MORPHOLOGY AND PATHOMORPHOLOGY

STATE OF THE DENDRITIC SPINES OF PYRAMIDAL NEURONS IN LAYER V OF THE RAT SENSOMOTOR CORTEX AFTER 14-DAY SPACE FLIGHT

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Morphological evaluation of the state of interneuronal junctions in the cerebral cortex of animals taking part in space flight is an essential part of the study of the mechanisms lying at the basis of adaptation of the animal to a state of weightlessness. In previous investigations [1] we discovered the general principles governing changes in the number of dendritic spines (DS) of the pyramidal neurons of layer V of the sensomotor cortex, which are densely covered with spines, in rats after exposure to space flight factors for 7 days on the "Kosmos-1667" biosatellite.

The aim of this investigation was to analyze the number of DS on analogous neurons in the sensomotor cortex of rats kept under conditions of weightlessness during a 14-day space flight on the biosatellite "Kosmos-2044."

EXPERIMENTAL METHOD

Preparations of the sensomotor cortex of male Wistar-SPF rats of the flight group (F) (seven rats), the synchronous ground control group (GC) (five rats), the animal house control (AH) (six rats), and also of rats which, in order to abolish the supporting load on the hind limbs, were suspended for 14 days by their tail, and rested only on their forelimbs (group S) (three rats). During 3 months after decapitation of the animals, a frontal block of the right sensomotor cortex (PA^s, PA^m, FP^p, according to [4]) was excised from the animals' brain and the tissue was impregnated by Golgi's method. The spines were counted under an "Ortholux" microscope ("Leitz," West Germany) under a magnification of 312, along the length of 100 μ of secondary dendrites on pyramidal neurons of layer V of the sensomotor cortex, which are densely covered with spines. The number of DS was counted separately on apical and oblique dendrites passing through layers III-IV, and on basal dendrites. The significance of differences was calculated by the Kolmogorov—Smirnov and Wilcoxon—Mann—Whitney tests and the results were presented as the median quartiles (lower and upper).

EXPERIMENTAL RESULTS

Counting the number of DS on pyramidal neurons of layer V of the sensomotor cortex of the rats gave the results shown in Table 1. In rats of the F group, after a space flight lasting 14 days a significant increase was found in the number of DS on pyramidal neurons of layer V and on the trunk of the apical dendrites in layer III-IV on average by 12% compared with rats taking part in ground experiments (GC, S, and AH). The number of DS on oblique dendrites of layers III-IV increased significantly in rats of the F and S groups, but only by comparison with AH (on average by 14%). Meanwhile the number of DS on the basal dendrites was significantly increased in all the experimental groups of animals (F, GC, S) compared with AH (on average by 25%). It must be noted that in the rats of group S the number of DS of the basal and oblique dendrites was intermediate in position between the number of DS in the rats of the F and AH groups, whereas the number of DS on the apical dendrites was virtually indistinguishable from that in rats of the GC and AH groups.

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

Dendrite	Group of animals							
	F		GC		AH		S	
	n	values of parameters	n	values of parameters	n	values of parameters	n	values of parameters
Basal	22	47 (41—54)*	30	45 (35—52)*	38	36 (31—43)	22	44 (36—51)*
Apical, layers III-IV	28	55 (49—67)**	39	49 (39—57)	50	49 (38—54)	27	54 (46—57) 54 (46—57)
Oblique, layers III-IV	34	50 (47—58)*	44	47 (38—52)	47	44 (37—50)	29	50 (42—56)

Legend. Values of parameters shown as follows: median, lower and upper quartiles in parentheses; n) number of measurements. *) Significant difference of parameter in animals of groups F, GC, and S from AH ($\alpha = 0.05$); **) the same for rats of group F from GC, AH, and S groups ($\alpha = 0.05$).

Comparison of previous results concerning the number of DS on pyramidal neurons in the sensomotor cortex of rats after a 7-day space flight [1] with the results of the corresponding tests after a 14-day flight demonstrated the time course of the change in the number of DS of pyramidal neurons as a function of flight duration. On basal dendrites of rats after the corresponding ground control experiments, no changes in the number of DS by comparison with AH were observed, whereas in a 14-day experiment a significant increase in the number of DS (on average by 18%) was observed in rats of all the groups (F, GC, S) compared with AH. This increase in the number of DS was evidently connected with the animals' long stay in a complex experimental situation, saturated with additional stimuli, and is not specific for the state of weightlessness.

On apical dendrites of pyramidal neurons the number of DS in layer III-IV increased during the first 7 days of space flight [1]. With an increase in the duration of the flight to 14 days the number of DS on these dendrites continued to remain high, but the number of DS also increased significantly on the trunks of the apical dendrites passing through these layers. This increase in the number of DS we regarded as a sign of the establishment of new, additional interneuronal connections. We know that oblique dendrites of pyramidal neurons of layer V receive afferent impulsation from callosal fibers in layer III-IV of the sensomotor cortex [3, 5], and apical dendrites receive them from the thalamic nuclei [3]. Consequently, an increase in the number of DS on the oblique dendrites after 7 days of weightlessness can be regarded as a reflection of the process of formation of new, additional interhemispheric connections, which persist until the 14th day of space flight. An increase in the number of DS on the apical dendrites evidently reflects the formation of new connections with the thalamic nuclei. After a 7-day flight the morphological features of this process (an increase in the number of DS) are not yet present, but are found later, after a 14-day stay in weightlessness. The formation of new connections of the pyramidal cells of the sensomotor cortex in rats during weightlessness is a compensatory process, developing during a deficiency of afferent impulsation from the exteroceptors and proprioceptors of muscles, tendons, and joint surfaces, as is shown by a decrease in the number of axo-dendritic synapses in layer III-IV of the sensomotor cortex of rats after a 7-day space flight [2]. The formation of new connections in the sensomotor cortex of rats during weightlessness also is indicated by a sharp increase in the number of axonal and dendritic growth bulbs, which are found in rats after a 14-day space flight [6]. An increase in the number of DS on oblique dendrites of pyramidal cells took place also in the rats of group S, kept for 14 days in a ground experiment under conditions of an afferent impulsation deficit from the hind limbs, and in rats kept for 14 days in weightlessness, confirming the view that a deficiency of afferent impulsation is the cause of formation of new connections of the pyramidal cells of the sensomotor cortex in rats during weightlessness.

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