Department of Cell Physiology
Division of Aerospace Medicine

Susumu Minamisawa, *Professor* Masamichi Sudoh, *Professor*

General Summary

Our main research interests are gravitational physiology and aerospace medicine.

Research Activities

Gravitational physiology and aerospace medicine

1. Elucidation of the re-adaptation of attitude control after the return from long-term space flight

Astronauts returning from a long stay in space will be observed to learn more about the adaptive processes in the somatosensory system and the lower limb skeletal muscles and to acquire data that could contribute to astronaut rehabilitation after returning from space. We are collaborating with the Japan Aerospace Exploration Agency (JAXA) to perform this research. In this experiment, astronauts staying for a long time in space will be studied to measure the following items before and after their stay in orbit:

(1) Comparison of muscle activation patterns in lower limb antagonistic muscles
(2) Blood flow measurement in the lower limb skeletal muscles
(3) Body sway balance measurement

We collected and are analyzing data from 3 astronauts. We have obtained a preliminary result that the combination of skeletal muscles that are actived while the body sway balance is maintained did not recover to a nomal combination, even months after the astronauts returned to Earth. On the other hand, the astronauts' gait motion recovered and they could walk normally immediately after they returned to Earth.

2. Biomedical analyses of human hair exposed to long-term space flight

As a sample for experimental analysis, human hair has many advantages. Hair matrix cells actively divide in a hair follicle and sensitively reflect physical conditions. The hair shaft has an advantage to record the metabolic conditions of the subject's environment. The environment of space differs from that of the Earth in many factors, such as microgravity, space radiation, and mental stresses. These factors often induce physiological changes in our body. Hair samples will give us useful physiological information to examine the effect of space flight. In space experiments, we believe that hair is a suitable biological specimen because no special hardware or handling is required. We have recently published a paper in *PLOS ONE* reporting the results of this experiment. In this paper, we demonstrate that in some astronauts, genes related to hair growth are upregulated during flight, suggesting that space flight inhibits cell proliferation in hair follicles.

3. Effects of heat stress on skeletal muscle properties

Space flight causes the loss of muscle mass, particularly in antigravity muscles. Astronauts exercise for 2 hours almost every day on the International Space Station to prevent

the negative adaptation of skeletal muscles. However, the effect is limited. Skeletal muscles are exposed to various stressors during and after exercise. These stressors activate intracellular signaling and strengthen skeletal muscles. We hypothesized that stressors might be insufficient during space flight, even if astronauts exercise well and if external stimuli, which induce activation of intracellular signaling in muscles, could be useful as another countermeasure for astronauts. We are now focusing on heat stress and studying its effect to maintain and increase skeletal muscle properties.

Publications

Islamov RR*[1]*, Gusev OA*[2]*, Tanabe A*[3]*, Terada M, Tyapkina OV*[4]*, Petrov KA*[4]*, Rizvanov AA*[4]*, Kozlovskaya IB*[5]*, Nikolskiy EE*[1]*, Grigorjev AI*[5]*(*[1]Kazan State Med Univ,** [2]***Kazan (Volga Region) Federal Univ,*** [3]***Subio Inc.,*** [4]***Kazan Inst Biochem Biophys Russ Acad Sci,*** [5]***Inst Biomed Prob Russ Acad Sci).*** Full-genome study of gene expression inlumbar spinal cord of mice after 30-days pace flight on Bion-M1 biosatellite. *Acta Astronaut.* 2016; **122:** 231-6. Epub 2016 Feb 15.

Indo HP*[1]*, Tomiyoshi T*[1]*, Suenaga S*[1]*, Tomita K*[1]*, Suzuki H*[1]*, Masuda D*[1]*, Terada M, Ishioka N*[1]*, Gusev O*[1]*, Cornette R*[1]*, Okuda T*[2]*, Mukai C*[3]*, Majima HJ*[1] *(*[1]Kagoshima Univ,*** [2]***Natl Inst Agrobiol Sci,*** [3]***JAXA).*** MnSOD downregulation induced by extremely low 0.1 mGy single and fractionated X-rays and microgravity treatment in human neuroblastoma cell line, NB-1. *J Clin Biochem Nutr.* 2015; **57:** 98-104.

Ishihara A*[1]*, Nagatomo F*[1]*,Terada M, Fujino H*[2]*, Kondo H*[3]*, Ishioka N*[4] *(*[1]Kyoto Univ,*** [2]***Kobe Univ,*** [3]***Nagoya Women's Univ,*** [4]***JAXA).*** Effects of microgravity on the mouse triceps branchii muscle. *Muscle Nerve.* 2015; **52:** 63-8.

Terada M, Seki M*[1]*, Takahashi R*[1]*, Yamada S*[2]*, Higashibata A*[3]*, Majima HJ*[3]*, Sudoh M, Mukai C*[2]*, Ishioka N*[3] *(*[1]Adv Engn Serv Co., Ltd.,*** [2]***JAXA,*** [3]***Kagoshima Univ).*** Effects of a closed space environment on gene expression in hair follicles of astronauts in the international space station. *PLoS One.* 2016; **11:** e0150801.