1. Title
   FY2005 Ground-based Research Program for Space Utilization Research Report
2. Research Term
   FY2005〜2007
3. Research Fields
   Life Science
4. Research Categories
   Incoming Research for Space Utilization
5. Research Theme
   Study of the development of effective device to maintain skeletal muscle in the space
6. Investigators
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8. Summary of Research

[Background] The mechanical load on the musculoskeletal system remarkably decreases under the microgravity environment, and the skeletal muscles and bones are atrophied. However, the effective countermeasures are not available, and the prevention of the musculoskeletal disuse atrophy is considered important for the future human space exploration. In the weightlessness environment, it also is considered important to make the resistance on the musculoskeletal system instead of the gravity. We developed ‘Hybrid exercise’ method that is designed to maintain the musculoskeletal system by using electrically stimulated antagonist muscles to resist volitional contraction of agonist muscles (Fig.1). In other words, the Hybrid exercise produces resistance force against the human activity in the human body using simple device instead of gravity in the weightlessness. This approach also has the advantage that it may minimize the need for external stabilization that is currently necessary during exercise in a weightlessness environment. The conventional electrical stimulation uses electrical stimulation regardless of the intention of the user. However, Hybrid exercise stimulates the antagonist as the motion of the user’s intention.

[Purpose] The purposes of this study were 1) development of the device to maintain the skeletal muscles for the astronaut, and 2) evaluations of muscle strength and hypertrophy, 3) evaluation of effect on the bone, and 4) evaluation of clinical effect and practical use.

[Study contents and the results summary] 1) Hybrid training system for the astronauts was developed with improvement of stimulating electrodes, electrical stimulator and virtual reality system (Fig.2). 2) Influence to finger skill, gait, and serum activities were also evaluated with the muscle force. 3) Muscle biopsy was carried out to evaluate the mechanisms of the Hybrid exercise. Appropriate stimulation intensity was determined, and muscle strength increasing effect was observed safely. 4) Experiment was performed in the
microgravity environment by parabolic flight using the Hybrid exercise system which was installed in the intelligent suit. The hybrid exercise system worked well, and the exercise was possible in the microgravity. The Hybrid system was considered useful in the space.

[Future prospects and development] By the Hybrid exercise, which is the application of the technology of rehabilitation medicine, the musculoskeletal disuse atrophy could be prevented efficiently both in the space and in the clinic. Development of the device for the astronaut will be carried out with that of clinical experiments simultaneously, and the spin-off to the clinical field from the results of research of the space will be possible also. The study of development of Hybrid training system will be continued in the future to make it more effective and safer.

Fig.1

Fig. 1: Scheme of Hybrid exercise method.  Fig. 2: Intelligent suit used for parabolic flight.  Power supply, stimulator and electrodes of the Hybrid exercise system were installed in the ‘Intelligent suit’.

9. Publication List


10. URL