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BRAIN STEM CELLS, NEW NEURONS, AND RADIATION

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Manned exploration of space is accompanied by increased exposure to various types of radiation. There is emerging realization that among the risks associated with spaceflights are the effects that radiation may exert on the cognitive and emotional status of the explorers. These effects are mediated, in part, by the damage that radiation inflicts on neural stem cells and newly generated neurons of the adult brain. Newborn neurons that are produced in the adult hippocampus are involved in learning and memory, emotional state, and response to stress. Dividing stem and progenitor cells of the hippocampus are highly vulnerable to radiation, and various types of radiation exposure, e.g., during cancer therapy, effectively disrupt neurogenesis and production of new hippocampal neurons. Notably, this disruption is thought to underlie some of the impairments that with high incidence accompany radiation therapy, such as deficits in short- and long-term memory and learning, as well as increased anxiety and depression. Similar considerations pertain to spaceflights beyond low Earth orbit; therefore, understanding the basic mechanisms and consequences of radiation-induced damage to adult hippocampal neurogenesis is critical when considering the strategies for preventing or mitigating the neuropsychological effects of the deep space radiation exposure.

We study the effects of irradiation on adult hippocampal neurogenesis in animal models and humans. Our results reveal distinct changes that various types of radiation inflict on dividing neural progenitors and their immediate progeny. Unexpectedly, we found that quiescent neural stem cells, expected to be more resistant to the effects of radiation, show even higher sensitivity to radiation than their rapidly dividing progeny. Our results also demonstrate the delayed effects that exposure to radiation has on the cognitive reserve and complex features of learning and memory, such as pattern separation and re-learning. We will discuss the results in the context of differential susceptibility that radiation may have on distinct steps of the division and differentiation cascade of neural stem cells in the adult brain and on the associated cognitive function.

GRAVITY-DEPENDENT CHANGES IN THE FUNCTIONAL STATE OF THE NEUROMOTOR APPARATUS OF THE RAT CALF MUSCLES

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The study of the processes of reorganization of the motor function in the conditions of a changing gravitational environment is an urgent task of neurobiology and medicine.

On laboratory rats weighing 190–210 g, in compliance with all bioethical standards, the functional state of the neuromotor apparatus of the calf muscles was studied under conditions of simulated hypogravitation, as well as posthypogravitational readaptation. The method of antiorthostatic hanging (Ilyin E.A., Novikov V.E., 1980; Morey-Holton E.R. et al., 2002) in animals ($n = 15$) simulated of the hind limbs gravitational unloading (HU) for 35 days. After HU, as well as on days 1, 3, 7, and 14 of readaptation, the functional state of the following neuromotor systems was assessed: m. soleus (SM), m. tibialis anterior (TM) – the corresponding spinal motor centers. The motor and reflex responses of the muscles were recorded and analyzed. A decrement-test of the M-response was performed with repetitive stimulation of the sciatic nerve (3 Hz, 50 Hz). The data obtained in the study of intact animals ($n = 7$) were used as controls.

The results of assessing the parameters of the H-response after HU indicated an increase in the reflex excitability of the SM and TM motor centers ($p < 0.05$). However, already on day 1 of readaptation, a decrease in reflex excitability of the corresponding motor centers ($p < 0.05$). On day 3 of the readaptation period, an increase in the amplitude of the SM H-response ($p < 0.05$) and the H/M ratio ($p < 0.05$) was found. In addition, it was found that at all studied stages of readaptation, the duration of the SM H-response increased and, on average, was 126 ± 7 % ($p < 0.05$). When evaluating the parameters of the SM M-response, it was found that after 35 days of HU, the threshold of the M-response was 75 ± 13 % ($p < 0.05$); on day 1 of readaptation, the threshold of the M response increased to 156 ± 11 % ($p < 0.05$); maximum amplitude of the SM M-response after 35 days HU was 73 ± 11 % ($p < 0.05$), on day 1 of readaptation – 68 ± 13 % ($p < 0.05$), on day 3 of the readaptation period the amplitude increased to 128 ± 12 % ($p < 0.05$). Also, during the period of readaptation, an increase in the duration of the SM M-response, on average, up to 118 ± 6 % ($p < 0.05$). When testing TA, an increase in the M-response threshold to 121 ± 8 % ($p < 0.05$) was recorded on day 1 of readaptation. The results of the decrement-test (50 Hz) SM and TA M-response both after HU and during readaptation showed a significant decrease in the reliability of neuromuscular transmission.

Thus, under conditions of limitation and subsequent restoration of the action of the reaction force of support and axial loads and, as a consequence, changes in the intensity of peripheral afferentation, first of all, support afferentation, there is a change in the functional state of the motor centers and the peripheral structures of neuromotor systems under their control. The processes of gravitational-dependent motor reorganization are more pronounced in the tonic «anti-gravity» muscles.

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