Measuring the neuronal activity of hypothalamus and behavior of rats on the diffuse low gravity conditions

Y. Kumei[1], J L. Zeredo[2], S. Seki[1], M. Matsuura[3], M. Kimoto[4], D. Kageyama[5], Y. Fusejima[6], T. Ikeda[2], and K. Toda[2]
[1]Graduate School of Tokyo Medical and Dental University, [2] Graduate School of Nagasaki University, [3]Japanese Foundation for Cancer Research, [4]Japan Women's University, [5]Diamond Air Service, Co., [6]Japan Space Forum Foundation, Japan
kumei.bch@tmd.ac.jp

The purpose of the present study is to examine the rat behavior on diffuse low gravity conditions. We have succeeded for the first time in generating diffuse low gravity conditions from 0.4G through 0.01G by using the unique method of parabolic flights that were operated by Diamond Air Service, Co at the Nagoya airport in Japan. The final goal is to assess the potential risk and/or benefit for the animal and human activity on the low gravity conditions such as those encountered on the surface of the Moon and Mars. In parallel with the observation of rat behaviors, the neuronal activity in the hypothalamic arcuate nucleus (ARC) was measured by telemetry through chronically implanted microelectrodes in freely moving rats during the parabolic flights. All the rats were maintained in the facilities on a 12-hr light/dark cycling schedule with ad libitum access to food and water throughout the duration of the experiment. The treatment of the rats was in accordance with the guidelines of Tokyo Medical and Dental University, Nagasaki University, and the animal use committee of JAXA Japan Space Agency. The insertion site of the electrodes was identified histologically following rat sacrifice after all the experimental operations were completed post-flight. As the airplane produces low gravity conditions by a parabolic vertical flight path, the aircraft will exert less G force as relative to the aircraft. Shortly after the aircraft was heading upward at a certain angle, the pilot immediately started the rotation into the parabolic trajectory. While the aircraft flies on this locus, it loses altitude significantly to generate the targeted low gravity level for several seconds. The aircraft finally pulls into an upward posture to get back to the normal static flight. Four rats were used aboard the aircraft daily, and a total of 12 rats were used during four continuous days. Rats were exposed to a certain level of low gravity repeatedly for three times in each day. Rat behavior was recorded by digital video cameras throughout the static and parabolic flights at varied gravity conditions. Cowering was observed in rats that were exposed to 0.2G and 0.15G. Locomotor activity, grooming, freezing, depression, and rearing up were observed at varied low gravity levels from 0.15G through 0.05G. Tumbling, a typical sign that is observed in weightlessness, was observed at 0.01G. These stress-related behaviors were observed less frequently by the repeated exposure to the same level of low gravity. The rat "adaptation" to low gravity environments was assessed quantitatively by comparing the neuronal activity of the same rat in response to the 1st time exposure versus to the 3rd time exposure of the same gravity condition (paired t-test). Low gravity was the stressful condition for rats, of which activity was quantified by the neuronal activity at the neuroendocrine control center, hypothalamus. In conclusion, we have succeeded for the first time in assessing rat behaviors in diffuse low gravity conditions. Our success in the unique flight experiments would provide beneficial impacts on the future life sciences in differential gravity environments. The achievements in this study are useful to predict the human activity on the Moon and Mars in the future manned space flight missions.

This study was supported by Japan Space Forum Foundation to Y.Kumei (FY2006-2007) and by a Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science to Y.Kumei (No. 18659569, FY2006-2007).