1. Title

2. Research Term
FY 2002~2003

3. Research Fields
Space Medicine

4. Research Categories
Germinating Research

5. Research Theme
Study of the development of the effective device for maintaining the skeletal muscle in the space

6. Investigators
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7. Organization
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8. Summary of Research
Objective: We developed a novel ‘hybrid’ exercise method that is designed to strengthen and maintain the bulk of muscles by using electrically stimulated antagonist muscles to resist volitional contraction of agonist muscles as they move through their range of motion. This approach produces a minimum of inertial reaction forces and has the advantage that it may minimize the need for external stabilization that is currently necessary during exercise in a low gravity environment.

Objectives: 1) To develop a hybrid elbow flexion and extension muscle strengthening device, 2) To assess the effectiveness and safety of hybrid exercise in strengthening and maintaining the bulk of the elbow flexor and extensor musculature.

Method: Objective 1) Development of the elbow flexion-extension hybrid exercise device; Objective 2) Assessment of safety and effectiveness. 18 healthy sedentary males were divided into three groups (Hybrid, Dumbbell, and Electrical Stimulation (ES)) of 6 individuals. Elbow flexion and extension exercises were performed for 8 weeks on a 3 times a week schedule. Exercise sessions (including rest periods) lasted 15 minutes 40 seconds. Electrical stimulation intensities were adjusted to a level of 20-30% Maximal volitional contraction (MVC). The weight of dumbbell was determined as 40%MVC of elbow flexion torque in each
subject. Elbow flexion and extension torque and MRI measurement of biceps and triceps brachii cross sectional areas (CSAs) were assessed at the beginning and completion of the 8-week exercise period. Subject complaints of discomfort and serum creatine kinase (CK) concentration were assessed at the same times.

Results: Objective 1) The hybrid elbow flexion and extension exercise device was developed and bench tested. Objective 2) Elbow flexion and extension torques increased significantly in the Hybrid and Dumbbell groups. In the Hybrid group, elbow flexion torque increased from 24.51 ± 5.52 Nm at the beginning of the trial to 41.19 ± 9.75 Nm (p<0.01) at the end of the 8-week program; extension torques increased from 35.85 ± 7.73 Nm to 47.01 ± 11.52 Nm (p<0.01) over the same period. In the Dumbbell group, flexion and extension torques increased from 27.38 ± 8.10 Nm to 37.01 ± 8.24 Nm (p<0.01) and 27.75 ± 9.05 Nm to 36.01 ±11.12 Nm (p<0.01) respectively over the same period. Changes in the ES group did not reach statistical significance. Biceps and triceps CSAs in the hybrid exercise group increased by 14.8% (p<0.01 and 8.5% (p<0.05) respectively over the course of the trial. Changes in bicep and triceps CSA were 14.7% (p<0.01) and 0.9% (n.s.) respectively in the Dumbbell group and 13.4% (p<0.01) and 5.4% (p<0.05) in the ES group. Pain complaints were limited to the first few sessions of training and were minimal in all groups. CK elevations were not observed in any of the groups.

Conclusion and Potential for space-based exercise: Hybrid exercise appears to be as safe and effective as dumbbell exercise in increasing the strength and bulk of the biceps and triceps brachii muscles. Hybrid exercise, however, has the advantage of generating a minimum of inertial reactive forces and may be an effective approach to maintaining the strength and mass of skeletal muscles in a weightless environment. Further research will be performed to assess the effects of this approach on the muscles and bone density of the lower extremities.

9.Publication List

10.URL