

Planetary geomagnetic indices, human physiology and subjective complaints

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Abstract: *Geomagnetic variations of solar origin correlate with appearance of physiological problems, enhanced anxiety, sleep disturbances, altered moods, and greater incidences of psychiatric admissions. We have studied the influence of changes in geomagnetic activity (GMA) on human physiological, psycho-physiological parameters and behaviour reactions. In this article we looked for influence of changes in geomagnetic activity on the systolic, diastolic blood pressure, pulse-rate and subjective complaints and we examined 54 working volunteers. Four-way analysis of variance (MANOVA method) with factors: GMA, day, sex (males/females) and medicaments has been performed. When we employed four-way analysis of variance, the influence of some of the factors on the physiological parameters examined turned out to be statistically significant ($p < 0.05$). Our investigations indicate that most of the persons examined irrespectively to their status could be sensitive to the geomagnetic disturbances and the results impose the necessity of systematic investigations in this field.*

INTRODUCTION

The idea that solar activity changes should contribute to human health arose many years ago. In the middle of the last century Tchijevsky for the first time confirmed this contribution (Tchijevsky, 1936-1937). After that many authors have found impact of the solar activity variations and related to them geomagnetic activity (GMA) changes on the cardio-vascular system (Oraevskii, et al., 1998), circulatory system (Pikin, et. al., 1998), nervous system and respiratory system. In some papers it was shown that during increased GMA there is an increasing of platelets aggregation and blood coagulation (Pikin, et. al., 1998). Other authors compared geomagnetic and medical data rows and found that at least 75% of magnetic storms caused increase in hospitalization of patients in connection with suicides, mental disorders, myocardial infarction, defects of cerebrum vessels and arterial and venous diseases on 30-80% at average. The dependence of the value of biotropic effect on the duration and intensity of geomagnetic storm was also observed (Oraevskii, et al., 1998). Other authors (Gurfinkel' et al., 1998) showed that during

geomagnetic storms the number of cases of myocardial infarction increase to 2.5 times, the acute cerebral insult to 2 times, the angina pectoris and cardiac arrhythmia to 1.5 times and deaths to 1.2 times in regarding to the periods without the geomagnetic storms. Local anomalies that are generated during expressed decrease of geomagnetic field values (Delgado, 1982) and during geomagnetic storms (Persinger, 1987) compose the factors that provoke pathological processes in human beings. Geomagnetic variations of solar origin correlate with enhanced anxiety, sleep disturbances, altered moods, and greater incidences of psychiatric admissions (Hainsworth, 1983). In this article we looked for influence of everyday changes in GMA on the systolic and diastolic blood pressure (BP), pulse-rate, behaviour reactions and subjective complaints related to headaches, vertigo, sleep disturbances, , heart stitches, heart thumping etc.

MATERIALS AND METHODS

We examined 54 working volunteers (22 men and 32 women) of an average age 48.7. 17 persons of them (8 males and 9 females) had cardio-

vascular disturbances and were taking different medicaments. The registrations of the different physiological parameters were performed every day at one and the same time for each person during the period 1.10.2001 – 10.11.2001 (totally 950 registrations for each of the physiological parameters examined).

We registered systolic and diastolic BP and pulse-rate. We calculated and analysed the difference between systolic and diastolic BP and collected questionnaires data about subject's sleep during the night before measurements and subjective complaints during the day. We registered arterial BP by standard manometric method (as mm Hg) and the pulse-rate by palpatoric method as beats/min on the a. radialis. We collected data about quality and quantity of the sleep and also complaints of headache, dizziness, vertigo, and nausea, easy tiring, decreased working ability, stitches or aches in the heart area, heart thumping, tachycardia, and arrhythmia. All kind of subject's complaints we unified as "there are complaints" and marked them as "1". When there were not complaints we marked them as "0".

Four-way analysis of variance (MANOVA method) with factors: GMA, day, sex and medicaments was performed. We investigated influence of these factors on the following variables: systolic BP, diastolic BP, pulse-rate and complaints.

Table 1. Dividing of the GMA according to Ap- and Kp- indices

Ap<30; Kp>3	1 st GMA Level
30≤Ap<50	2 nd GMA Level
50≤Ap<100	3 rd GMA Level
100≤Ap	4 th GMA Level

GMA was divided into four levels according to the Kp- and Ap-indices values (Table 1). We accepted for the first level the days when the values of the Ap-index were less than 30 and at least one of the eight values of the Kp-index was larger than 3. It occurs during magnetosphere substorms (Akashofu and Chapman, 1972). For the second level we accepted the days when the values of the Ap-index were larger or equal to 30

and less than 50 (moderate geomagnetic storm). For the third level we accepted the days when the values of the Ap-index were larger or equal to 50 and less than 100 (major storm) and for the fourth level - the days when the values of the Ap-index were larger or equal to 100 (severe storm). The data for GMA were got from Internet (World Data Center for Geomagnetism, Kyoto). During the period when we performed our investigations there were several major (50<Ap<100) and severe (100<Ap) geomagnetic storms (Fig. 1).

The days examined were divided into six levels in relation to the day with increased GMA. For null days we accepted the days with a growth GMA from the relevant level and we regarded the registrations two days before the changes of the geophysical parameters as minus days and the registrations three days after the changes of GMA as plus days.

Factor "Medicaments" was divided into two levels: subjects taking medicaments and persons do not taking medicaments.

Factor "Sex" had two levels: males and females.

We used Microsoft Access to separate the data according to the factors levels and then we employed MANOVA method using the program for statistical analyses STATISTICA.

RESULTS

When we performed four-way analysis of variance, the influence of some of the factors investigated on the physiological parameters turned out to be statistically significant at $p < 0.05$ (p - level of significance).

When we employed four-way MANOVA method and analysed the simultaneous impact of the factors GMA, day, sex and medicaments we found that the arterial BP increases with the increase of the level of GMA. The main effect of the factor GMA on systolic BP turned out to be approximately statistically significant ($p < 0.06$) and GMA revealed statistically significant influence on diastolic BP ($p < 0.05$). The difference between the most disturbed and quietest days for systolic BP was 7.3 mm Hg and for diastolic BP was 4.7 mm Hg (Fig. 2a, b).

There is effect of the factor "day" on the arterial BP. The main effect of the factor day in the same four-way analyses of variance on systolic and diastolic BP revealed a trend for changes of

these physiological parameters (respectively: $p < 0.1$ and $p < 0.19$). The arterial BP increases from the day before till the second day after geophysical changes (Fig. 3a, b).

Figure 4a, b shows the two-way interaction of the factors GMA and day in the same four-way analyses of variance and its influence respectively on systolic and diastolic BP. We could notice that arterial BP increases with the increase of the level of GMA and the values are larger from -1 till $+2$ day.

The two-way interaction of the factors GMA and sex revealed that both males and females

increase the arterial BP with the increase of GMA but maybe females are more sensitive (Fig. 5a, b). It is possible that there is a difference in the physiological reaction of males and females. The difference between the most disturbed and quietest days for systolic BP for males was 5.2 mm Hg and for females - 9.2 mm Hg and for diastolic BP for males - 3.5 mm Hg and for females - 5.9 mm Hg and. To confirm this difference we need to complete the registrations.

Figure 6a, b show the two-way interaction of the factors GMA and medicaments. We could see

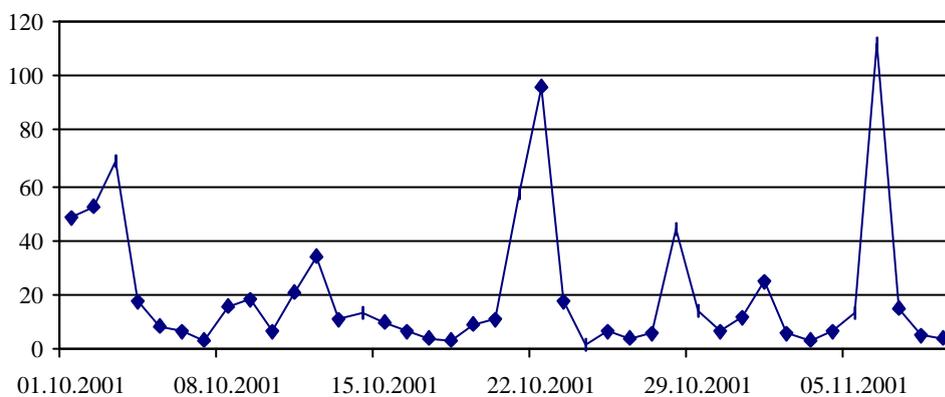


Fig.1 Geomagnetic field during the period of investigations

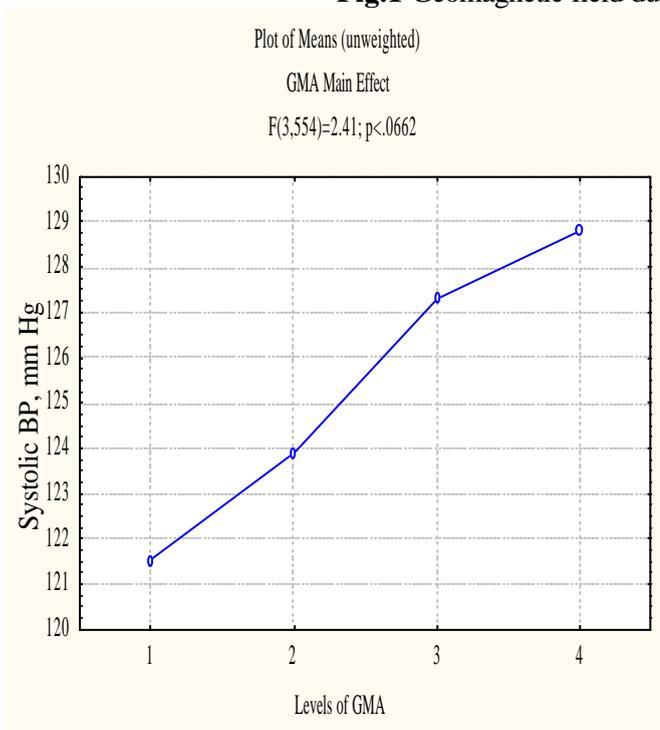


Fig. 2a. Main effect of the factor GMA level on systolic BP.

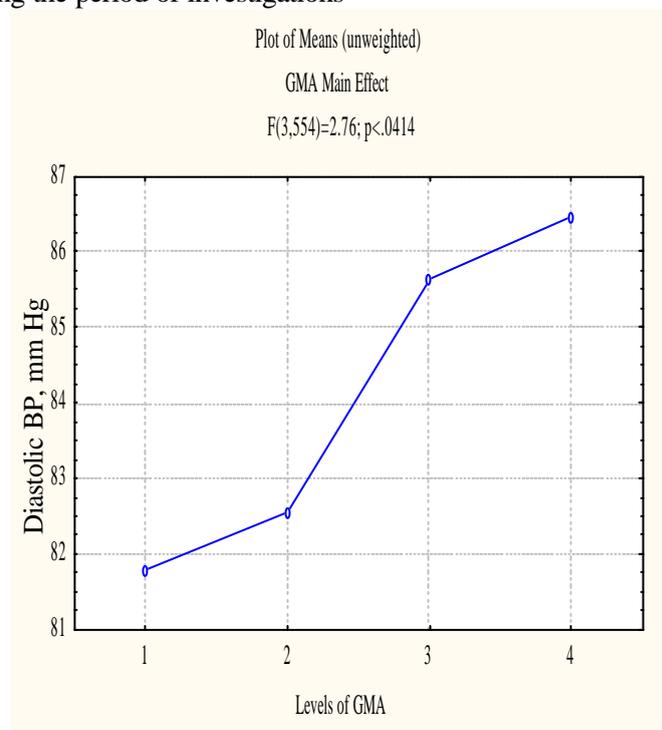


Fig. 2b. Main effect of the factor GMA level on diastolic BP.

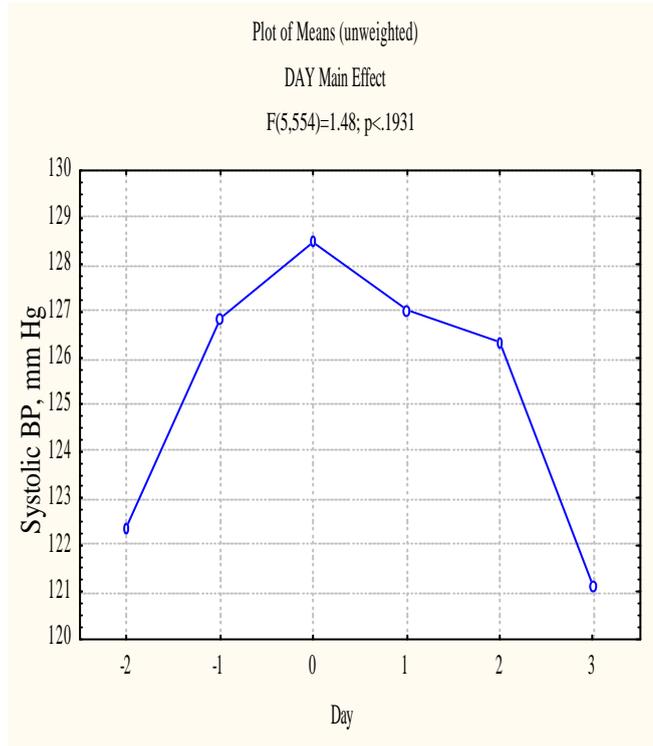


Fig. 3a. Main effect of the factor day on systolic BP.

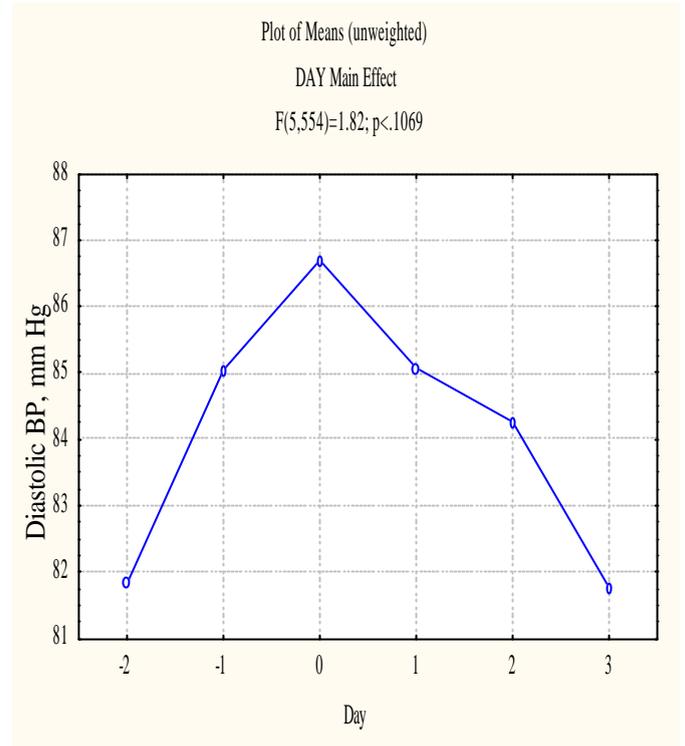


Fig. 3b. Main effect of the factor day on diastolic BP.

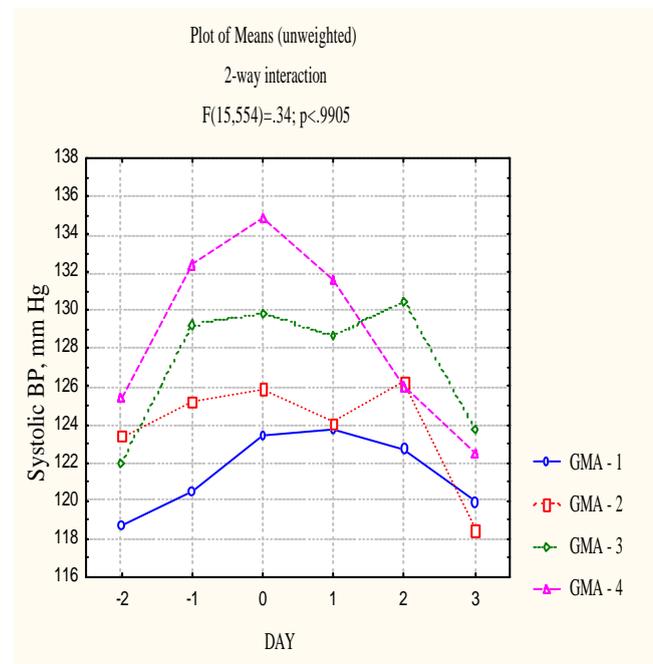


Fig. 4a. Influence of two-way interaction of the factors GMA level and day on systolic BP.

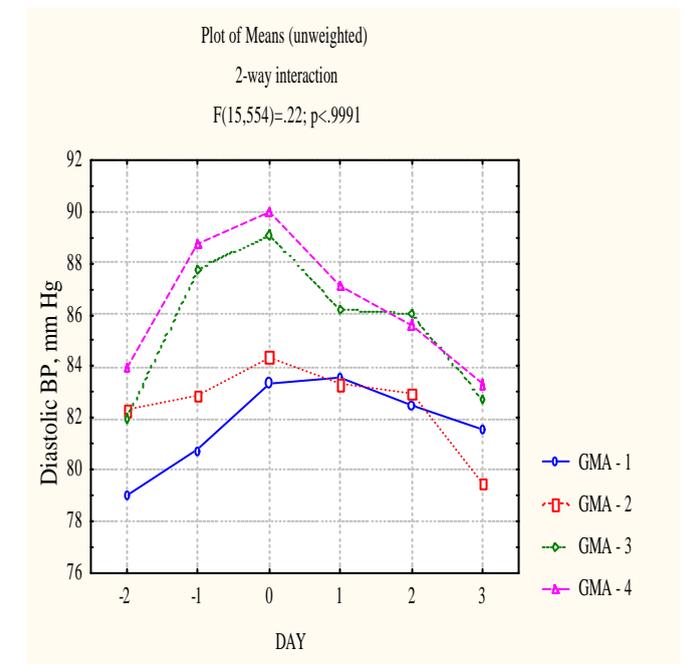


Fig. 4b. Influence of two-way interaction of the factors GMA level and day on diastolic BP.

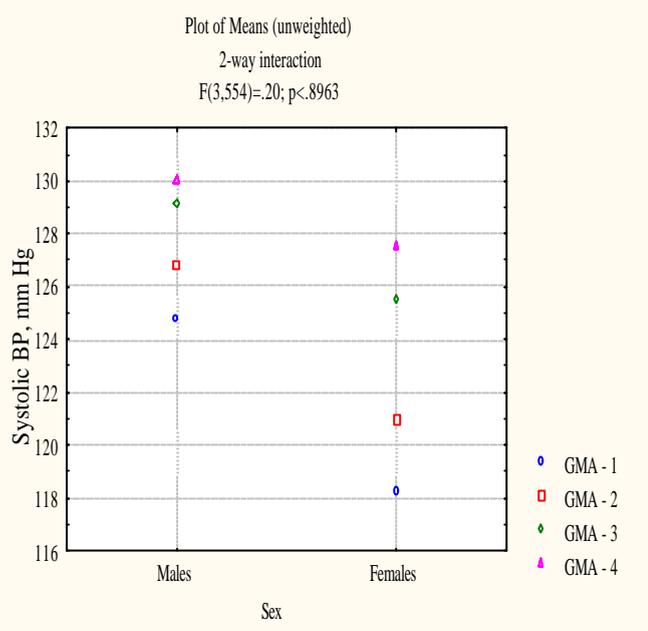


Fig. 5a. Influence of two-way interaction of the factors GMA level and sex on systolic BP.

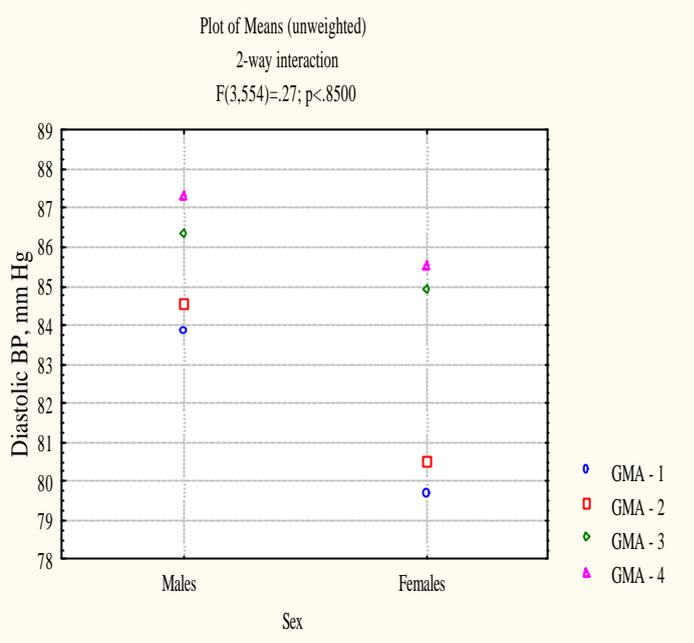


Fig. 5b. Influence of two-way interaction of the factors GMA level and sex on diastolic BP.

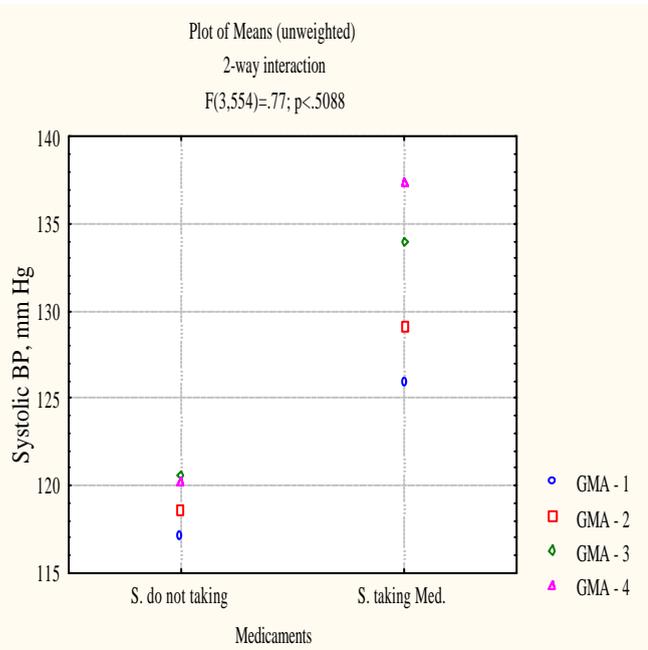


Fig. 6a. Influence of two-way interaction of the factors GMA level and medicaments on systolic BP.

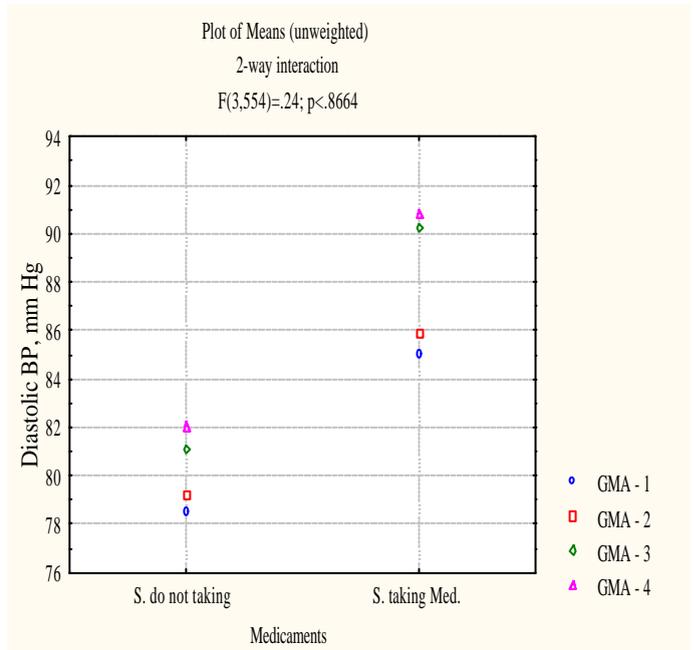


Fig. 6b. Influence of two-way interaction of the factors GMA level and medicaments on diastolic BP.

that both groups - subjects taking medicaments and subjects do not taking medicaments increase arterial BP with the increase of GMA without any statistically significant differences. The difference between the most disturbed and quietest days for systolic BP for the subjects do not taking medicaments was 3.5 mm Hg and for the subjects taking medicaments – 11.5 mm Hg and for diastolic BP respectively: 3.6 mm Hg and 5.7 mm Hg. This result reveals that both persons do not taking medicaments and subjects with cardiovascular disturbances taking medicaments that we examined could be sensitive to geomagnetic disturbances of solar origin.

The two-way interaction of the factors day and sex showed that both males and females have the largest arterial BP on the null days of the relevant GMA levels. The difference is that females begin increasing the arterial BP on the –1 days and reach the largest values on the null days while males begin increasing and reach the largest values on the null days and remain with large values on the +1 days.

The two-way interaction of the factors day and medicaments revealed that subjects taking medicaments have the largest arterial BP on the null days and remain with large values on the +1 and +2 days. The subjects do not taking medicaments reach the largest value on the –1 days and remain with large values on the 0 and +1 days. The three-way interaction of the factors day, sex and medicaments revealed the same trends without any significant differences with the sex factor.

The three-way interaction of the factors GMA, day and sex revealed that there are not significant differences with the factor sex but we noticed that females for the third and fourth levels of the GMA sharply increase the arterial BP.

The three-way interaction of the factors GMA, sex and medicaments revealed also that with the increase of GMA level the arterial BP increases and that females sharply increase it for the third and fourth level of GMA.

The three-way interaction of the factors GMA, day and medicaments revealed that all of the subjects investigated increase the arterial BP with the increase of GMA and there are not significant differences with the factors day and medicaments.

When we analysed the four-way interaction of the factors GMA, day, sex and medicaments we again noticed that with the increase of the GMA

the arterial BP increases and that females, especially females taking medicaments, sharply increase the arterial BP for the third and fourth levels of the GMA.

When we employed a four-way analysis of variance for the same factors to reveal any trends to changes of the pulse-rate, we did not obtain any significant influence on this physiological parameter. Figure 7 shows the two-way interaction of the factors GMA and day on the physiological parameter examined.

We also analysed the subjective evaluation of the behaviour and general status of the persons under consideration. We noticed that the observed persons increased complaints of headache, dizziness, faintness, aches and stitches in the heart area, heart thumping, tachycardia, arrhythmia, sleep disturbances, did not feel refreshed after sleeping and general physical and psychical indisposition with the increase of GMA levels and from the day before till the second day after increasing of GMA of the relevant level. When we investigated the main effect of the factor GMA levels complaints reached 22% for the severe storms while they were 15% for the first level of GMA (Fig. 8a). The main effect of the factor day revealed that on the null days complaints reached 27% while they were 12% on the third day after increasing of GMA (Fig. 8b). Figure 9 shows the two-way interaction of the factors GMA levels and day and we can see that complaints for the fourth GMA level on the null day were 34%.

In addition we can notice in Figure 3a, b that on the +2 day there is a detention in the decreasing of arterial BP and after that on the third day there is a sharp decreasing.

Figure 4a shows that there is an effect of GMA on systolic BP on the null day, on the +1 day it decreases but the main effect for the 2nd and 3rd GMA levels is on the +2 day. Figure 4b reveals similar changes and the difference is that there is only a detention in the decreasing of diastolic BP on the +2 day.

In Figure 7 we see that pulse-rate has a second peak on the +2 day for the 1st GMA level and for the 2nd GMA level the second peak is for the +3 day. Figure 8b also reveals a detention in the decreasing of the physiological complaints on the +2 day and Figure 9 shows a partial detention for the 2nd and 4th levels of GMA.

DISCUSSION

Our investigations obtained indicate that most of results suggest that the individual state is very important factor, which defines the reaction extended to the mentioned disturbances. Obviously

the persons examined could be sensitive to the geomagnetic disturbances. In agreement with other authors (Haraldson and Gissurason, 1987) our there is different "magnetic sense" in human beings by which geomagnetic variations might influence human health and behaviour (Baker, 1980).

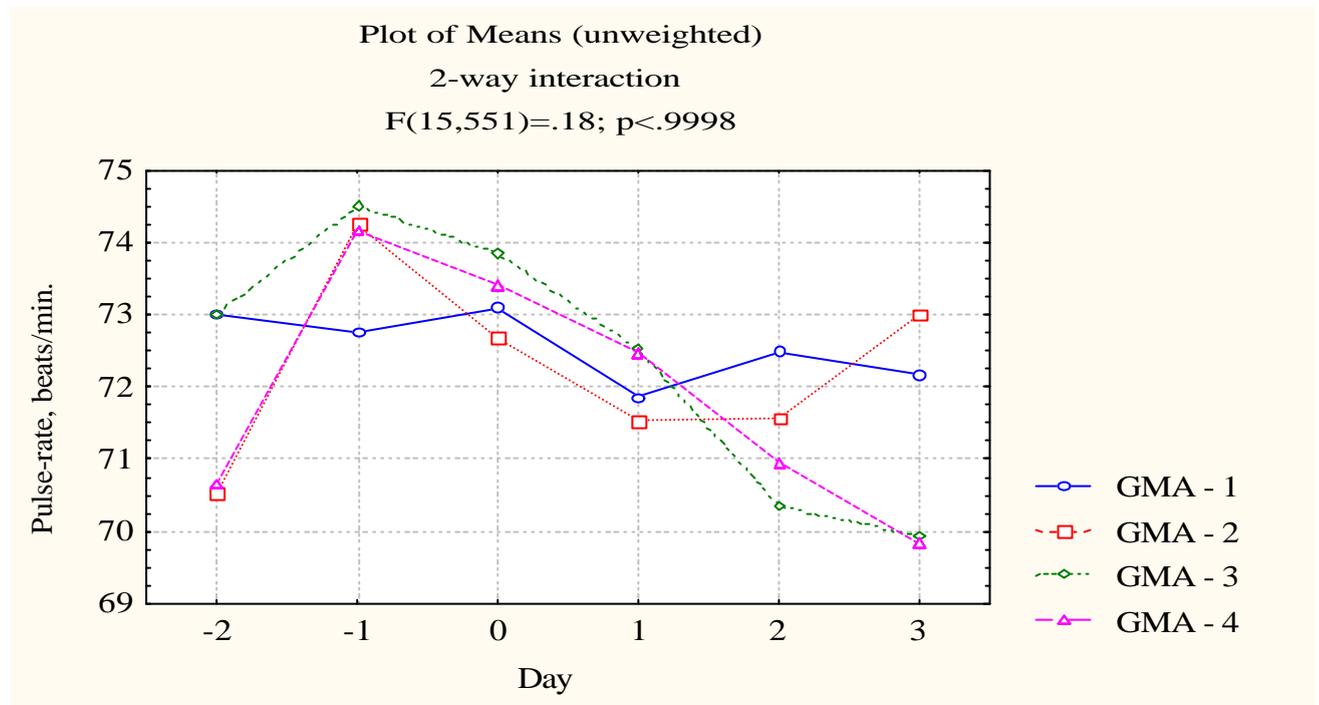


Fig. 7. Influence of two-way interaction of the factors GMA level and day on pulse-rate.

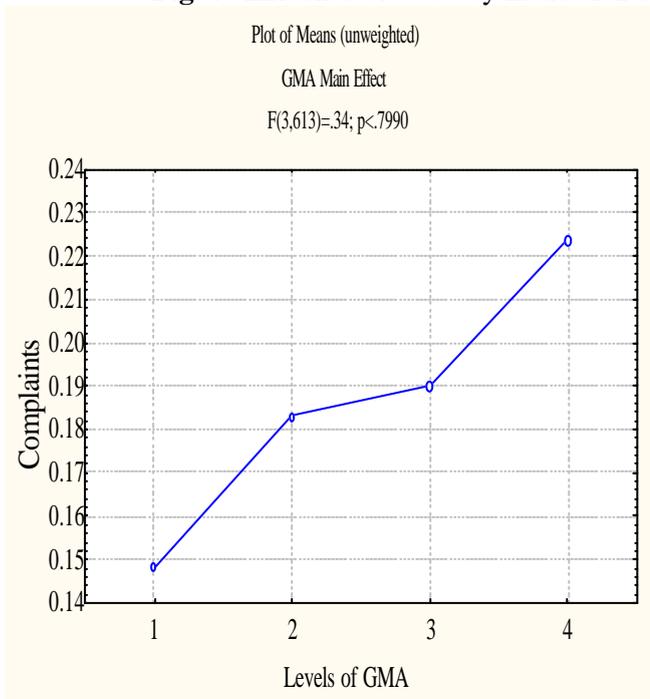


Fig. 8a. Main effect of the factor GMA level on complaints.

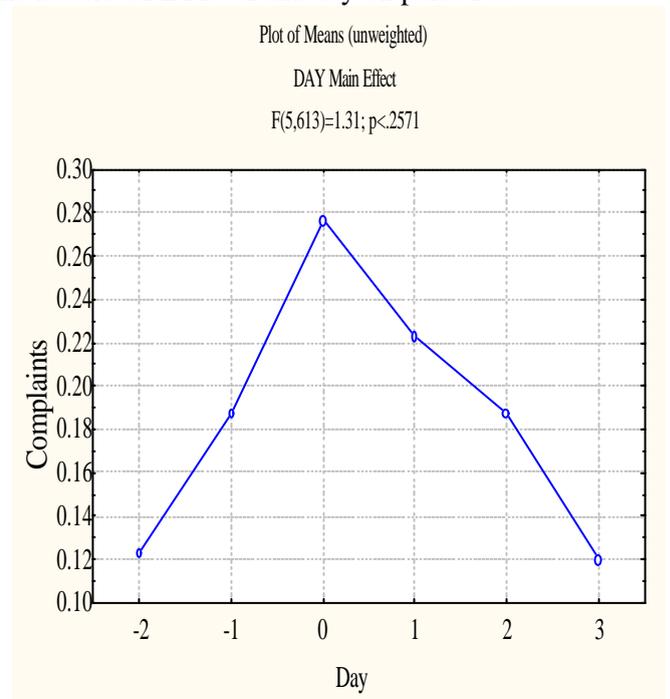


Fig. 8b. Main effect of the factor day on complaints.

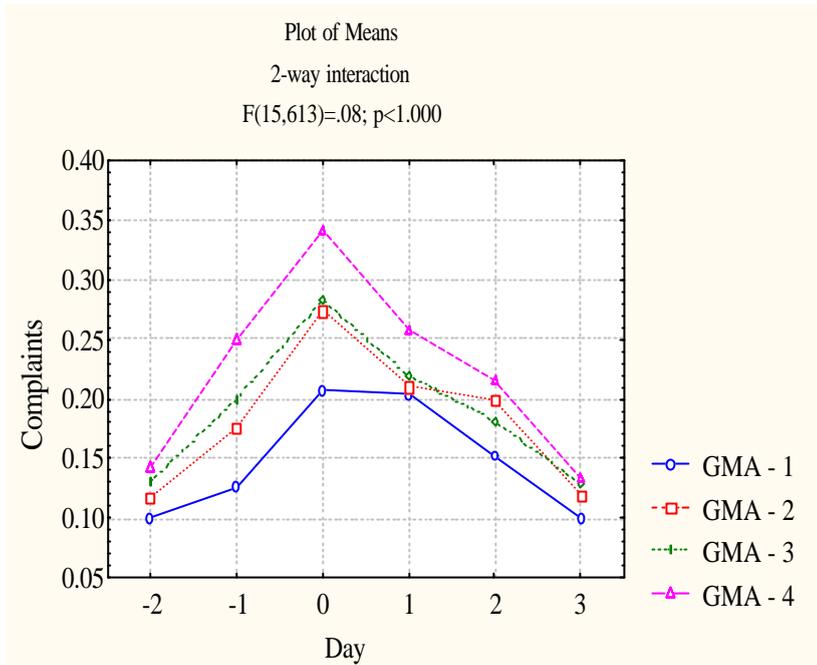


Fig. 9. Influence of two-way interaction of the factors GMA level and day on complaints.

It is possible that the electrical differences between central nervous system and the peripheral nerves may serve as a sensor for accepting geomagnetic waves (Becker, 1963).

In our investigations the trends to changes of systolic and diastolic BP upon influence of GMA differ. Systolic BP expressing heart contractions correlates more closely to emotional status. Diastolic BP is defined by the vessels state and correlates more closely to the physiological status. We suppose that because of this reason we obtained more distinguished changes for diastolic BP. It is true that at measurements of individual persons small deviations (5-8 mmHg) are permissible and are not significant but when changes of the same range are related to mean values of a big group registrations we should not ignore them especially when these changes are confirmed with a statistical significance.

On the other hand, the activity duration of the geomagnetic parameter changes is of an essential importance for all living organisms and especially for man. Thus the idea for a necessity to be determined the “dose” of the geomagnetic field variations to which a living system is exposed has been originated. It was pointed out that there is a necessity to develop a “dosimeter” method regarding the cumulative exposure to unstable or sharp geomagnetic field parameter changes (Persinger, 1987; Kleimenova, 1992).

The explanation for the detentions in the

decreasing or second peaks on +2 day for the examined physiological parameters could be as a result of that usually geomagnetic storms accompanied with sudden storm commencement (SSC) abate after 2-3 days but magneto-ionosphere storms and disturbances develop in the Earth environment. These ionosphere disturbances usually culminate on the second day after geomagnetic storms. In rare cases for our latitudes they can occur on the third day. That is so called “post-storm effect” (PSE) in the ionosphere (Velinov et al., 1970; Velinov et al., 1974). PSE is a result from precipitation of the trapped particles from the radiation belts in the ionosphere on the second day after SSC.

In our opinion it would be of a great importance to compare results obtained to the same investigations completed for the local geomagnetic field parameters and we have realized this type of investigation including for Dst-index and we suppose that results will be published in the near future.

The physiological parameters examined and statistical analyses that we performed confirm the presence of changes and there are no doubt that the level of GMA effect the human physiological reactions, but the biological input of this influence require further clarification. There is no statistical significance in all cases, nevertheless trends to changes were observed in different physiological

and behavioural reactions and they are indicators for the existence of this relationship.

Our investigations suggest that females are more sensitive in comparison to the males and also the taking medicaments have an effect on the subject's sensibility, but to confirm this difference we need to complete the registrations.

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