Dynamics of Blood Values in Experimental Geomagnetic Deprivation (*In Vitro*) Reflects Biotropic Effects of Natural Physical Factors during Early Human Ontogeny

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Heliogeophysical situation during prenatal development of humans is essential for blood rheology, hemostasis, and spectral and frequency parameters of the blood. The relationship between these parameters and natural physical factors is determined by the intensity of solar activity and geomagnetic induction during postnatal ontogeny. Analysis of changes in the functional relationship between hematological values and heliogeophysical factors under conditions of simulated hypogeomagnetic space included evaluation of possible consequences of distortions of the heliobiospheric relationships in large cities, particularly pronounced for cardiovascular patients.

Key Words: *in vitro blood; heliogeophysical factors; attenuated geomagnetic field; human ontogeny*

The heliogeophysical factors are essential for the spatial and time organization of biosystems of all levels, including humans [5,6,9]. Naturally regulated electromagnetic fields in modern megalopolises are modified by numerous ferroconcrete constructions and technogenic field streams: local hyper- and hypomagnetic zones appear, in which preformed geophysical fields become a more and more manifest bioactive anthropoecological factor [4]. Our data indicate that attenuated geomagnetic field (GMF) is characterized by specific biotropic effect in a megalopolis [5,6].

Increased cardiovascular morbidity in modern megalopolises and its close relationship with disorders in blood rheology [10,13] make studies of biotropic effects of natural physical factors reflected by changes in blood rheology, hemostasis, and other parameters [7], including studies in simulated hypomagnetic space, an important trend of research.

Using geomagnetic shielding we studied possible relationship between blood rheology, hemostasis, and other parameters and the dynamics of heliogeophysical factors during human pre- and postnatal ontogeny.

MATERIALS AND METHODS

The study was carried out from October, 2005, to May, 2006. Blood specimens from volunteers (men and women aged 18-65 years): patients without cardiovascular diseases (reference group; n=70), patients with arterial hypertension (AH; n=102) and coronary disease (n=36) were analyzed *in vitro* before and after 30-min exposure of the samples in attenuated GMF.

The following characteristics were evaluated: erythrocyte sedimentation rate (ESR; after Panchen-

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kov), prothrombin index (after Quick), blood clotting time (after Mas-Magro), blood viscosity (by capillary viscosimetry modified by V. G. Kunitsyn, 1984), computer-aided gas discharge visualization (GDV; after K. G. Korotkov, 2002) [3] of blood samples; in addition, the data of satellite monitoring of space heliogeophysical environment on GOES devices (NASA) with registration of solar, space radiation (proton and electron streams of different energies) and geomagnetic activity, evaluated by A_p index, were used. Heliogeophysical situation during the early ontogeny was evaluated using Helios software (certificate on official registration of computer software No. 970125 of March 24, 1997). Attenuated geomagnetic field was simulated using a hypogeomagnetic device designed by Yu. A. Zaitsev (patent of the Russian Federation for invention No. 2012175 of April 30, 1994), reducing the complete vector of the Earth magnetic field induction 10- to 600-fold.

The data were statistically processed using paired Student's *t* test; the differences were considered significant at $p<0.05$. Analysis of correlations was carried out using Spearman's method; coefficients of correlation were considered significant at $p<0.05$.

RESULTS

A relationship between rheological, hemostatic, and other blood parameters and the intensity of heliogeophysical factors was detected. A relative increase of the whole blood (8.50±0.27 sP *vs.* the normal value up to 5 sP) was revealed in 99% of cardiovascular patients, this increase directly correlating with the number of sun spots on the day of the study ($r=0.61$; $p<0.05$). In cardiovascular patients, high sensitivity of the blood system to heliogeophysical factors was detected: increase of solar activity was associated with a trend to a reduction of blood fluidity and increase to its coagulation (Table 1). No appreciable relationship of this kind was observed in the reference group ($n=31$).

A significant inverse correlation between ESR and area of sun spots ($r=-0.33$; $p<0.05$) on the day of the study was detected in cardiovascular patients ($n=36$); in other words, ESR decreased with increase of solar activity. No relationship of this kind was noted in the reference group ($n=19$).

The spectral and frequency characteristics of the blood, recorded by computer GDV, are sensitive indicators of helio-biospheric effects [8]. A

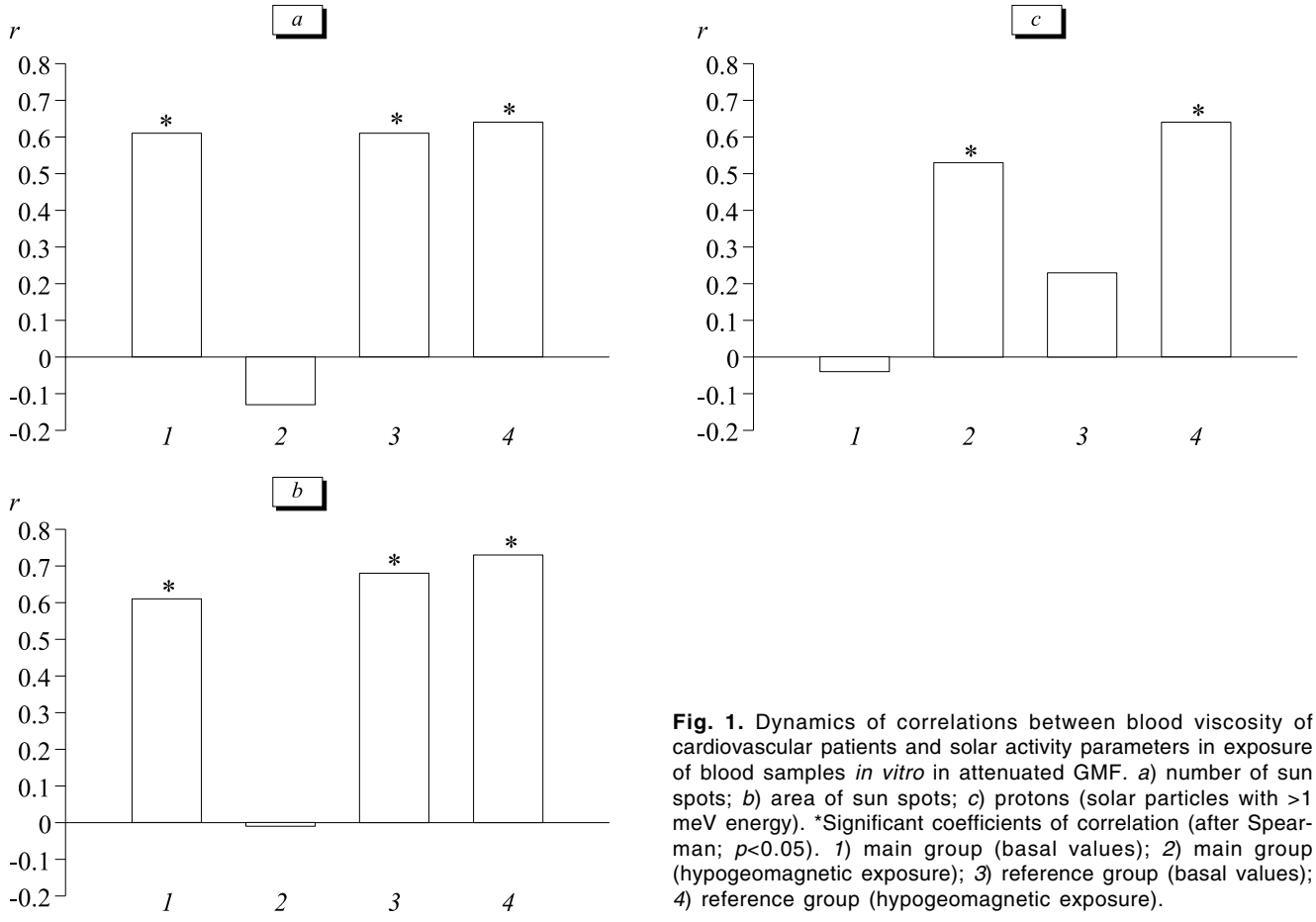

Fig. 1. Dynamics of correlations between blood viscosity of cardiovascular patients and solar activity parameters in exposure of blood samples *in vitro* in attenuated GMF. *a*) number of sun spots; *b*) area of sun spots; *c*) protons (solar particles with >1 meV energy). *Significant coefficients of correlation (after Spearman; $p<0.05$). *1*) main group (basal values); *2*) main group (hypogeomagnetic exposure); *3*) reference group (basal values); *4*) reference group (hypogeomagnetic exposure).

TABLE 1. Correlations between Hemostasis Parameters and Heliogeophysical Factors during the Study

Parameter	Main group (n=37)			Reference group (n=31)		
	CT	PI	BT	CT	PI	BL
NSS	-0.36*	0.46*	-0.01	-0.06	-0.15	-0.04
SR	-0.07	0.53*	0.14	-0.18	0.03	-0.08
A_p	-0.41*	-0.41*	-0.31	-0.14	0.02	0.32
Protons	0.06	-0.26	-0.11	-0.08	0.01	0.38*
Electrons	0.38*	-0.18	0.15	0.13	-0.09	0.33

Note. Here and in Table 2: CT: clotting time; PI: prothrombin index; BT: bleeding time; NSS: number of sun spots; SR: solar radiation in the 220 mHz band; A_p: mean circadian geomagnetic index; protons: solar particles with energy >1 meV; electrons: solar particles with energy >0.6 meV. *Significant coefficients of correlation (after Spearman; p<0.05).

TABLE 2. Type of Correlations between Hemostasis Parameters and Heliogeophysical Factors during Different Stages (Months) of Embryogenesis

Parameter	Main group (n=37)			Reference group (n=31)		
	CT	PI	BT	CT	PI	BL
A_p DC	0.13	0.44*	-0.04	0.26	-0.08	0.005
A_p 2	-0.02	0.10	0.46*	0.12	0.07	0.10
A_p 3	0.05	0.10	0.06	-0.13	-0.38*	0.42*
A_p 7	-0.38*	0.26	0.35*	-0.23	-0.21	0.32
A_p 8	-0.01	0.37*	0.25	-0.07	-0.08	0.15
A_p 10	-0.01	-0.01	0.50*	0.16	0.06	0.19
SA 1	-0.15	0.40*	0.27	0.20	0.14	0.16
SA 2	-0.10	0.38*	0.27	0.11	0.09	0.12
SA 3	-0.09	0.28	0.40*	0.13	0.02	0.09
SA 4	-0.15	0.28	0.37*	0.22	0.07	0.14
SA 8	-0.23	0.37	0.39*	0.05	-0.02	0.10
SA 9	-0.20	0.28	0.41*	0.16	0.17	0.05
SR DC	-0.52*	-0.08	0.28	-0.003	-0.02	0.28
SR 1	-0.52*	0.26	0.35	0.16	0.18	0.20
SR 4	-0.45*	0.10	0.47*	0.20	0.09	0.17
SR 5	0.57*	0.04	0.49*	0.09	0.13	0.17
SR 6	-0.58*	-0.01	0.49*	0.25	0.18	0.08
SR 7	-0.63*	-0.01	0.44*	0.14	0.22	0.04

Note. SA: solar activity values; DC: date of conception; 1-10: embryogenesis months; 11: postnatal month. *Significant correlations (after Spearman; p<0.05).

direct correlation (r=0.51; p<0.05) between the area of GDV fluorescence of blood samples from AH and coronary patients (n=65) and the intensity of solar activity, determined by the intensity of stream of protons with energy >10 meV, and a significant inverse relationship (p<0.05) of these GDV parameters with the intensity of streams of solar electrons (r=-0.35), low-energy (1-10 meV) protons (r=-0.54), and geomagnetic activity, evaluated by A_p index (r= -0.38), were detected. No relationships of this kind were detected in the reference group (n=20).

It seems that under experimental conditions of geomagnetic shielding, simulating individual elements of multilevel shielded megalopolis space [1], essentially modulating the degree of biotropic effects of natural physical factors, the group of cardiological patients exhibited reduction of correlations between blood viscosity and ESR (*in vitro*) and Wolf numbers and showed a new correlation between blood viscosity values and intensity of solar proton flows (r=0.53; p<0.05; n=32; Fig. 1).

Short-term (30 min) exposure of blood samples from cardiovascular patients to attenuated geomagnetic field led to a significant (9-fold) decrease in the number of significant relationships between blood GDV values and heliogeophysical factors. The only significant inverse correlation was detected: between the area of GDV fluorescence and intensity of protons with >1 meV energy (r=-0.38; p<0.05; n=65). No effects of this kind were detected in the reference group.

We evaluated possible relationship between rheological, hemostatic, and other parameters of the blood system and the heliogeophysical environment status not only during postnatal development, but also at the early stages of ontogeny. The results indicated a significant association (inverse correlation) between cardiovascular patients' blood viscosity and geomagnetic induction values during the 1st postnatal month (r=0.50; p<0.05; n=32). Significant (p<0.01) inverse correlations between blood viscosity and Sun radiation intensity during the early ontogeny were detected in 12 subjects of the reference group. Numerous significant coefficients of correlations (p<0.05), indicating an association of coagulation and fibrinolysis processes in the blood of AH and coronary patients with prenatal heliogeophysical fluctuations (changes in solar radiation intensity and geomagnetic induction fluctuations) were detected throughout all periods of intrauterine development (Table 2).

Short-term attenuation of geomagnetic field led to repeated manifestation of inverse correlation between blood viscosity and intensity of geomagnetic induction during month 3 of early ontogeny (r=-0.56; p<0.05; n=32) and a direct correlation between ESR and magnetospheric turbulence during the same prenatal period (r=0.38; p<0.05; n=36). Month 3 of embryonal development, characterized by the appearance of the bone marrow hemopoietic function, can be considered as one of the "critical" periods for the formation of functional relationships in the blood system, determining its sensitivity to many exogenous factors, including the heliogeophysical ones.

Comparison of blood samples' GDV parameters before and after short-term exposure to attenuated geomagnetic field showed that these parameters of cardiovascular patients were also associated with prenatal heliogeophysical situation: they exhibited a significant direct correlation (p<0.05; n=65) with the values of geomagnetic induction during months 1 and 2 of gestation (r=0.58, r=0.69, respectively) and solar radiation in the 220 mHz band during month 8 of intrauterine development (r=0.71) and during birth (r=0.66). No associations of this kind were observed under conditions of basal GMF (~49 000 nT at the latitude of Novosibirsk) in any of the groups of patients.

The mechanisms of "heliogeophysical imprinting", discovered by Novosibirsk scientists 20 years ago [2], remain little studied. Involvement of the blood system in imprinting of prenatal environmental factors was detected in cardiovascular patients, which seems important for further studies of mechanisms, including the genetic ones [14], through which the memory about conditions of early development can be imprinted in the cells till adult status and be needed by adult body [12]. Imprinting of heliogeophysical environmental factors, presumably realized through DNA methylation and blocking of gene expression at the earliest stages of prenatal ontogeny [11], can be an important factor in the pathogenesis of cardiovascular and other diseases.

Hence, the dynamics of bioheliogeophysical conjunctions between some human blood parameters under conditions of simulated hypomagnetic space demonstrated its biotropic effect on the blood clotting system in cardiovascular patients: many blood values in these patients proved to be much more functionally dependent on the values of heliogeophysical factors than in patients without AH or coronary diseases during the study and during prenatal development.

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