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Geomagnetic-Biological Correlations : Some New Results*

B J Srivastava & Subhash Saxena
National Geophysical Research Institute, Hyderabad 500 007

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Daily admissions of myocardial infarction (heart attack) cases to the Intensive Coronary Care Units of the three main hospitals in Hyderabad and Secunderabad for 1978 (high sunspot year, $R_z = 92{\cdot}5$) are studied against the corresponding daily sums of the three-hourly planetary geomagnetic activity indices K_p and the local indices K. The correlation coefficients and their standard errors are computed with the daily data for each month as well as with the monthly mean values for the whole year. Similar computations are made with the freshly abstracted medical data and the geomagnetic data for 1972 (medium sunspot year, $R_z = 68{\cdot}9$) for a comparison of the results. Most of the correlation coefficients are not statistically significant. However, for the monthly mean data of 1972, the correlation coefficient ($r = +0{\cdot}59 \pm 0{\cdot}20$) is significant, but not for 1978. Daily data on the number of road accidents in Hyderabad and Secunderabad for 1978 are also investigated against the geomagnetic activity indices, and the correlation coefficients computed and discussed. Average values of the daily hospital admissions for myocardial infarction and the number of road accidents for different levels of geomagnetic activity are also given for the two years and their implications examined. Air accident data due solely to the pilot's error of judgement obtained from the Air Headquarters, New Delhi, for the period 1970-74, are also analyzed along with the K-indices and the magnetic pulsation activity at Choutuppal (Hyderabad). The pulsation activity (pc 2 - pc 5) parameter is found to influence the air accidents more than the K-indices, and appears to be a possible link in triggering biological effects during magnetic storms in weak and imperfect cardio-vascular and nervous systems.

1. Introduction

Over the past fifty years, various investigators have discussed the solar-geomagnetic-biological correlations using data series for several years, and given conflicting results.[1,2] The reality of these correlations is still being questioned and calls for fresh investigations.

Intensive Coronary Care Units (ICC Units) now exist in the three main hospitals (Osmania General Hospital, Gandhi Hospital and Nizam's Institute of Orthopaedics, Cardiology and Specialities) of the twin cities of Hyderabad and Secunderabad, from where the daily data on admissions for myocardial infarction (heart attack) are readily available in an accessible form. These data were extracted for 1978 (high sunspot year, $R_z = 92{\cdot}5$). Similar data on hospital admissions for myocardial infarction in Hyderabad and Secunderabad for 1972 (medium sunspot year, $R_z = 68{\cdot}9$) were extracted from the final hospital records on daily admissions, in the absence of the ICC Units, for the sake of comparison. These medical data were found to be different from those already studied by Srivastava *et al.*[3] and Malin and Srivastava.[4] Daily data on the number of road accidents in Hyderabad and Secunderabad for 1978 (Jan.-Aug.), were obtained from the Traffic Police Department of the twin cities. Air accident data involving IAF planes and those classified as due solely to the pilot's error of judgement, were also obtained for the period 1970-74, from the Air Headquarters, New Delhi.

These daily medical and accident data have been studied against the corresponding daily sums of the three-hourly planetary geomagnetic activity indices K_p (*IAGA Bull.*[5] and *the Gottingen reports on K_p indices for* 1978), the local K-indices from the Hyderabad Magnetic Observatory and the geoelectric pulsation data of Choutuppal (*NGRI Bull.*[6-10] and from the records for 1972, 1973 and 1978), month by month, as well as for the year. The monthly mean values have also been examined against the corresponding sunspot numbers (R_z). The air accident data have been investigated against the simultaneous geomagnetic pulsation activity data (pc 2 - pc 5) as recorded at Choutuppal (Hyderabad), besides the K-indices of Hyderabad.

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2. Data Analysis and Results

The correlation coefficients and their standard errors between the daily sums of the three-hourly planetary geomagnetic activity indices K_p and the number of daily admissions for myocardial infarction to the main hospitals in Hyderabad and Secunderabad for 1972 and 1978 have been computed month by month using the well known statistical formulae. The correlation coefficient between the monthly mean values of the geomagnetic and medical data have also been computed for the two years. Table 1 gives these results along with the correlation coefficients between the daily geomagnetic activity parameter and the daily number of road accidents in Hyderabad and Secunderabad for 1978.

Figs. 1 and 2 give plots of the daily medical data against geomagnetic activity data, month by month for 1972 and 1978, respectively. Fig. 3 shows the daily road accident data plotted against the daily geomagnetic activity data for the different months of 1978. The monthly mean data are shown graphically in Figs. 4 and 5 along with the sunspot numbers for 1972 and 1978, respectively.

Table 2 gives the annual mean values of the magnetic and the medical data along with the sunspot numbers and the total admissions for myocardial infarction, and brings out a systematic increase in the values for 1978 as compared to 1972.

The average values of the daily hospital admissions for myocardial infarction and the incidence of road accidents in Hyderabad and Secunderbad for different

Table 1—Correlation Coefficients (r) between the Daily Sums of Three-hourly Planetary Geomagnetic Activity Indices (K_p) and the number of Daily Admissions of Myocardial Infarction Cases to the ICC Units of the Hospitals and Road Accidents in Hyderabad-Secunderabad for 1972 and 1978

	$r \pm$ SE		
	1972 (Myocardial infarction)	1978 (Myocardial infarction)	1978 (Road accidents)
Jan.	-0.18 ± 0.18	-0.02 ± 0.18	$+0.31 \pm 0.17$
Feb.	$+0.10 \pm 0.19$	-0.05 ± 0.19	$+0.22 \pm 0.18$
Mar.	-0.09 ± 0.18	$+0.01 \pm 0.18$	-0.03 ± 0.18
Apr.	$+0.01 \pm 0.19$	$+0.20 \pm 0.18$	$+0.21 \pm 0.18$
May	$+0.14 \pm 0.18$	-0.14 ± 0.18	$+0.11 \pm 0.18$
June	$+0.25 \pm 0.17$	$+0.33 \pm 0.17$	-0.00 ± 0.18
July	$+0.16 \pm 0.18$	$+0.12 \pm 0.18$	-0.17 ± 0.18
Aug.	$+0.06 \pm 0.18$	-0.14 ± 0.18	$+0.10 \pm 0.18$
Sep.	-0.10 ± 0.18	$+0.16 \pm 0.18$	—
Oct.	$+0.43 \pm 0.15$	-0.09 ± 0.18	—
Nov.	$+0.22 \pm 0.18$	-0.39 ± 0.16	—
Dec.	-0.16 ± 0.18	$+0.43 \pm 0.15$	—
Year	$+0.59 \pm 0.20$	$+0.01 \pm 0.30$	—

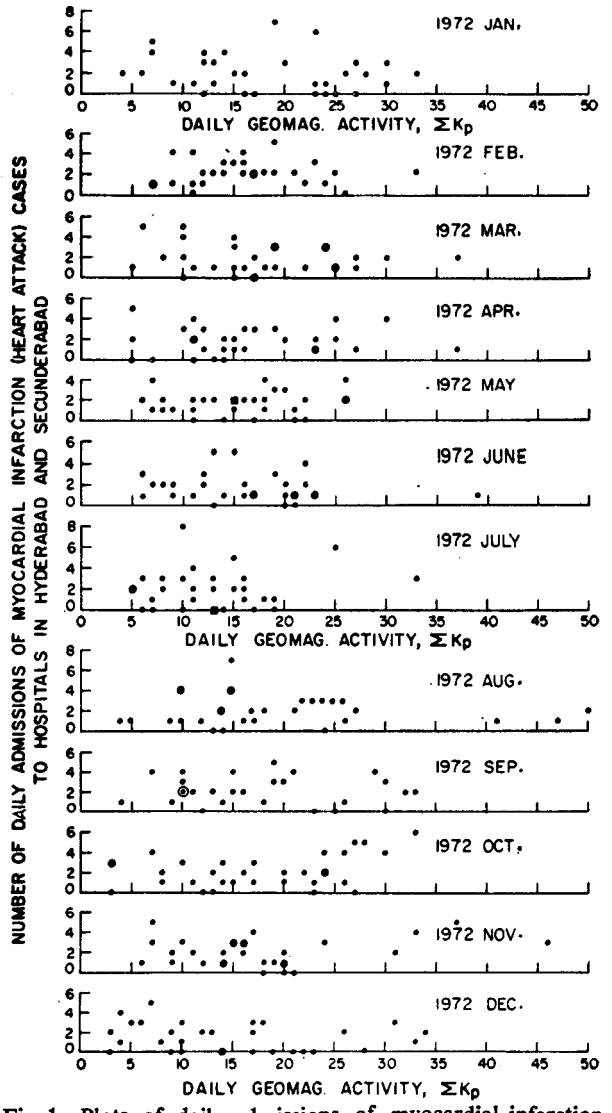

Fig. 1—Plots of daily admissions of myocardial infarction (heart attack) cases to the main hospitals in Hyderabad and Secunderabad against the daily sums of the three-hourly planetary geomagnetic activity indices, K_p, for 1972 (•, Occurrence once; ●, twice; ■ thrice; and ○, four times.)

levels of geomagnetic activity (ΣK_p) for 1972 and 1978 are presented in Table 3. The drop in the medical and accident data for $\Sigma K_p = 41$-50, is remarkable and possibly corresponds to a decrease in the pulsation activity. The dependence of pulsation activity (pc 2-pc 5) on K_p indices has been discussed by Jacobs.[11]

Table 4 summarizes the results of analysis of the air accident data for IAF planes against the geomagnetic activity data including pulsations as recorded at Hyderabad during 1970-74.

3. Discussion

It is noticed from Table 1, that the daily data of geomagnetic activity and hospital admissions for

myocardial infarction in Hyderabad and Secunderabad for the different months of both 1972 and 1978 do not yield significant correlation coefficients except for a month in each year. These new results revise our earlier results based on faulty medical data.[3,4] The correlation coefficient between the monthly mean geomagnetic and medical parameters for 1972 is, however, statistically significant

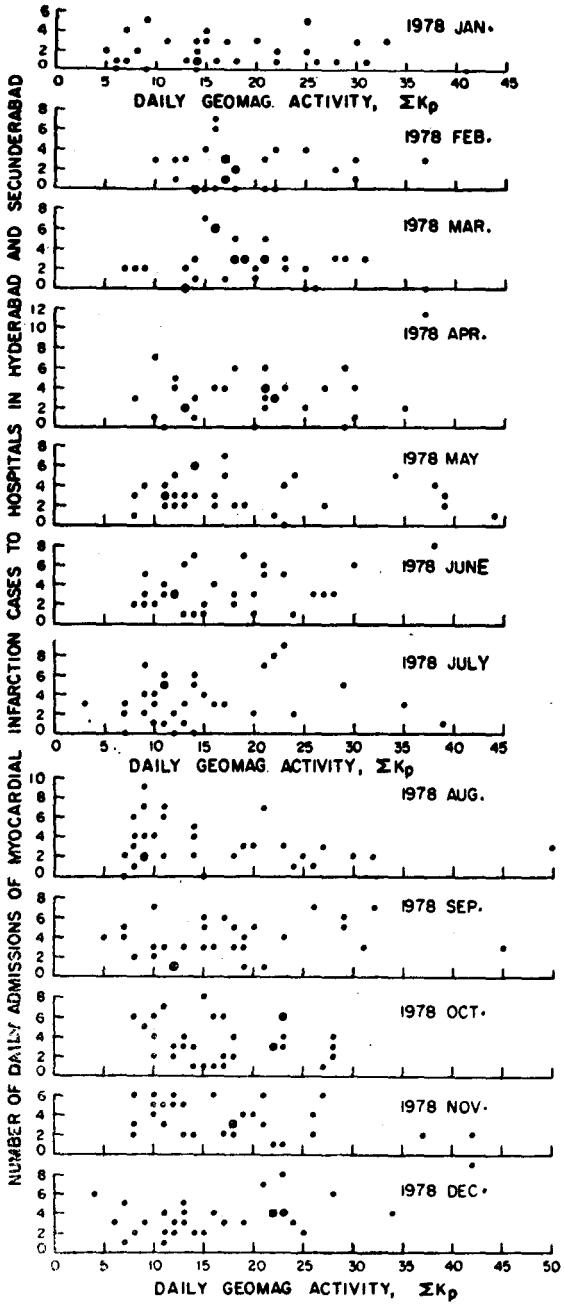

Fig. 2—Plots of daily admissions for myocardial infarction (heart attack) to the ICC Units of the main hospitals in Hyderabad and Secunderabad for 1978 against the daily sums of the three-hourly planetary geomagnetic activity indices K_p (•, Occurrence once; ●, twice; and ■, thrice.)

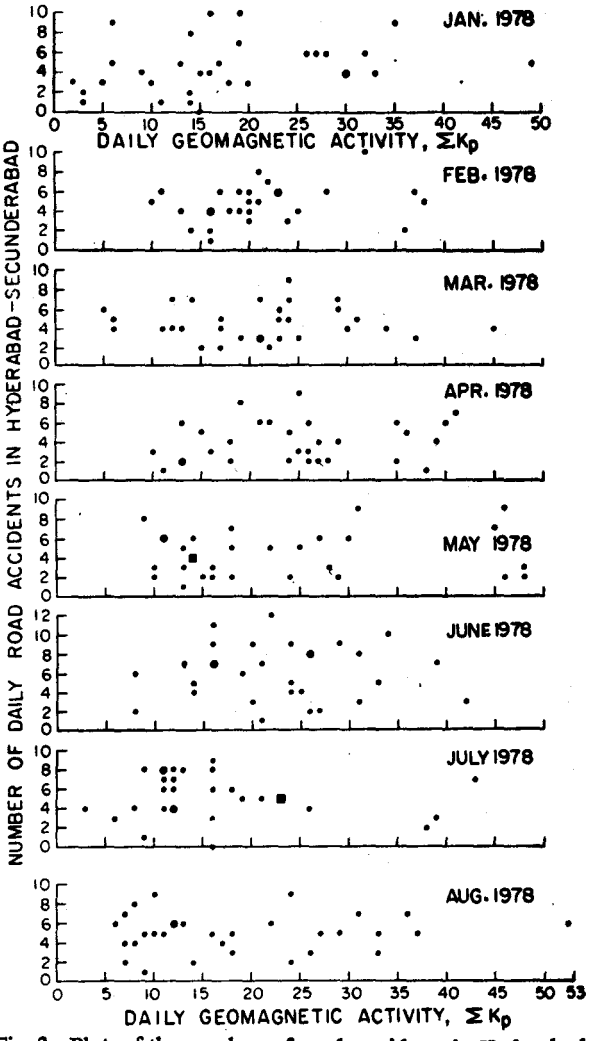

Fig. 3—Plots of the number of road accidents in Hyderabad and Secunderabad against the daily geomagnetic activity parameter (K_p sum) for the period Jan.-Aug. 1978 (•, Occurrence once; ●, twice; and ■, thrice.)

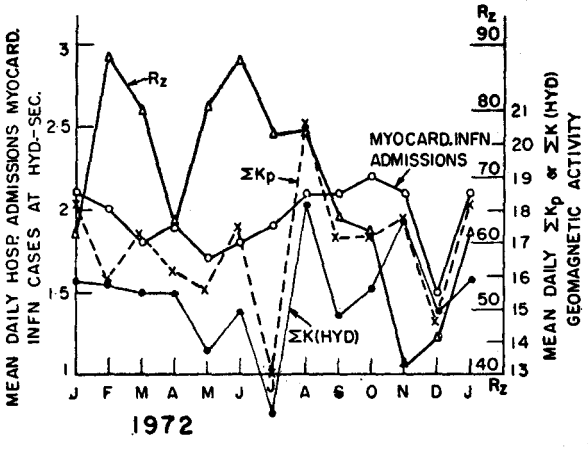

Fig. 4—Plots showing the monthly mean values of the daily hospital admissions for myocardial infarction in Hyderabad and Secunderabad, the daily sums of K_p and K indices of geomagnetic activity and the sunspot numbers for 1972

($r = +0{\cdot}59 \pm 0{\cdot}20$), and compares well with the Russian results on the subject.[12] Fig. 4 depicts this correlation for Hyderabad-Secunderabad graphically.

The graphs of monthly mean sunspot numbers, however, do not suggest any correlation with the medical data for 1972 and 1978 (Figs. 4 and 5). Nor is there any indication of a positive correlation between the geomagnetic activity data and the road accident data for 1978 (Table I, Figs. 3 and 5). Verma *et al.*,[13] however, obtained a good positive correlation between the daily geomagnetic activity indices and the road accidents in Ahmedabad. The present results revise our earlier results based on faulty accident data.[14]

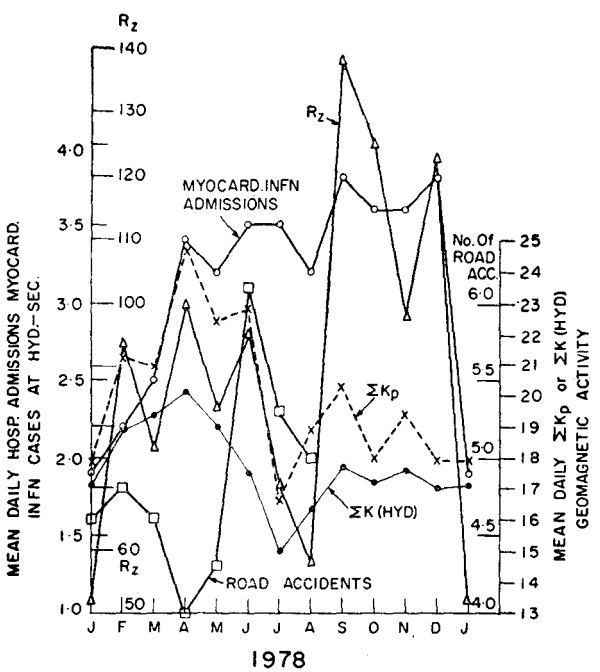

Fig. 5—Plots showing the monthly mean values of the daily admissions of myocardial infarction cases to the ICC Units of three main hospitals in Hyderabad and Secunderabad, the incidence of road accidents in the twin cities, the daily sums of K_p and K indices of geomagnetic activity and the Zurich relative sunspot numbers R_z for 1978

Although the daily and the monthly mean road accident data for Hyderabad and Secunderabad do not correlate with the solar and geomagnetic activity as shown here, Masamura[15] demonstrated that the annual number of road accidents per 1,000 automobiles revealed the 11-yr solar cycle variation in the accident data as recorded in Tokyo as well as the whole of Japan. It would thus appear that the annual values of bio-medical data show a better gross correlation with solar and geomagnetic activity than do the monthly and daily values. Chapman and Bartels[16] pointed out the lack of general correlation between sunspot numbers and geomagnetic activity on individual days.

Turning now to Table 2, it is seen that the year 1978 (high sunspot year, $R_z = 92{\cdot}5$) registered an increase of about 50% in the hospital admissions for myocardial infarction in Hyderabad and Secunderabad, as compared to the year 1972 (medium

Table 2—Annual Mean Values of Magnetic and Medical Data along with Sunspot Numbers

Year	Sunspot number R_z	Daily K_p-sum	Daily admissions for myocardial infarction in Hyderabad-Secundrabad	Total admissions for myocardial infarction in Hyderabad-Secunderabad
1972	68·9	16·8	1·93	708
1978	92·5	20·1	3·20	1168

Table 3—Average Values of Daily Hospital Admissions for Myocardial Infarction and Road Accidents at Hyderabad-Secunderabad for Different Levels of Geomagnetic Activity ΣK_p

Year	ΣK_p 0-10	11-20	21-30	31-40	41-50	51-60
	Myocardial infarction cases					
1972	2·1	1·8	2·0	2·3	2·2	4·0
1978	3·2	3·1	3·3	3·3	2·8	3·0
	Road Accidents					
1978	4·3	4·7	5·0	5·5	5·1	6·0

Table 4—Error-of-judgement Air Accidents versus Geomagnetic Activity during 1970-74

Year	Annual mean Zurich sunspot number (R_z)	Number of air accidents due to pilot's error of judgement	Number of air accident days which were geomagnetically disturbed and preceding day also disturbed	Number of air accident days with magnetic storms in progress	Number of air accidents which occurred when the 3-hourly geomagnetic activity index K at Hyderabad >3	Number of air accidents during geomagnetic pulsation activity (pc 2, pc 3, pc 4 and pc 5) at Choutuppal, Hyderabad
1970	104·5	53	29	35	11	37
1971	66·6	37	11	17	10	27
1972	68·9	49	22	30	10	39
1973	38·0	44	26	31	19	37
1974	34·5	42	29	32	18	31
Total	—	225	117	145	68	171
Percentage	—	—	52%	64%	30%	76%

sunspot year, R_z=68·9). It is quite possible that the annual mean values may bring out better, the influence of solar and geomagnetic activity on the medical and accident data. The results given in Table 3 show that there is a drop in the daily medical and accident data for 1972 and 1978 for the geomagnetic activity level as defined by ΣK_p = 41-50; otherwise they increase with the activity level. There are clearly two peaks in the average daily data on medical admissions and road accidents, viz. one for the activity level ΣK_p = 21-40, and another for ΣK_p = 51-60, which may correspond to peaks in the pc 2 pulsation activity.

Table 4 shows that the total annual number of air accidents due to the pilot's error of judgement decreased from 1970 (high sunspot year) to 1974 (low sunspot year) following the sunspot number. Air accidents registered during magnetic storms account for 64% of the total accidents, while those occurring during enhanced pulsation activity (pc 2, pc 3, pc 4 and pc 5) as recorded at Choutuppal, Hyderabad, account for 76% of the total accidents. The geomagnetic activity indices K and the pulsation data of Hyderabad are quite representative of the whole country, and reflect the regional characteristics of global geomagnetic disturbances. The analysis of air accidents clearly shows the strong control exercised by the electromagnetic pulsations on the human brain. Vladimirskii *et al.*[17] have convincingly demonstrated by means of laboratory experiments the influence of artificially generated electromagnetic pulsations, as during magnetic storms (pc 2 type), on rabbits and dogs and found that the cardio-vascular and nervous systems of weak and sick animals worsened during such disturbances.

It would thus appear that the biological effects observed during magnetic storms are the direct consequences of pulsation activity, and a correlation study between the daily bio-medical data and the pulsation activity data alone will provide additional confirmation. A daily planetary geomagnetic pulsation activity index of the type discussed by Troitskaya *et al.*[18] and Saito[19] (not yet compiled) will have to be used in such investigations, in the future.

Although the daily magnetic activity index ΣK_p or ΣK, and the daily medical admissions for myocardial infarction do not yield significant positive correlation coefficients, the monthly and annual mean values do indicate a definite association. This could be attributed to the monthly and annual mean values reflecting better the pulsation activity than the daily values of ΣK_p or ΣK. The medical data studied by Knox *et al.*[20] and Verma *et al.*[21] will also have to be examined from this point of view.

4. Conclusions

(i) The daily index of geomagnetic activity, ΣK_p, and the daily hospital admissions for myocardial infarction in Hyderabad and Secunderabad for the different months of 1972 and 1978 do not yield significant correlation coefficients. These new results revise our earlier results based on faulty medical data.[3,4]

(ii) The correlation coefficient between the monthly mean geomagnetic and medical data for 1972 ($r = +0{\cdot}59 \pm 0{\cdot}20$), is statistically significant and compares well with the Russian results.[12] Reliable and confirmed medical data on daily admissions for myocardial infarction should be examined for a few more years and cities, to confirm this finding.

(iii) A 50% increase in the hospital admissions for myocardial infarction in Hyderabad and Secunderabad has been observed during 1978 (high sunspot year, R_z = 92·5) as against 1972 (medium sunspot year, R_z = 68·9). The annual mean values appear to reveal the influence of solar and geomagnetic activity on the medical and accident data.

(iv) The daily geomagnetic activity index, ΣK_p, and the daily number of road accidents in Hyderabad and Secunderabad for 1978 do not give statistically significant correlation coefficients. These results revise our earlier results.[14] More accident data should be studied for two or three cities for greater confidence of the results.

(v) The total annual number of air accidents involving IAF planes and due solely to the pilot's error of judgement decreased from 1970 (high sunspot year R_z = 104·5) to 1974 (low sunspot year, R_z = 34·5), following the sunspot number. Air accidents occurring during enhanced geomagnetic pulsation activity (pc 2, pc 3, pc 4 and pc 5) account for 76% of the accidents.

(vi) The geomagnetic pulsation activity appears to play a key role in triggering cardio-vascular and nervous disturbances in weak and imperfect systems. It would be desirable to carry out statistical correlation studies with reliable and confirmed bio-medical data and geomagnetic pulsation activity indices (which are yet to be quantified).

(vii) Active participation of cardiologists and neurophysicians is not only desirable but important, especially for the extraction of the medical data

from the hospital records, in the interpretation of the results, and in laboratory experiments on animals. Need is emphasized for conducting laboratory experiments on animals exposed to rapidly oscillating artificial electromagnetic fields (pulsations) as during magnetic storms for several hours, and then studying the biophysical, biochemical and bioelectromagnetic (ECG and EEG) changes in their cardio-vascular and nervous systems, in collaboration with cardiologists, neuro-physicians and pathologists.

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References

1. Gnevyshev M N & OI' AI, *Effects of solar activity on the earth's atmosphere and biosphere*, Academy of Science, USSR—Astronomical Council 1971 ; Translated from Russian under Israel Programme for scientific translations, 1977.
2. Lipa B J, Sturrock P A & Rogot E, *Nature Lond.*, 259 (1976), 302.
3. Srivastava B J, Bhaskara Rao D S & Saxena S, *Indian J. Radio Space Phys.*, 5 (1976), 114.
4. Malin S R C & Srivastava B J, *Nature, Lond.*, 277 (1979), 646; 283 (1980), 111.
5. *International Association of Geomagnetism and Aeronomy (IAGA) Bull. No.* 32c, 1973.
6. *NGRI Bull. Suppls* 9-12, 1970
7. *NGRI Bull. Suppls* 13-16, 1971.
8. *Observatory Data Vol.* NGRI, 1974.
9. *Rep. Geoelect. Observatory*, 1972.
10. *Rep. Geoelect. Observatory*, 1973.
11. Jacobs J A, *Geomagnetic micropulsations*, Springer-Verlag Berlin, Heidelberg, New York, 1970, 33-44.
12. Novikova K F & Ryvkin B A, cited in *Effects of solar activity on the earth's atmosphere and biosphere*, edited by M N Gnevyshev and AI OI', English translation from the original Russian under Israel Programme for scientific translations, 1977, 184.
13. Verma S D, Singhal K P & Sinha V, *Indian J. Radio Space Phys.*, 6 (1977), 12.
14. Bhaskara Rao D S & Srivastava B J, *Bull. NGRI*, 8 (1970), 39.
15. Masamura S, cited in *Effects of solar activity on the earth's atmosphere and biosphere*, edited by M N Gnevyshev & AI OI', 1977, 238.
16. Chapman S & Bartels J, *Geomagnetism* (Clarendon Press, Oxford), 1 (1940), 376.
17. Vladimirskii B M, Volynskii A M, Vinogradov S A Brodovskaya Z I, Temur' yants N A, Achkasova Yu N, Rozenberg V D & Chelkova Z H D, cited in *Effects of solar activity on the earth's atmosphere and biosphere*, edited by M N Gnevyshev & AI OI', 1977, 259.
18. Troitskaya V A, Guel' et'mi A V' Bolshakova O V, Mateeva E T & Schepetnov R V, *Planet. Space Sci.*, 20 (1972), 849.
19. Saito T, *Rep. Ionos. Space Res. Japan*, 18 (1964), 260.
20. Knox E G, Armstrong E, Lancashire R, Wall M & Hynes R, *Nature, Lond.*, 281 (1979), 564.
21. Verma S D, Sinha V & Nigam M, *Indian J. Radio Space Phys.*, 7 (1978), 119.