1. Title
FY2006 Ground-based Research Program for Space Utilization Research Report

2. Research Term
FY2006~2008

3. Research Fields
Life Science

4. Research Categories
Exploratory Research for Space Utilization

5. Research Theme
Effects of hyperbaric oxygenation on unloading-induced degeneration of neuromuscular units

6. Investigator
Akihiko Ishihara

7. Organization
Graduate School of Human and Environmental Studies
Kyoto University
Sakyo-ku, Kyoto 606-8501, Japan

8. Summary of Research
Mammalian skeletal muscle fibers are classified into slow-twitch (ST) and fast-twitch (FT) on the basis of their enzyme histochemical profiles. ST fibers perform relatively low-intensity and prolonged antigravity activities such as the maintenance of posture and walking. In contrast, FT fibers are responsible for strength and power activities of a relatively high-intensity and short-duration. Exposure to microgravity induces an atrophy of fibers, especially of ST fibers and a type shift of fibers from ST to FT. Furthermore, decreased oxidative enzyme activities in the spinal motoneurons innervating skeletal muscle fibers, predominantly ST fibers, were observed following exposure to microgravity. An atrophy of fibers and a decreased oxidative metabolism in skeletal muscles also induce life-style related diseases such as diabetes and hypertension.

This study investigated the changes in the fiber type composition, cross-sectional area, and oxidative enzyme activity in the soleus muscle and the deep and surface portions of the plantaris and tibialis anterior muscles in rats following unloading. In addition, this study investigated the unloading-induced changes in the number, cell body size, and oxidative enzyme activity of spinal motoneurons innervating the soleus and plantaris muscles in rats.

An increase in the atmospheric pressure accompanied by a high concentration of oxygen enhances the partial pressure of oxygen and increases the concentration of dissolved oxygen in the blood and plasma. Such an increase in the pressure and oxygen enhances the
oxidative enzyme activity in mitochondria and consequently increases the oxidative metabolism of cells. Furthermore, an enhancement in the oxidative metabolism of cells increases the carbon dioxide concentration in the surrounding region, and this in turn facilitates the release of oxygen from hemoglobin and causes dilation of the blood vessels. Therefore, it is suggested that the adaptations of neuromuscular units to hyperbaric oxygenation enhance the oxidative metabolism of cells and thus recover the unloading-induced degeneration of neuromuscular units. This study investigated the effects of hyperbaric oxygenation on the unloading-induced degeneration of neuromuscular units.

Ten-week-old male rats were hind limb-suspended for 2 weeks. Thereafter, the rats were recovered with or without hyperbaric oxygenation (1.25 atmospheric pressure and 36% oxygen concentration) for 2 weeks. An atrophy of fibers, a type shift of fibers from ST to FT, and a decrease in the fiber oxidative enzyme activity of the soleus muscle and in the deep and surface regions of the plantaris muscle, which were induced by unloading, were not recovered under normal conditions, but they were recovered with hyperbaric oxygenation. Blood volumes on the surface of the soleus and plantaris muscles were decreased after unloading, but they were increased during recovery with hyperbaric oxygenation. There were no changes in the number, cell body size, or oxidative enzyme activity of motoneurons innervating the soleus and plantaris muscles in rats after hindlimb suspension or recovery with or without hyperbaric oxygenation.

It is concluded that hyperbaric exposure with high oxygen concentration provides a new approach for the prevention of degeneration in the neuromuscular units.

9. Publication List

10. URL
None