The intracellular regenerative processes in neurons in different parts of LHR differ in intensity. Repair processes begin initially and end sooner in neurons in the middle part (30th day), followed by in the anterior (50th day) part of LHR; normalization of neuronal structure in the posterior part proceeds more slowly and is not complete until the 70th day after resumption of feeding.

The results are thus not only of theoretical, but also of practical scientific importance, for they provide a basis for the development of methods of pathogenetic treatment of the diseases of starvation.

LITERATURE CITED

1. B. M. Abushov, Byull. Éksp. Biol. Med., No. 2, 205 (1976).
2. B. M. Abushov and L. B. Verbitskaya, Current Problems in Epidemiology, Clinical Features, Treatment, and Prevention of Tropical Diseases [in Russian], Moscow (1984), p. 62.
3. B. M. Abushov and L. B. Verbitskaya, Arkh. Anat., No. 1, 40 (1984).
4. D. S. Sarkisov, Regeneration and its Clinical Importance [in Russian], Moscow (1970).

QUANTITATIVE ANALYSIS OF DENDRITIC SPINES OF PYRAMIDAL NEURONS IN LAYER V OF THE SENSOMOTOR CORTEX OF RATS EXPOSED ON THE "KOSMOS-1667" BIOSATELLITE

P. V. Belichenko

UDC 629.78:612.825.22.014.2

KEY WORDS: sensomotor cortex, factors of space flight, spines.

The study of the variability of the number of dendritic spines (DS) during exposure to various physiological or chemical factors [1, 3, 6-11] has shown that this parameter is sufficiently labile and reflects a functional principle expressed as unique adaptation of the neuron to changing environmental conditions, involving restoration or loss of synaptic connections. The rodent sensomotor cortex accounts for almost one-third of the neocortex and is the dominant factor in the formation of adaptive responses of rats, by comparison with the visual and auditory cortex [4].

The aim of this investigation was to study the number of DS on pyramidal neurons in layer V of the sensomotor cortex, which are densely covered with spines, in rats exposed for 7 days to space-flight conditions on the "Kosmos-1667" biosatellite and in control experiments.

EXPERIMENTAL METHODS

Four groups of male Wistar-SPF rats (three animals in each group) were used: the flight group (F), the animal house control for the flight group (AHC-1); the ground control experiment group (GCE), i.e., the animals of this group remained on the ground and were exposed to the action of spaceflight factors, excluding weightlessness; and the animal house control for this group (AHC-2). The animals were decapitated and during the next 3 min the frontal block of the sensomotor cortex (PA^s and PA^m, FPP according to [4]) was excised and impregnated by Golgi's method. Spines were counted under the "Ortholux" microscope (Leitz, West Germany) under a magnification of 312, along a 100-μ long segment of dendrites, densely covered with spines, of pyramidal neurons in layer V of the sensomotor cortex. The number of DS was counted separately in the right and left cerebral hemispheres on apical and oblique dendrites, passing through layer III-IV, on apical dendrites passing through layer I-II, and on basal dendrites. The absence of data for layer I-II in the left cerebral hemisphere is explained by the use of this part of the brain for other purposes. In each animal DS were

---

Laboratory of Neuronal Structure of the Brain, Brain Institute, All-Union Mental Health Research Center, Academy of Medical Sciences of the USSR, Moscow.

(Presented by Academician of the Academy of Medical Sciences of the USSR O. S. Adrianov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 105, No. 6, pp. 736-738, June, 1988. Original article submitted May 25, 1987.

0007-4888/88/0006-0876$12.50

TABLE 1. Number of Spines per 100 μ Length of Dendrites of Large Pyramidal Neurons of Layer V of Rat Sensomotor Cortex

Dendrites	Cerebral hemisphere	Group of animals			
		F	AHC-1	GCE	AHC-2
Basal	R	41 (31—54)	47 (35—53)	43 (35—49)	33 (30—47)
	L	44 (39—58)	33 (27—47)	39 (30—43)	42 (34—50)
Apical:					
layer III-IV	R	61 (42—78)*	55 (43—61)	58 (44—66)*	47 (35—60)
	L	55 (38—69)*	40 (34—50)	51 (40—66)*	45 (39—51)
oblique layer III-IV	R	54 (41—57)**	44 (40—51)	46 (34—50)	46 (32—54)
	L	58 (44—66)**	42 (34—50)	45 (41—57)	46 (38—52)
layer I-II	R	18 (11—20)	16 (11—19)	16 (12—25)	14 (11—19)
	L	—	—	—	—

Legend. Values of parameter presented as median (lower and upper quartiles). R) Right, L) left hemisphere. *) Values of parameter in animals of group F differ significantly from those in group AHC-1 and those in group GCE differ significantly from those in AHC-2 ($\alpha = 0.05$); **) the same in group F from groups GCE, AHC-1, and AHC-2 ($\alpha = 0.05$).

counted on five neurons, so that in each group there were 15 values of the parameter. The significance of differences was calculated by the Kolmogorov—Smirnov test and the results were presented as the median (the lower quartile – upper quartile).

EXPERIMENTAL RESULTS

The results of morphometric determination of the number of DS on the large pyramidal neurons in layer V of the rat sensomotor cortex are given in Table 1. In these results no significant changes could be found in the number of DS in the right and left cerebral hemispheres, just as no significant changes were found in the number of spines on basal and apical dendrites passing through layer I-II. The most significant changes in the number of DS took place in cortical layer III-IV: for apical dendrites a significant increase in the number of spines was observed under experimental conditions (F and GCE) on average by 21% compared with the controls (AHC-1 and AHC-2), and for oblique dendrites a significant increase of 26% on average was observed under flight conditions compared with those on the ground (GCE, AHC-1, AHC-2).

The study of variability of the number of DS includes several different aspects. For instance, comparison of data in the literature showing that afferent fibers terminate predominantly in different layers of the cortex (see the reviews [2, 5]) indicates that specific fibers running from the thalamus into the sensomotor cortex terminate in layers III and IV; meanwhile there is evidence that callosal fibers terminate on spines of oblique branches of apical dendrites at the level of layer III [9]. With regard to our own data, we found what appeared to be a step by step increase in the number of functioning synaptic connections: the number of spines on apical dendrites was increased in GCE on account of powerful changes in the external environment and an increase in the inflow of impulses from the thalamus, whereas under the influence of weightlessness additional mechanisms were brought into action, and this was reflected in an increase in the number of spines on oblique dendrites, evidently as a result of consolidation of interhemispheric connections. Meanwhile there was no change in the number of DS on the basal dendrites under experimental conditions, although data in the literature indicate the ending of intracortical [2, 9] and extracortical afferents [5] on these dendrites. The negative data evidently indicate that space flight factors do not affect these afferent structures.

From the functional point of view, every factor acting on the body and the change in the number of DS associated with it can be subdivided into positive and negative. For instance, during exposure to positive factors (increased physical exertion, enrichment of the external living environment, learning, etc.) an increase is observed in the number of DS [1, 3, 9, 11], whereas exposure to negative factors (visual and motor deprivation) leads to a decrease in the number of DS [3, 8, 10]. Consequently the increase in the number of DS observed in the present experiments under the influence of space flight factors must be regarded as the effect of positive factors, although the increase in the number of DS is a change that lies within normal physiological limits, for it does not exceed the increase in the number of DS in response to exposure to various influences [1, 3, 6, 11].

LITERATURE CITED

1. L. F. Ivlieva, Functional-Structural Bases of Systemic Activity and Mechanisms of Plasticity of the Brain [in Russian], No. 3, Moscow (1974), p.175.
2. V. M. Mosidze and V. L. Ézrokhi, Relations between the Cerebral Hemispheres [in Russian], Tbilisi (1986).
3. É. N. Popova, S. K. Lapin, and G. N. Krivitskaya, Morphology of Adaptive Changes in Nerve Structures [in Russian], Moscow (1976).
4. V. M. Svetukhina, Arkh. Anat., No. 2, 31 (1962).
5. R. A. Chizhenkova, Structural-Functional Organization of the Sensomotor Cortex: Morphological, Electrophysiology, and Neurotransmitter Aspects [in Russian], Moscow (1986).
6. I. A. Shimko and É. N. Popova, Zh. Évol. Biokhim. Fiziol., 16, No. 6, 580 (1980).
7. R. G. Coss and D. H. Perkel, Behav. Neural Biol., 44, 151 (1985).
8. E. Fifkova, J. Comp. Neurol., 140, 431 (1970).
9. A. Globus and A. B. Scheibel, Science, 156, 1127 (1967).
10. A. Ruiz-Marcos, J. Sala, and R. Alvares, Brain Res., 170, 61 (1979).
11. S. Schapiro and K. R. Vukovich, Science, 167, 292 (1970).

SUBCELLULAR MECHANISMS OF THE ACTION OF WEAK SUPERFLOW-FREQUENCY ELECTROMAGNETIC FIELDS ON THE CEREBRAL CORTEX

I. M. Akimova and T. A. Novikova

UDC 612.825.1.014.426

KEY WORDS: weak superlow-frequency electromagnetic field, ultrastructure of neurons and glia.

Much interest is currently being displayed in the study of the action of electromagnetic fields (EMF) with parameters close to those of EMF of natural geophysical origin. Advantages of exposure to EMF include their high penetrating capacity, a no-contact method of application, and the possibility of regulating their parameters and conditions within wide limits. Accordingly, research into the action of EMF on subcellular changes in brain structures lying at the basis of changes in functional activity and the state of the CNS assumes particular importance.

We know that EMF can give rise to morphological changes in brain structures [3, 7-12]. However, data in the literature are clearly insufficient to explain the actual mechanism of the ultrastructural changes arising in the brain under the influence of EMF in general, and of weak superlow-frequency EMF (WSLEMF) in particular. Preference in research is often awarded to the study of one particular component of nerve tissue or a neuron, and the majority of investigations have been conducted at the light-microscopic level. The results have been interpreted variously, they are often contradictory, and this is evidence of the complexity of the problem, the fine nonlinear dependence on a multitude of parameters, the different orientation adopted toward the elucidation of morphological responses of the CNS, and different techniques of approach.

Moreover, the electromagnetic fields used by investigators differ sharply in their parameters from EMF of geophysical origin. The aim of this investigation was to study the effect of WSLEMF on the ultrastructure of the cerebral cortex.

EXPERIMENTAL METHODS

The brain of rabbits and rats, previously subjected to single (for 4 h) and repeated (for 4 h daily for 5 days) exposure to a square-pulse WSLEMF, with calculated induction of

I. P. Pavlov Physiological Department, Institute of Experimental Medicine, Academy of Medical Sciences of the USSR, Leningrad. (Presented by Academician of the Academy of Medical Sciences of the USSR N. P. Bekhtereva.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 105, No. 6, pp. 738-741, June, 1988. Original article submitted May 26, 1987.

 0007-4888/88/0006-0878$12.50