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Exposure to 1 Gy protons, 1 Gy neutrons or their combination at a dose of 0.5 Gy for each particle does not affect emotional state, but affected body weight of rats

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Ionizing radiation (IR) is one of the major limiting factors of human deep-space missions. Studies have shown that biological effects are non-linearly dependent on the dose and composition of ionizing radiation. Both negative effects (impairment locomotor and cognitive abilities, anxiogenic effect) and positive one (enhanced cognitive abilities, exploratory and novelty-seeking behavior) were found in rodent experiments. Attention is paid to the study is devoted to the analysis of the mechanisms of radiation-induced effects on the CNS and their relationship with physiological characteristics after exposure to ionizing radiation. Here, we study the effects of protons, neutrons and their combination irradiation on body weight and emotional state of Sprague Dawley rats. At the age of 2 months, animals were irradiated in the following scenarios: 1 Gy of neutrons or protons separately or 0.5 and 0.5 Gy of neutrons and protons sequentially to get a combined effect. The animal's behavior was studied using the open field test and elevated plus maze, which enables assessment of emotional state, 30- and 90-days post-irradiation. Also, body weight was assessed. Since the data obtained followed a Gaussian distribution, the analysis was performed using the one-way ANOVA method followed by the Games-Howell post-hoc test. There are no effects of radiation exposure in all scenarios used on the emotional state of the rats were found, both 30 and 90 days after exposure. At the same time, radiation affected the weight of rats at Day 30 ($F_{3.24}=3.1$, $p=0.048$) and Day 90 ($F_{3.24}= 4.3$, $p=0.01$) after irradiation. Thus, protons irradiation resulted in an increase in rats' body mass by 4% ($p=0.03$) compared naïve animals at the Day 30 after irradiation. On the contrary, at Day 90 day after irradiation, an increase in body weight was found in rats exposed to protons and a combination of protons and neutrons, respectively, by 7.8% ($p=0.02$) and 6.5% ($p=0.03$) compared to the naïve rats. We consider it important to note the observed tendency towards an increase in grooming acts ($F_{3.24}=3.2$, $p=0.04$) in animals exposed to proton irradiation at Day 90 post-irradiation – by 37.5% ($p=0.076$) compared to naive rats. Earlier studies have shown a decrease in body weight in rats after 7 months (combined 0.4 Gy γ-rays and 12C 0.14 Gy, 10.3 keV/μm) and body weight gain in mice 21 months post-irradiation (252Cf source, 1 mGy/day; 0.2 Gy totally). At the same time, a number of studies revealed no effect of irradiation on the body weight of mice under different irradiation scenarios: 28Si (0.2 or 1 Gy, 67 keV/μm), 56Fe (0.1 or 0.5 Gy, 151 keV/μm), and mixed HZE (H+, 4He, 12C, 16O, 28Si, 48Ti, 56Fe with different energy, 0.75 Gy totally). Thus, in spite of the effects detected, IR has no critical effect on the physical development of rodents. We suggest that IR (within the range of composition and doses used) can be relatively safe for the functions of the CNS.

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