

ORIGINAL ARTICLE

Eliahu Stoupel · Eugeny Abramson · Jaqueline Sulkes
Joseph Martfel · Nechama Stein · Meir Handelman
Michael Shimshoni · Pnina Zadka · Uri Gabbay

Relationship between suicide and myocardial infarction with regard to changing physical environmental conditions

Received: 10 January 1994 / Revised: 16 December 1994 / Accepted: 17 December 1994

Abstract In recent years, the possible association of changes in mortality from cardiovascular disease and myocardial infarction (MI) and deaths related to violence and the suicide rate has been repeatedly discussed. This study examined the relationship between cosmic physical changes (solar, geomagnetic and other space activity parameters) and changes in the total number of in-hospital and MI-related deaths and deaths from suicide to determine if a relationship exists between the distribution of total and MI-related deaths with suicide over time; some differences in the serotonergic mechanisms involved in the pathogenesis of MI and suicide were also taken into account. All suicides ($n=2359$) registered in the State of Israel from 1981 to 1989 (108 months) were analysed and compared with the total number of deaths ($n=15601$) and deaths from MI ($n=1573$) in a large university hospital over 180 months (1974–1989). The following were the main features of the Results. (1) Monthly suicide rate was correlated with space proton flux ($r=0.42$, $P=0.0001$) and with geomagnetic activity ($r=-0.22$, $P=0.03$). (2) Total hospital and MI-related deaths were correlated with solar activity parameters ($r=0.35$, $P<0.001$) and radiowave propagation ($r=0.52-0.44$, $P<0.001$), and with proton flux ($r=-0.3$ to -0.26 , $P<0.01$). (3) Monthly suicide distribution over 108 months was

correlated with MI ($r=-0.33$, $P=0.0005$) and total hospital mortality ($r=-0.22$, $P=0.024$). (4) Gender differences were prominent. We conclude that the monthly distributions of suicides and deaths from MI are adversely related to many environmental physical parameters and negatively correlated with each other.

Key words Myocardial infarction · Suicide · Solar activity · Geomagnetic activity · Serotonergic activity

Introduction

The photo-neuroendocrine mechanism underlying the metabolism of serotonin to melatonin, the final product of the pineal gland, is central to the understanding of biorhythmicity (Reiter et al. 1994). Melatonin synthesis is light-(sun) dependent and is influenced by the geomagnetic field (Jankovic et al. 1994). Its powerful anti-oxidant activity plays a role in many anti-aging mechanisms, and declines with time. Such basic pathologies as atherosclerosis, malignancy, Parkinsonism, cataract, and Alzheimer's disease are connected to a fall in melatonin synthesis and the related neuroendocrine and metabolic consequences.

Platelets, as the major serotonin accumulators in the blood, are pivotal in the pathogenesis of myocardial infarction and circulation in the coronary arteries, especially in atherosclerotic vessels (McFadden 1991). In our previous studies we have shown that serotonin-related clinical syndromes are, in turn, related to the level of geomagnetic activity (Stoupel 1992). As well as cardiovascular problems, we have also investigated some central nervous system disorders, such as depression, migraine, and behavioural changes preceding suicide.

In recent years, the possible association of changes in mortality from cardiovascular disease and myocardial infarction (MI) with deaths from violence and suicide rate has been discussed. The present study examines the relationship between cosmic physical changes (solar, geomagnetic and other parameters of space activity) and changes in the total number of in-hospital and MI-related

E. Stoupel (✉)
Toor Heart Institute, Beilinson Medical Centre,
Petah Tiqva 49100, Israel, Fax 972-3-924 0489

J. Martfel
Admissions Department, Beilinson Medical Centre,
Petah Tiqva 49100, Israel

E. Abramson · J. Sulkes · U. Gabbay
Department of Epidemiology, Beilinson Medical Centre,
Petah Tiqva 49100, Israel

N. Stein · M. Handelman
Ministry of Health, 91010, Jerusalem, Israel

P. Zadka
Central Bureau of Statistics, 91130, Jerusalem, Israel

M. Shimshoni
The Weizmann Institute of Sciences, Rehovot, Israel

A monthly comparison was chosen because solar energy reaches our planet's surrounding areas at different speeds, and despite available data on the distribution of daily and hourly events we cannot precisely determine the timing of the effects of this energy on a daily basis. Data recorded by the central space centres regarding the monthly parameters of geomagnetic activity were used for comparison. This study is the most recent of our series of work on clinical cosmobiology conducted over the last 20 years. We did not include changes in climate per se, since this was not one of our target factors; such changes have been covered in publications elsewhere. However, they are indirectly taken into account in our calculations of distribution by month and by year.

The suicide data (1981–1989, 108 months) were obtained from the Central Bureau of Statistics and Ministry of Health of the State of Israel. A total of 2359 cases were analysed.

We used daily, weekly and monthly data released by the National Geophysical Data Center, Boulder, Colo., USA (Solar Indices Bul-

letin; Geomagnetic Indices Bulletin), NOAA-USAF Space Environment Services Center, USA (Preliminary Report and Forecast of Solar Geophysical Data), and cosmic data of the Izmiran Institute for Atmosphere, Ionosphere and Radiowave Propagation of the Academy of Sciences, USSR (now Russia). Data were compared on a monthly basis with attention to the following parameters: (1) geomagnetic activity (GMA) K-index; (2) hours of negative (–) ionization of the ionosphere; (3) hours of positive (+) ionization of the ionosphere; (4) sudden magnetic disturbances of the ionosphere (Sd); (5) sunspot number (W); (6) smoothed sunspot number (R) (i.e. sunspot number related to isolated and groups of sunspots, observation technique, etc.); (7) solar radioflux at 2800 megahertz; (8) radiowave propagation at the minimal (early morning) solar activity hours (Fof2 min); (9) radiowave propagation at the maximal (noon) solar activity hours (Fof2 max); (10) proton flux in the ionosphere (P).

We compared the suicide and cosmophysical data with: (a) total monthly hospital mortality, and (b) monthly mortality from MI in the largest multidisciplinary university hospital in Israel.

Student's *t*-test and Pearson's correlation coefficients were used for a comparative study of the above-mentioned parameters. Results with a probability at the 95% level or more were considered significant. In accordance with our previous practice, results at the >89–94% level were considered to indicate “trends”.

Of the 2359 subjects who committed suicide, 1595 were men (67.61%) and 764 (32.39%) women. Table 1 dem-

^a Total months=108; total years=9

Table 2 Pearson correlation coefficients between monthly suicide in Israel (1981–1989) and 10 cosmophysical parameters

Suicides ^b	Cosmophysical parameters ^a									
	K	+	–	W	Solar radioflux 2800 Megahertz	Sd	Fof2 min	Fof2 max	R	P
Total (<i>n</i> =2359)	–0.2188 <i>P</i> =0.03	NS	NS	NS	NS	–0.23 <i>P</i> =0.020	NS	–0.188 <i>P</i> =0.06	NS	0.4176 <i>P</i> =0.0001
Male (<i>n</i> =1595)	–0.277 <i>P</i> =0.006		–0.213 <i>P</i> =0.037	NS	NS	–0.278 <i>P</i> =0.006		–0.215 <i>P</i> =0.035		0.4342 <i>P</i> =0.0001
Female (<i>n</i> =764)	NS	NS	NS	NS	NS	NS	NS	NS		NS

^a K, Geomagnetic activity index; +, hours of positive ionization of the ionosphere; –, hours of negative ionization of the ionosphere; W, sunspot number; Sd, sudden magnetic disturbances of the ionosphere; Fof2 min, radiowave propagation in the minimal (early

morning) solar activity hours; Fof2 max, radiowave propagation in the maximal (noon) hours; R, smoothed sunspot number; P, proton flux

^b Total months=96–108

Table 3 Pearson correlation coefficients and their probability between monthly total, myocardial infarction, and cardiovascular

hospital mortality and 10 cosmophysical parameters^a over 108 months (1974–1988)

Hospital deaths	K	W	R	Sd	Solar flux (2800 Megahertz)	Fof2 min	Fof2 max	–	+	P
Total (<i>n</i> =15601)	NS	0.491 <i>P</i> <0.001	0.297 <i>P</i> <0.001	0.329 <i>P</i> <0.001	0.341 <i>P</i> <0.001	NS	0.435 <i>P</i> <0.001	NS	NS	–0.258 <i>P</i> <0.01
Myocardial infarction (<i>n</i> =1573)	NS	0.40 <i>P</i> <0.001	0.438 <i>P</i> <0.001	0.399 <i>P</i> <0.001	0.352 <i>P</i> <0.001	NS	0.515 <i>P</i> <0.001	NS	NS	–0.305 <i>P</i> <0.01
Stroke (<i>n</i> =1020)	NS	NS	NS	NS	NS	NS	NS	NS	NS	–0.210 <i>P</i> <0.05

^a Abbreviations are as given in Table 2

Table 4 Pearson correlation coefficients between total monthly number^a of suicides and total hospital, cardiovascular, and myocardial infarction mortality in Israel (1981–1989)

	Hospital mortality		
	Total	Cardiovascular	Myocardial infarction
Suicides (Total)	–0.217 <i>P</i> =0.024	–0.178 <i>P</i> =0.06*	–0.3285 <i>P</i> =0.0005
Male	–0.153 <i>P</i> =0.11*		–0.353 <i>P</i> =0.0002
Female	–0.194 <i>P</i> =0.044		

^a Total months=108; total victims=2359

* Trends

onstrates the monthly and yearly number of suicides by gender. The mean annual number of deaths from suicide in 1981–1989 was 262±49 (median 234, range 209 to 353). The highest number of deaths from suicide occurred in May, July and March. For males, the maximum number of suicides occurred in May, July and January; for females, in March and November. We did not analyse the absolute increase in the number of suicides, because this may have been partially related to the changing population in Israel, especially in the late 1980s. When subjects were considered by age, 12 suicides (0.5%) oc-

curred in children up to age 14 years, 290 (12.29%) in subjects aged 15–24 years; 739 (31.33%) in subjects aged 25–44, 601 (25.47%) in subjects aged 45–64 years, and 717 (30.39%) in the elderly age group (>65 years).

The data of Table 2 present the correlation between monthly suicide distribution and ten cosmophysical activity levels. The results show significant negative correlations between total number of suicides and between suicides in men and: (a) GMA (K-index); (b) radiowave propagation in the maximal solar activity hours; (c) sudden magnetic disturbances of the ionosphere (Sd). There was a positive and highly significant correlation to proton flux.

Table 3 presents the correlation between the ten cosmophysical parameters and monthly total (*n*=15601), MI (*n*=1573) and hospital stroke mortality (*n*=1020) in a consecutive 180-month study (1974–1988) conducted by Stoupel and Shimshoni (1991). The total monthly MI deaths are significantly and positively correlated with solar activity parameters and radiowave propagation in the maximal (noon) hours (Fof2 max). The correlation with proton flux is significant and negative for all three categories.

Table 4 demonstrates the 108-month (1981–1989) relationship between total hospital deaths, deaths from MI, and total suicides in men and women. There was a significant negative correlation between total hospital mortality and total suicides in women. The correlation was

even stronger between monthly deaths from acute MI and total and monthly suicide distribution in men, achieving a high level of significance ($r=-0.33$ to -0.35 , $P=0.0005-0.0002$).

Discussion

A wide spectrum of problems has received attention from the scientific community in recent years, via medical, biological and social-psychiatric forums around the world. These include, among others, the brain-heart interrelationship, the effect of behavioural changes (violence-suicide), different preventive measures in cardiovascular medicine, the prognostic role of depression following MI, and central nervous system and cardiovascular responses to physiological and pathological changes of neurotransmitters such as 5-hydroxytryptamine-serotonin, endogenous opioids, nitrites, and oxidative radicals (Franceschi et al. 1992; Cohen 1990; Angus et al. 1990; Brown et al. 1990; Cowen and Anderson 1990).

The present study was conducted subsequent to our observation of an episodic discrepancy between a decrease in the number of suicides and many other medical behavioural parameters on days of a major geomagnetic storm (March 1989; Stoupel 1992). Other pertinent observations were the correlative links (noted over 15 years) between many cosmophysical parameters and the distribution of deaths from MI, cardiovascular and total hospital mortality (Stoupel and Shimshoni 1991), severity of migraine attacks (Kuritzky et al. 1987; De Matteis et al. 1994), platelet aggregation (Stoupel 1980) and other serotonin-related phenomena (Stoupel et al. 1983; Stoupel 1992), cardiac arrhythmias and sudden death (Stoupel 1987, 1993). In a parallel study related to monthly mortality of the entire population of Lithuania (Stoupel et al., unpublished) we found a similar relationship between ischaemic heart disease and the monthly number of suicides.

In the early 1970s, Sulman (1967, 1974) related complex serotonin-associated changes in human health to climatic changes, namely, hot dry winds in tropical zones. Recent studies have suggested that abnormalities in serotonin metabolism are one of the major factors in the pathogenesis of depression, anxiety, and violent behaviour and in the biochemical basis of suicidal "activities" (Van Praag 1988, 1992; Brown et al. 1990; Cowen and Anderson 1990; Mayes et al. 1993). Different forms of suicide (violent, nonviolent) have also been associated with meteorological and climatic fluctuations. The latest (1993) study from the Karolinska Institute, Stockholm and also from Finland confirmed gender differences in the prognostic-risk expression of depression on ischaemic heart disease, being mostly significant in male patients (Orth-Gomer et al. 1993; Uutela et al. 1993). The results of the multicentre European study on the prognostic significance of depression for recurrent MI or death from ischaemic heart disease stressed the same relationships (Ladvig et al. 1991).

We decided to study suicide per se in relation to cosmophysical activity and to compare the distribution of suicides over time with similar parameters of death from MI. The results indicate a negative correlation between monthly suicide distribution and the level of geomagnetic activity for all suicide victims and for males, but not for females. Similar gender differences have been noted in relation to solar and GMA changes (Stoupel et al. 1991) in many other, but not all, fields of medicine (Stoupel et al. 1993). Similarly to suicide, a negative correlation with GMA has generally been seen with sudden cardiac death, supraventricular and ventricular extrasystole (Stoupel 1993; Stoupel et al. 1990), paroxysmal atrial fibrillation (recent results of a study submitted by E. Stoupel, J. Martfel and Z. Rosenberg), pregnancy-induced hypertension (Stoupel et al. 1990), primary admission of psychiatric patients (Raps et al. 1991), basophil count in the peripheral blood (Stoupel 1980; Stoupel 1992), and leukocyte adhesiveness and aggregation (Stoupel and Arber 1993). The opposite relationship has been noted for platelet count and aggregation, diastolic blood pressure, intensity of migraine attacks and anterior wall myocardial infarction (Stoupel 1980; Stoupel et al. 1988; Sicuteri et al. 1990).

The suicide distribution did not show any correlation with the solar activity parameters that were significantly correlated with total and MI-related hospital mortality, such as sunspot number, or radiowave propagation. The last mentioned a complex parameter influenced by solar activity and GMA and showing a high and significant correlation with MI and total hospital mortality (Stoupel and Shimshoni 1991).

One of the strongest adverse relationships between suicide and MI was in their fluctuations according to space proton flux. In all situations in which the medical phenomena (total, MI mortality) were correlated with solar activity, there were significantly negative correlations with proton flux level (Stoupel and Shimshoni 1991). In contrast, the suicide distribution was highest and very significantly and positively correlated with proton flux. This discrepancy was the basis for our comparing the monthly distribution of total and MI-related hospital deaths with the monthly distribution of suicide deaths occurring out of the hospital. A significant negative relationship was found between the monthly number of hospital deaths (both total and MI) and the number of suicide victims. This observation may help explain the concomitant rise in noncardiac deaths (suicides) and drop in cardiovascular and MI mortality described in some other studies (Jacobs and Blackburn 1993; Zheng-Ming et al. 1993). The involvement of serotonin-related processes including vascular pathology, coagulation disorders, and central nervous system phenomena, such as depression (one of the background factors in suicide and anxiety) (Brown et al. 1990; Van Praag 1992) or migraine attacks (Cohen 1990; Sicuteri et al. 1990), suggest that such a pathogenetic scheme in the presence of environmental changes is very possible.

Conclusion

The following features were deduced from the present study.

- (1) The monthly number of suicides (total and male only) is significantly and adversely correlated with the GMA level and increases with the proton flux in the ionosphere.
- (2) The suicide-cosmic activity relationship is different from and, in many cases, adverse to, the monthly distribution of MI and total hospital mortality.
- (3) Monthly distributions of deaths from suicide and of total and myocardial infarction-related hospital deaths are significantly and negatively correlated.

This study also implied that there are periods that are more dangerous for people with depressive disorders. Possible preventive measures in such situations, based on space activity data, may be considered for the future, including the use of melatonin derivatives (Kloeden et al. 1994).

Acknowledgements We are indebted to Mrs. Gloria Ginzach for editing and to Mrs. Charlotte Sachs for secretarial assistance in the preparation of the manuscript.

References

- Angus JA, Broughton A, Cocks TM, Wright CE (1990) Coronary circulation and 5-hydroxytryptamine. In: Saxena PR et al. (eds) *Cardiovascular pharmacology of 5-hydroxytryptamine*. Kluwer Academic Publishers, Dordrecht, pp 363–378
- Brown L, Korn ML, Van Praag HM (1990) Serotonin in depression and anxiety. In: Paoletti R et al. (eds) *Serotonin*. Kluwer Academic Publishers, Dordrecht, pp 487–491
- Cohen ML (1990) Receptor for 5-hydroxytryptamine in the cardiovascular system. In: Saxena PR et al. (eds) *Cardiovascular pharmacology of 5-hydroxytryptamine*. Kluwer Academic Publishers, Dordrecht, pp 295–302
- Cowen PJ, Anderson JM (1990) Investigations of 5-HT neuroendocrine function in depression. In: Paoletti R et al. (eds) *Serotonin*. Kluwer Academic Publishers, Dordrecht, pp 493–497
- De Matteis G, Vellante M, Marrelli A, Vellante N, Sautalucia P, Turi P, Prencipe M (1994) Geomagnetic activity. Humidity, temperature and headache: is there any correlation? *Headache* 2:41–43
- Franceschi C, Crepaldi G, Cristopalo VJ, Giacomoni PU, Vijg J (1992) Aging and the cell, self defence mechanism. *Ann NY Acad Sci* 663:1–4
- Jacobs DR, Blackburn H (1993) Models of mortality effects of low blood cholesterol: health policy implications. Abstract Book 071, 3rd International Conference on Preventive Cardiology, Oslo, July p 22
- Jankovic BD, Nikolic P, Cupic V, Hladni K (1994) Potential of immune responsiveness in aging by static magnetic fields applied to the brain. *Ann NY Acad Sci* 718:410–418
- Kloeden PE, Rossler R, Rossler OE (1994) Artificial life extension. *Ann NY Acad Sci* 719:474–482
- Kuritzky A, Zoldan Y, Herring R, Stoupe E (1987) Geomagnetic activity and severity of migraine attacks. *Headache* 27:87–89
- Ladvig KH, Kieser M, Konig J, Breithardt G, Borggreffe M (1991) Affective disorders and survival after acute myocardial infarction. Results from the post-infarction late potential study. *Eur Heart J* 12:959–964
- Mayes M, Cosyns P, Meltzer MJ, DeMeyer F, Peters D (1993) Significant seasonability in violent suicide but not in non-violent suicide or homicide. *Am J Psychiatry* 150:1380–1385
- McFadden EP, Marce JG, Davies GJ, Kaski JC, Haider AW, Maseri A (1991) Effect of intracoronary serotonin on coronary vessels in patients with stable angina and patients with variant angina. *New Engl J Med* 324:658–659
- Orth-Gomer K, Schenk-Gustafsson K, Eriksson J, Moser V, Hogbom M (1993) Psychosocial factors and CHD in women. Abstracts of Book 082, 3rd International Conference on Preventive Cardiology, Oslo, Abstract Book 082, p 25
- Raps A, Stoupe E, Shimshoni M (1991) Solar activity and admissions of psychiatric inpatients, relations and possible implications on seasonability. *Isr J Psychiatry Relat Sci* 28:50
- Reiter RJ, Dun-Xian Tan, Poeggeler B, Menedez-Pelaez A, Li-Dun-Chen, Saarela S (1994) Melatonin as free radical scavenger: implications for aging and age-related diseases. *Ann NY Acad Sci* 719:1–12
- Sicuteri F, Poggioni M, Ponconesi A (1990) Upregulation of pain transmission from deficient serotonergic analgesia in migraine. In: Paoletti R et al. (eds) *Serotonin*. Kluwer Academic Publishers, Dordrecht, pp 391–404
- Stoupe E (1980) Solar terrestrial predictions. Aspects of preventive medicine. *Solar-Terrestrial Predict Proc* 4:29–40
- Stoupe E (1987) Sudden cardiac deaths and VPC's more in low geomagnetic activity days. *Pacina And Clinical Electrophysiology (PACE)* 3, part II, 749
- Stoupe E (1992) Serotonin "interested" clinical syndromes in different geomagnetic activity. Abstract Book, 2nd International Symposium on Serotonin, Houston, September 15–18, p 60
- Stoupe E (1993) Sudden cardiac deaths and ventricular extra-systoles on days with four levels of geomagnetic activity. *J Bas Clin Physiol Pharmacol* 4:357–366
- Stoupe E, Arber N (1993) The effect of geomagnetic activity on leucocyte adhesiveness and aggregation. *Eur J Int Med* 4:1–4
- Stoupe E, Shimshoni M (1991) Hospital cardiovascular deaths and total distribution of deaths in 180 consecutive months with different cosmic physical activity (1974–1988). *Int J Biometeorol* 35:6–9
- Stoupe E, Keret R, Assa S, Kaufman H, Shimshoni M, Row LA (1983) Secretion of growth hormone, prolactin and corticosteroids during different levels of geomagnetic activity. *Neuroendocrinol Lett* 5:365
- Stoupe E, Shimshoni M, Agmon J (1988) Is the localisation of myocardial infarction time-related? *Clin Cardiol* 2:45–49
- Stoupe E, Hod M, Shimshoni M, Friedman S, Ovadia Y, Keith L (1990) Pregnancy induced hypertension. *Clin Exp Obstet Gynecol* 18:7–12
- Stoupe E, Martfel I, Rotenberg Z (1991) Admissions of patient with epileptic seizures (E) and dizziness (D) related to geomagnetic and solar activity levels: differences in female and male patients. *Med Hypoth* 36:384–388
- Stoupe E, Goldenfeld M, Shimshoni M, Siegel P (1993) Intraocular pressure in four levels of geomagnetic activity and extreme solar activity. *Int J Biometeorol* 37:42–45
- Sulman FG (1967) Wirkung des subtropischen Klimas auf die Arbeitsfähigkeit. Inform für den Werksarzt 14:154–161
- Sulman FG (1974) Bioklimatologie trocken-heißer Wind. *Meteorol Fortbildung* 2:17–19
- Uutela A, Vartiainen E, Haukka A (1993) Life satisfaction and depression as predictor of ischemic heart disease (IHD): a 13-year follow-up in two Eastern provinces of Finland. Abstract Book 084, 3rd International Conference on Preventive Cardiology, Oslo, p 25
- Van Praag HM (1988) Serotonergic mechanism and suicidal behavior. *Psychiatr Psychobiol* 3:335–346
- Van Praag HM (1992) Serotonin and suicide. Abstract Book, 2nd International Symposium on Serotonin, Houston, September 15–18, p 2
- Zheng-Ming C, Keech A, Collins R, Peto R (1993) Low cholesterol and non-cardiac death: causal or not? Abstract Book 070, 3rd International Conference on Preventive Cardiology, Oslo, p 22