Clinical cosmobiology: distribution of deaths during 180 months and cosmophysical activity. The Lithuanian study, 1990–2004 The role of cosmic rays

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Key words: *solar and geomagnetic activities; cosmic rays; neutrons; death number.*

Summary. *The aim of this study is a next step of our previous, initial, publications – to explore the links between monthly death number (total, and for the major death causes and each gender) with levels of monthly cosmophysical activity in a long-term, big cohort observation.*

Methods. Death number during 180 consecutive months from the National Registry of Lithuania for years 1990–2004 were studied. A total of 630 205 deaths were analyzed (333 035 males). For comparison, monthly indices of solar activity, geomagnetic activity, and cosmic ray activity and year and month (1–12) of the study were used. The cosmophysical data were obtained from space research centers in the USA, Russia, and Finland.

Statistics. Pearson correlation coefficients (r) and their probabilities (P) between compared parameters were calculated. A multivariate model of prediction was designed.

Results. It was a significant correlation between total monthly death number and indices of cosmic ray activity and, inverse, of solar activity; in men stronger than in women. Monthly geomagnetic activity was significantly correlated with traffic accidents, ischemic heart disease/ stroke ratio, suicide victim number. Deaths from stroke, noncardiovascular causes, suicide, traffic accidents were related with cosmic ray activity and, inverse, with solar activity.

Relationship of ischemic heart disease/stroke ratio to year of observation showed additional evidence for the growing role of stroke in cardiovascular mortality.

Conclusions. Monthly death number is linked to cosmic ray activity, and inverse, to solar activity. Central place of stroke-related deaths in cardiovascular mortality is emerging. Geomagnetic activity, in monthly account, plays a relatively minor role.

We presume that forces antagonistic to cosmic ray activity, like solar activity and geomagnetic activity, can prevent some negative biologic effects of cosmic ray.

"Pedes ad terram ad sidera visum"

(Latin proverb)

Background

In our previous publications (1991, 1995) (1, 2), we studied connection between monthly deaths in a tertiary university hospital and some cosmophysical factors in 180 consecutive months (1974–1988) and the same for a whole country, but only in 36 months (1990–1992). The aim of this study is to explore cosmophysical links in a much longer observation time (180 consecutive months) in a whole country, using not only the traditional cosmophysical parameters – solar activity (SA), geomagnetic activity (GMA) – but also cosmic ray activity (CRA), which is one of the most powerful and still a bit mystical part, in the family of space physics (3–5).

Methods

We studied monthly distribution of deaths in the Republic of Lithuania in years 1990–2004 – 180 consecutive months. Data were obtained from the National Registry for total deaths (n=630 205), deaths from ischemic heart disease (IHD) (n=225 909), stroke (CVA) (n=75 752), accidents (n=54 302), traffic accidents (14 814), suicide (n=22 363) – total and for both genders. Excluding from the total death number those from IHD and CVA, we analyzed as a noncardiovascular death group (n=328 544). Taking in account their importance, IHD/CVA ratio was also included in the study (Tables 1, 2).

The cosmophysical data were gathered from the National Oceanic Atmospheric Administration

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Table 1. **Monthly death number and cosmophysical activity – Pearson correlation coefficients and their probabilities. Data of 180 consecutive months, Lithuania 1990–2004**

Cosmophysical factor	Total			Ischemic heart disease			Stroke (CVA)			IHD/CVA		
	All	Male	Female	All	Male	Female	All	Male	Female	Ratio–All	Male	Female
1. Sunspot number	–0.3 P<0.0001	–0.39 P<0.0001	–0.19 P=0.01	N.S.	N.S.	N.S.	–0.18 P=0.018	–0.16 P=0.036	–0.16 P=0.0028	N.S.	N.S.	N.S.
2. Smoothed sunspot number	–0.28 P=0.0001	–0.38 P<0.0001	–0.16 P=0.03	N.S.	N.S.	N.S.	–0.16 P=0.03	–0.15 P=0.049	–0.14 P=0.05	0.13 P=0.076	N.S.	0.13 P=0.07
3. Solar flux 2800 MGH, 10.7 cm	–0.23 P=0.0020	–0.345 P<0.0001	N.S	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
4. Adjusted solar flux	–0.267 P=0.0003	–0.375 P<0.0001	–0.14 P=0.06	N.S.	N.S.	N.S.	–0.13 P=0.09	–0.12 P=0.10	N.S.	N.S.	N.S.	N.S.
5. GMA indices:												
Ap.	N.S.	N.S.	N.S.	N.S.	0.14 P=0.06	N.S.	N.S.	N.S.	–0.14 P=0.059	0.23 P=0.0016	0.215 P=0.0037	0.21 P=0.005
Cp.	N.S.	N.S.	N.S.	0.15 P=0.04	0.2 P=0.007	N.S.	N.S.	N.S.	N.S.	0.26 P=0.0004	0.24 P=0.001	0.23 P=0.0018
Am.	N.S.	N.S.	N.S.	0.133 P=0.07	0.17 P=0.019	N.S.	N.S.	N.S.	N.S.	0.23 P=0.0007	0.21 P=0.004	0.21 0.005
6. Cosmic ray activity (Neutron monitoring data)	0.275 P=0.0002	0.345 P<0.0001	0.182 P=0.014	N.S.	N.S.	N.S.	0.185 P=0.01	0.13 P=0.078	0.19 P=0.0096	N.S.	N.S.	N.S.
7. Year (1990–2004)	–0.132 P=0.078	–0.198 P=0.0077	N.S.	–0.47 P<0.0001	–0.51 P<0.0001	–0.4 P<0.0001	0.175 P=0.019	N.S.	0.24 P=0.001	–0.77 P<0.0001	–0.67 P<0.0001	–0.71 P<0.0001
8. Month (1–12)	–0.18 P=0.016	N.S.	–0.25 P=0.0009	–0.25 P=0.0008	–0.18 P=0.01	–0.29 P<0.0001	–0.25 P=0.0007	–0.22 P=0.036	–0.23 P=0.0017	N.S.	N.S.	–0.125 P=0.09
9. Death number	630 205	333 035	297 170	225 909	103 593	122 316	75 752	28 624	47 128			

CVA – cerebrovascular accident; GMA – geomagnetic activity; IHD – ischemic heart disease; N.S. – nonsignificant.

Table 2. **Monthly death number and cosmophysical activity – Pearson correlation coefficients and their probabilities**
Data of 180 consecutive months, Lithuania 1990–2004

Cosmophysical factor	Noncardiovascular causes			Accidents			Traffic accidents			Suicides		
	All	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female
1. Sunspot number	–0.437 P<0.0001	–0.535 P<0.0001	–0.236 P=0.014	–0.21 P=0.004	–0.2 P=0.007	–0.23 P=0.002	0.24 P=0.001	0.245 P=0.0009	0.17 P=0.02	–0.365 P<0.0001	–0.26 P=0.0003	–0.34 P<0.0001
2. Smoothed sunspot number	–0.45 P<0.0001	–0.55 P<0.0001	–0.24 P=0.0013	–0.234 P=0.0016	–0.224 P=0.0024	–0.24 P=0.0013	0.223 P=0.0026	0.225 P=0.0024	0.17 P=0.02	–0.4 P<0.0001	–0.4 P<0.0001	–0.28 P=0.0001
3. Solar flux 2800 MGH, 10.7 cm	–0.378 P<0.0001	–0.507 P<0.0001	–0.152 P=0.04	–0.16 P=0.03	–0.156 P=0.036	–0.15 P=0.047	0.16 P=0.03	0.16 P=0.03	0.121 P=0.1	–0.43 <0.0001	–0.47 P<0.0001	–0.38 P<0.0001
4. Adjusted solar flux	–0.393 P<0.0001	–0.52 P<0.0001	–0.17 P=0.02	–0.16 P=0.03	–0.15 P=0.04	–0.164 P=0.027	0.17 P=0.02	0.17 P=0.02	0.121 P=0.10	–0.39 P<0.0001	–0.51 P<0.0001	–0.445 P<0.0001
5. GMA indices:												
Ap.	N.S.	N.S.	N.S.	0.125 P=0.09	0.135 P=0.07	N.S.	0.18 P=0.015	0.21 P=0.005	N.S.	–0.17 P=0.02	–0.16 P=0.03	–0.17 P=0.02
Cp.	N.S.	N.S.	N.S.	0.135 P=0.07	0.138 P=0.06	N.S.	0.16 P=0.03	0.18 P=0.017	N.S.	–0.215 P=0.004	–0.2 P=0.006	–0.21 P=0.0055
Am.	N.S.	N.S.	N.S.	0.133 P=0.07	0.135 P=0.07	N.S.	0.17 P=0.02	0.19 P=0.01	N.S.	–0.22 P<0.0001	–0.2 P=0.005	–0.21 P=0.004
6. Cosmic ray activity (Neutron monitoring data)	0.37 P<0.0001	0.47 P<0.0001	0.177 P=0.017	N.S.	N.S.	N.S.	–0.16 P=0.03	–0.17 P=0.02	N.S.	0.36 P<0.0001	0.36 P<0.0001	0.245 P=0.0009
7. Year (1990–2004)	0.22 P=0.0028	N.S.	0.314 P<0.0001	0.396 P<0.0001	0.381 P<0.0001	0.399 P<0.0001	–0.467 P<0.0001	–0.45 P<0.0001	–0.39 P<0.0001	0.22 P=0.0027	0.24 P=0.001	N.S.
8. Month (1–12)	N.S.	N.S.	N.S.	0.178 P=0.017	0.186 P=0.01	0.129 P=0.08	0.54 P<0.0001	0.53 P<0.0001	0.46 P<0.0001	N.S.	N.S.	–0.14 P=0.047
9. Death number	328 544	200 818	127 726	54 302	43 046	12 356	14 814	11 336	3478	22 363	18 342	4021

GMA – geomagnetic activity; N.S. – nonsignificant.

(NOAA) National Geophysical Data and National Space Service Centers, USA (6–8), Izmiran and Polar Geophysical Institutes and Moscow Neutron Monitoring Station of the Russian Academy of Sciences (9–11) and neutron monitoring data from Oulu University, Finland (12). For SA, the sunspot number and smoothed sunspot number, solar flux at 2800 MGH, 10.7 cm wave length data were used. For GMA monthly indices Ap., Cp., Am. – indices accepted in most international cosmophysical studies. For CRA – the neutron monitoring data in impulses/minute on the Earth's surface. The year and month (1–12) of each year of observation were also included in the comparative calculation.

Statistics

Pearson correlation coefficients (r) and their probabilities (P) were established between the death numbers and cosmophysical parameters. Probabilities of 95% and higher were described as significant, those of 94–90% – as a strong trend for significance. The lower results – as nonsignificant (N.S.).

Using parameters with significant correlation with monthly death number, a multivariate analysis prediction models were build for the total death and other mentioned subgroups of death causes.

Results

Tables 1 and 2 present the main results of the interrelationship between monthly cosmophysical activity indices and monthly death number.

The total monthly death number shows significant correlation with year, month (1–12) for the total, but only in the female population, not in male. Also, CRA and, inverse, SA links are significant. IHD is related to year (a drop), month, also in women stronger, and at borderline level to GMA – only for men. The results in this group need special attention discussing the results of the study. For stroke (CVA), it is rising by year, a higher death number at the beginning of the year in monthly account and correlation with CRA and, inverse, with SA. The IHD / CVA ratio is strongly and inverse related to years of observation and GMA. Monthly links were not significant. Noncardiovascular deaths are yearly growing in women and, as a consequence, in the whole population.

CRA and, inverse, SA are significantly correlated with this big group of deaths.

Accident-related fatalities are rising yearly, related to month of the year – more at the last months of the year, inverse related to SA, at trend level rising with higher GMA.

Traffic accidents are bringing higher monthly number of victims at the end of the year (monthly), diminished at the years of observation, correlated with SA, GMA and, inverse, with CRA. The gender discrepancy for GMA in comparison with men may be a result of much smaller number of women in this category of deaths.

Suicide was slightly and inverse related to the month of the year only in women, rising in the years of the study and significantly related to CRA, and, inverse, to SA and GMA.

It was a highly significant and inverse correlation between monthly death number from IHD and suicide ($r=-0.52$, $P<0.0001$).

Table 3 shows the results of multivariate prediction analysis with factors significantly correlated with monthly death number in this study. In addition to year (excluding total deaths), month of the year was included in IHD, stroke, accidents, and traffic accidents mode, but not in the distribution of noncardiovascular and suicide deaths in the year. SA and CRA were included in most of prediction models of groups analyzed in the study. The number of traffic accident victim was linked to SA and GMA and, inverse, with CRA and, in addition, what is not surprising, the month of the year – rising by 1–12-month comparison.

Discussion

Humankind is fighting for survival and improvement of life conditions. Better economy, success in prevention and treatment of some infections, children, cardiovascular diseases, malignancies, *etc.* result in expanding in the average lifespan in both genders. However, despite all those achievements, the environment surrounding remains us challenging the weak, old, and less adaptive individuals.

The influence of such factors as sun, stars, weather phenomena on the fate of separate human beings and whole communities is accompanying the history of all civilizations. In the 20th century, many studies were published, which were related to the rhythmicity in solar activity (sunspot number) with identical periodicity in epidemics (13, 14). Advances in geophysics and study of the space stimulated research disclosing links between biologic events temporal distribution and time per se – chronobiology (15–17), GMA level, especially geomagnetic storm influence on human health (arterial pressure, blood coagulation, cardiovascular morbidity and mortality, hormone secretion, *etc.*) (18–26).

The progress in obtaining cosmophysical informa-

Table 3. **Multivariate prediction analysis of cosmobiologic links with monthly death number Lithuania, 1990–2004**

Prediction of	Variables	Regression coefficient	SE	Probability		Gender
1. Total death number	Intercept	3475		<0.0001		
	Month 1–12	–19.16	7.1		0.0076	
	Sunspot N	–7.43	1.81	<0.0001		
	Solar flux	5.21	1.76		0.0036	
2. Ischemic heart disease	Intercept	46 506		<0.0001		
	Year	–22.61	3.06	<0.0001		
	Month	–14.93	3.83		0.0001	
	Sunspot N	–3.31	0.56	<0.0001		Female
	Solar flux	2.97	0.54	<0.0001		Female
3. Stroke (CVA)	Intercept	–4059.5			0.016	
	Year	2.17	0.84		0.01	
	Month	–3.78	1.05		0.0004	
	Cosmic ray (Neutrons)	0.02	0.007		0.005	
4. Accidents	Intercept	–8970.4			0.0007	
	Year	5.18	1.28	<0.0001		
	Month	4.42	1.52		0.004	
	Sunspot N	–1.37	0.21	<0.0001		
	Cosmic ray (Neutrons)	–0.12	0.02	<0.0001		
5. Traffic accidents	Intercept	6284.61		<0.0001		
	Year	–3.08	0.33	<0.0001		
	Month	4.45	0.41	<0.0001		
	Cosmic ray (Neutrons)	–0.01	0.003		0.0002	
6. Suicide	Intercept	–4492.59		<0.0001		
	Year	2.29	0.49	<0.0001		
	Sunspot N	0.65	0.16	<0.0001		
	Solar flux	–0.076	0.15	<0.0001		
	Cosmic ray (Neutrons)	0.012	0.007		0.079	
7. Noncardiovascular causes	Intercept	–119 88		0.04		
	Year	6.98	2.93		0.02	
	Sunspot	–1.66	0.27	<0.0001		

tion and its computation brought to further observations related to influences of solar activity on many biologic parameters such as newborn development, hormone secretion, immunologic changes, intraocular pressure, time distribution of diseases and death (27–31).

At the end of the 20th century, more medical data emerged connecting medical-biologic events not only with the "traditional" environmental influences – time, SA, GMA – but also looking to some major forces inverse related by their influences on our planet to SA and GMA – the Cosmic Ray (CRA) (by neutron activity monitoring on the Earth's surface) and, very close to them connected, space proton flux at high-energy levels (>90–100 MeV) (3, 4, 32–35). Daily, monthly, and yearly observations were published. In the yearly studies, higher levels of growth hormone at the maximum of the 11-year solar cycle and increase in newborn length and weight (more male) at this time was seen (29). Changes in immunoglobulin level, intraocular pressure, leukocyte function (29, 24). This group of studies is also including many analyzing seasonality in timing of medical events (16, 17). Most of fatal cardiovascular events are circannualy rhythmic. The acrophase of those deaths is in the winter

months – beginning of February to March, for suicide – the middle of summer (16, 17, 32).

Fainleb *et al.* (36) in 1975 published a study claiming that SA had no influence on the mortality rate in the USA.

Recent monthly studies put attention to the inverse death number with SA and links with CRA and high-energy (>90–100 MeV) space proton flux (33–35). CRA and high-energy proton flux are inversely related to SA and GMA. The levels of CRA are described using neutron activity (imp/min) monitoring data on the Earth's surface (5). The level of high energy CRA is extreme, and their, possible, extragalactic origin is widely discussed. The neutrons that are counted as the CRA characteristic are remains of atoms broken by Cosmic Ray (3–5). Until the last years, it was supposed that biologic effects of CRA, maybe, have effect on human beings only at spaceflights or high altitude flights, like by Concorde aircraft. In special studies a rise in the number of leukemia, breast cancer *etc.* in people exposed to CRA were discussed (37, 34).

In recent studies, the correlation of neutron activity on the Earth's surface with occurrence of acute myocardial infarction, sudden cardiac death, and stroke is published (38–41). In addition, possible effect of CRA on newborn development, some congenital anomalies related to chromosome aberration (Down syndrome) was shown in a recent publications (42).

The daily effects for a long time were concentrated on the biologic effects of high or extreme GMA – geomagnetic storms (21–26). It was shown that on those days many physiologic and pathophysiological parameters are changing (25, 26). Some differences and adverse response to those changes by different subsets of IHD and CVA can explain the generally sober links of those two groups to the studied physical parameters: different groups of fatal events are responding in a different way to changing physical environment. There are some examples: such important "acute phase" messengers like fibrinogen, C-reactive protein, many blood coagulation ingredients predisposing to thrombosis, are higher in high GMA days (26, 44). In addition, arterial pressure shows such trend. The number of ischemic stroke-related deaths is rising (26). We mentioned analogical changes for prolactin and 17-ketosteroids (31, 41–47). It is also remarkable that stormy days of GMA are relatively rare – in the last 30 years, in the middle latitudes, 3.5–6.0% of days yearly (47). This is one of the explanations that despite all mentioned effects, in the monthly or yearly account, the influence of GMA is not dominating, and the leading influences on biological events are more related to SA, CRA, high-energy proton flux, *etc*.

On the other hand, growth hormone, 11-hydroketosteroids, cardiac arrhythmia, including atrial fibrillation of new origin, related to some 30% of ischemic strokes (CVA) due to cerebral embolism, ventricular tachycardia and fibrillation, the main background for sudden cardiac death, are rising at lowest GMA levels (41–47). Such multidirectional response of the human organism to environment can be connected with the absence of decisive links of many large groups (IHD, CVA) of pathology that include subgroups of events with opposite answers to changing physical parameters (Table 1).

The inverse links of suicide-related deaths with GMA, closely linked with depressive disorders, have some practical applications. Ten years ago, the treatment of severe depressive patients by electric shocks was partially replaced by magnetic field therapy (48).

Recent observations of the positive effect of magnetic resonance imaging (MRI) test on the course of most severe depression is changing the way of treatment, using artificial magnetic fields in psychiatry (49). The rising number of suicide-related deaths at low GMA is accompanied also by analogical trend in homicide victims (32). Those changes are followed by higher CRA (neutron activity in imp/min). Similar relationship is registered also for occurrence of acute myocardial infarction (40) and sudden cardiac death (38) and, as it was shown in this study, on the total monthly death number.

The way that CRA (neutron activity on the Earth surface) is involved in the regulation of human homeostasis must be a chapter for future explorations. Here it is appropriate to quote the famous physicist R. Feinmann: "One of the ways of stopping science would be only to do experiments in the region you know the law" (50).

We conclude:

1. Monthly death number is linked with cosmic ray activity and, inverse, with solar activity.
2. Stroke (CVA) related deaths are emerging as rapid growing central group between ingredients of cardiovascular mortality.
3. In the death monthly account, in contradiction to daily data, geomagnetic activity plays a relatively minor role.
4. It is presumed that forces antagonistic to cosmic ray activity, like solar and geomagnetic activity, are preventing some negative cosmic ray biologic effects.

Klinikinė kosmobiologija: mirčių pasiskirstymas per 180 mėnesių ir kosmobiologinis aktyvumas (Lietuvos 1990–2004 m. studija)
Kosminių spindulių vaidmuo

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Raktažodžiai: saulės ir geomagnetinis aktyvumas, kosminiai spinduliai, neutronai, mirčių skaičius.

Santrauka. *Studijos tikslas.* Įvertinti ryšį tarp vyrų ir moterų mirčių nuo pagrindinių priežasčių skaičiaus įvairiais mėnesiais ir kosmofizinio aktyvumo lygių.

Metodai. Mirčių skaičius per 1990–2004 metų 180 mėnesių gautas iš Lietuvos mirčių registro. Išanalizuota 630205 mirtys, iš jų – 333035 vyrų. Įvertintas mirčių pasiskirstymo ryšys su saulės aktyvumu, geomagnetiniu aktyvumu ir kosminių spindulių aktyvumu vertinant pagal neutronų aktyvumą žemės paviršiuje. Šie kosmofiziniai duomenys gauti iš JAV, Rusijos bei Suomijos erdvės tyrimų centrų. Koreliacijai vertinti taikytas Pearsono koreliacijos koeficientas. Sudaryti daugiaveiksnio prognozavimo modeliai.

Rezultatai. Statistiškai reikšminga tiesioginė koreliacija nustatyta tarp bendrojo mirčių skaičiaus per mėnesį ir kosminių spindulių aktyvumo bei atvirkštinė tarp saulės aktyvumo. Vyrams šie dėsningumai buvo žymesni nei moterims. Geomagnetinis aktyvumas reikšmingai koreliavo su mirtingumu nuo transporto traumų, išeminės širdies ligos ir insulto santykio bei savižudybių. Mirtys nuo insulto, savižudybių, transporto traumų ir visų ne širdies ligų buvo tiesiogiai susijusios su kosminių spindulių aktyvumu, ir atvirkščiai – su saulės aktyvumu. Išeminės širdies ligos ir insulto santykio pokyčiai parodė didėjantį insulto skaičių tarp kitų širdies ir kraujagyslių ligų.

Išvados. Mirčių pasiskirstymas įvairiais mėnesiais yra tiesiogiai susijęs su kosminių spindulių aktyvumu, ir atvirkščiai – su saulės aktyvumu. Geomagnetinis aktyvumas turi santykinai nedidelę įtaką mirčių pasiskirstymui mėnesio laikotarpiu. Antagonistinės kosminių spindulių aktyvumui jėgos, tokios kaip saulės ir geomagnetinis aktyvumas, gali sumažinti negatyvius kosminio spinduliavimo biologinius poveikius.

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