.** Two-way interaction effect for factors Ap-index and gender on SBP

Although two-way interaction effect for factors Ap-index and gender on the physiological parameters was not statistically significant (Table 4), it was established that females were probably more sensitive to GMA increment in comparison to males. Females increased SBP with 12.1% (Fig. 6), DBP with 10.7% and PP with 14.8% while males respectively with 7.3%, 9% and 3.9%.

## 2. MANOVA (two-factorial analysis of variance) for cardiologic patients examined in Moscow

### 2. 1. Factors hourly Dst-index and gender

Table 5 shows significance levels  $p$  of main effect and interaction effect for the factors investigated (Dst-index and gender) on the physiological parameters (SBP, DBP, PP and HR) of persons with hypertension examined in Moscow.

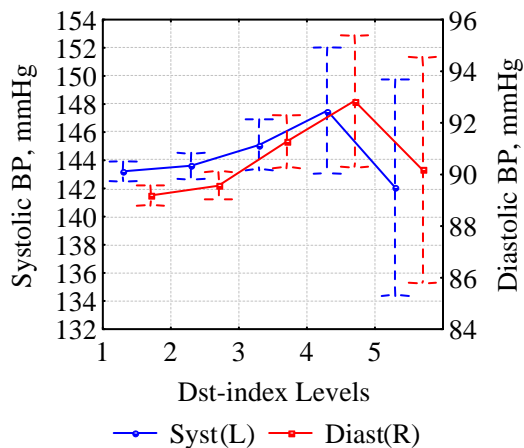
The main effect for Dst-index was statistically significant only on DBP (Table 5). The mean value of ABP of the group increased with the decrease of Dst-index values up to 4<sup>th</sup> GMA level. At 5<sup>th</sup> GMA level ABP decreased. The maximal increment for SBP was 3% and for DBP 4% (Fig. 7). PP of cardiologic patients decreased and the maximal range of changes was 5.4% (Fig. 8). HR was not statistically significantly changed (Table 5) however patients with hypertension increased that physiological parameter during severe geomagnetic storms and in comparison with 1<sup>st</sup> GMA level the increment was 4.7% (Fig. 8).

**Table 5.** Significance levels ( $p$ -values) of the main effect and interaction effect for the factors investigated (Gender and GMA, estimated by hourly Dst-index) on the physiological parameters of cardiologic patients recorded in Moscow

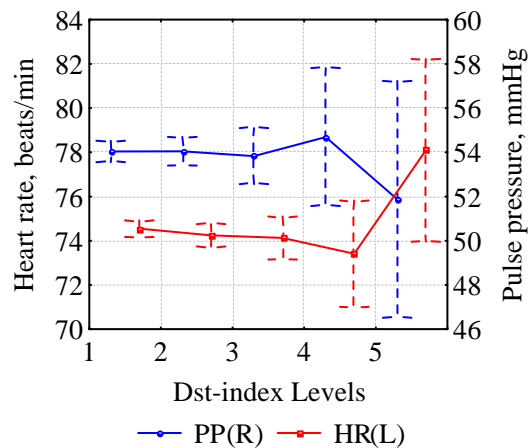
Effect (main and interaction effect for the factors)	$p$			
	SBP	DBP	PP	HR
Dst	0.143	0.000	0.926	0.292
Gender	0.000	0.001	0.000	0.001
Dst*Gender	0.000	0.000	0.042*	0.003

\* - statistically significant result

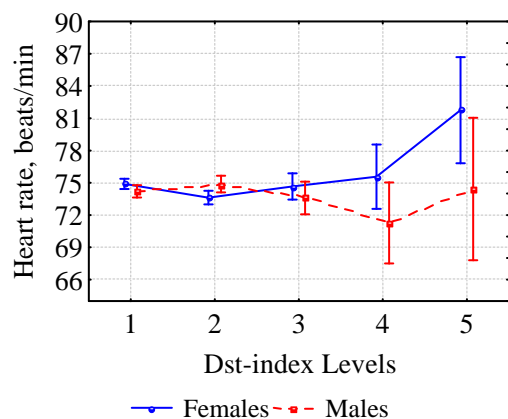
Two-way interaction effect for factors Dst-index and gender revealed statistically significant influence on all of the physiological parameters examined (Table 5). It suggests that males and females reacted in a different way to geomagnetic changes. It was established that females were probably more sensitive at GMA increase than males. The maximal range of changes for females' SBP was 5% while for male's SBP 2.8%. For DBP the respective values were 7.3% and 2.6%. There was a distinguished increment of HR for females at severe geomagnetic storms with 11.1% (Fig. 9).



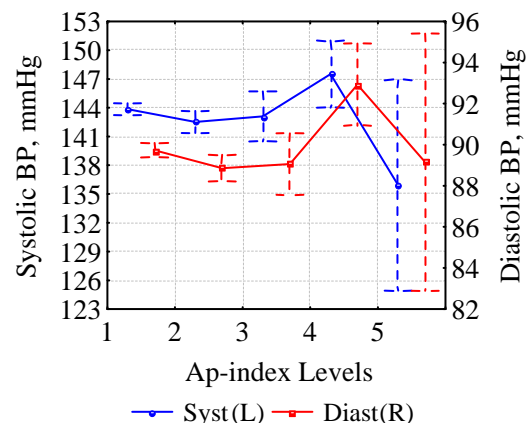
**Fig. 7.** Main effect for factor Dst-index on SBP and DBP



**Fig. 8.** Main effect for factor Dst-index on PP and HR



**Fig. 9.** Two-way interaction effect for factors Dst-index and gender on HR



**Fig. 10.** Main effect for factor Ap-index on SBP and DBP

## 2. 2. Factors Ap-index and gender

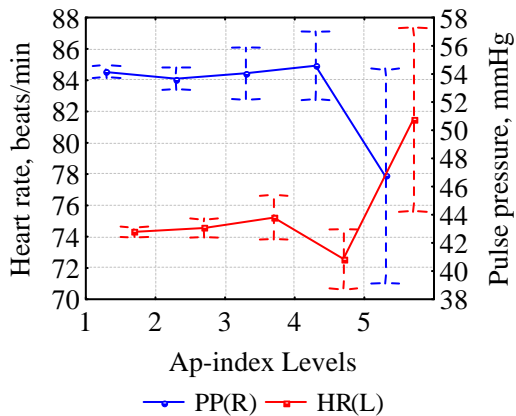
Table 6 shows significance levels  $p$  of main effect and interaction effect for the factors investigated (Ap-index and gender) on the physiological parameters (SBP, DBP, PP and HR) of persons with hypertension examined in Moscow.

**Table 6.** Significance levels ( $p$ -values) of the main effect and interaction effect for the factors investigated (Gender and GMA, estimated by Ap-index) on the physiological parameters of cardiologic patients recorded in Moscow

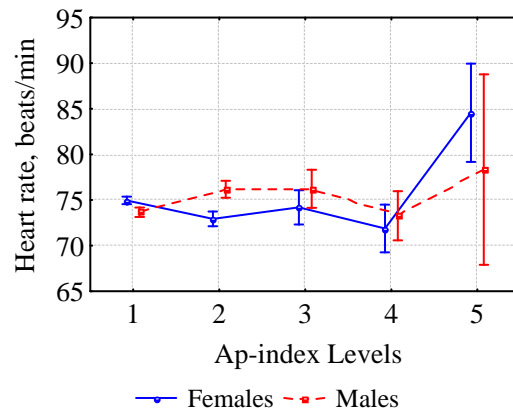
Effect (main and interaction effect for the factors)	$p$			
	SBP	DBP	PP	HR
Ap	0.028*	0.002*	0.316	0.027*
Gender	0.212	0.046*	0.873	0.893
Ap*Gender	0.000*	0.000*	0.000*	0.000*

\* - statistically significant result

The main effect for factor Ap-index on SBP, DBP and HR of the group was statistically significant (Table 6). The sharpest increase of ABP was during major geomagnetic storms (Fig. 10). The maximal growth for SBP was 2.5% and for DBP 3.6%. PP decreased with 17% at 5<sup>th</sup> GMA level (Fig. 11). HR of the persons with hypertension increased at 5<sup>th</sup> GMA level in comparison with 1<sup>st</sup> GMA level with 9.7% (Fig. 11).



**Fig. 11.** Main effect for factor Ap-index on PP and HR



**Fig. 12.** Two-way interaction effect for factors Ap-index and gender on HR

Two-way interaction effect for factors Ap-index and gender on the physiological parameters of cardiologic patients was statistically significant (Table 6). The maximal range of variations for females' DBP was 7.4% and for male's DBP 5%. For SBP the respective values were 6.7% and 19.5% and for HR respectively 12.8% and 6.2% (Fig. 12).

### Discussion and conclusion

We have tried to compare the results about investigation of geomagnetic changes influence on physiological state of healthy persons and patients with anti-hypertension therapy having in mind gender.

ABP and PP were found to increase statistically significantly with the increase of GMA level for the healthy patients.

It was obtained significant increment of ABP and HR for cardiologic patients but in some cases at the largest geomagnetic field changes the reaction of ABP increment was not manifested in that way. HR changes confirm the setting in a misbalance in vegetative effect on cardiac activity and a higher sensitivity is observed for the part of simpaticus system (Breus and Rapoport, 2003).

Analyzing the results obtained we have in mind that each extreme influence which exceeds the threshold of physiological adaptation causes pressure in physiological reactions up to stress. Thus the stress may be a physiological network that helps for coordination of the dynamic equilibrium of the organism (Stratakis and Chrousos, 1995). The threshold for involving a stress-reaction for healthy persons is significantly higher while for persons with pathologic deviations is significantly reduced and a tear down of adaptation mechanisms is set in (Vediaev and Vorobiova, 1983). It is quite possible that this is the explanation of the decrease observed in ABP at 5<sup>th</sup> GMA level. It can be due also to the small number of measurements at that level or the persons examined had already lost their abilities to react adequately to the increased environmental requirements.

The more expressed reactions of females' physiological parameters in comparison with males' to GMA increase revealed a higher sensitivity for females in both groups examined. It is known that females are more emotionally dependent which is often presented through more distinguished and faster reaction to external irritating factors. However males' reaction although in a lower degree often is kept for a longer period of time (Dimitrova, 2004).

It can be summarized from the analyses of the results about PP that for healthy persons the increase of PP is due to the larger SBP increment. Probably as a result of the treatment applied for cardiologic patients SBP reaction to GMA changes is weaker and the increment of DBP contributed for the decrease of PP. In that sense the treatment applied turns to be more effective for SBP.

More investigations are needed to confirm the results obtained.

### Acknowledgment

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