Effects of and Interventions for Muscle Loss in Space

Student Researcher: Allison I. Schacht

Advisor: Lee Grinonneau

Owens Community College
Physical Therapists Assistant Program

Abstract

Many experiments and studies have been conducted regarding the effects of weightlessness in space. During space flight, gravity no longer influences the human body. In return, the musculoskeletal system changes in response to the demands placed upon it. Results from a musculoskeletal study compared the amount of atrophy seen in fast twitch and slow twitch fibers. Fast twitch fibers produce force for rapid movement and exercise, compared to slow twitch fibers which generate force for prolonged continuous activity and which are important for maintaining posture. The results from this study suggest slow twitch fibers tend to atrophy faster than those of fast twitch fibers. When slow twitch fibers are exercised, they rely on primarily an aerobic process, which require energy stored in carbohydrates, fats and proteins. Since the aerobic process is significantly altered in space, the loads placed on the slow twitch fibers in particular are also altered, eventually causing atrophy.

Maintaining a strict exercise program is crucial in order to maintain body mass and strength. After being strapped down, astronauts use stationary bikes and treadmills during in-flight exercise. Weight loading exercises are also used to simulate the gravity of earth in order to build muscle mass. Despite exercise, however, researchers believe that crewmembers are continuing to loose muscle strength. Additional interventions are currently being developed including those that provide the astronauts to exercise against different levels of resistance.

Project Objective

My objective is to research the causes of muscle loss in space, the specific effects these causes have on muscles and research interventions being used to reduce the effects of muscle loss in a weightless environment.

Methodology Used

I used information coming from research involving muscle atrophy in space, interventions for muscle atrophy in space and that particularly of the LMS musculoskeletal experiment. This musculoskeletal experiment took an interest in the muscles that move the ankle, elbow and wrist joints. Two muscles in the lower leg, the gastronemous and the soleus control the ankle. The soleus has more slow twitch fibers than the gastrocnemous with more fast twitch fibers. The Biceps (elbow flexion) and triceps, (elbow extension) are less critical in the resistance of gravity and have about the same percent of slow and fast twitch fibers. Since the calf group is an important anti-gravity group, and the biceps of the arm muscle are not, this investigation compares the effects of weightlessness on weight and non-weight bearing muscle groups. To investigate this system, the crewmembers will participate in a comprehensive series of tests before, during and after the mission to measure muscle performance. Oxygen intake and the utilization of oxygen, muscle size, and the percentages of slow and fast twitch fibers as well as cellular characteristics. These results will be added to measures of electrical responses of muscle tissue to control voluntary activation of muscles. These include EMG; electrical potentials produced by contractions of the muscle and ECGs, electrical potentials produced by contractions if the heart.

Results Obtained

Results from this combination of data will provide a more detailed understanding of how and why the activity of the muscular movements are affected by the immediate and prolonged exposure to microgravity in space. These results may also bring light to new or more advanced exercises or equipment that could be used in space to reduce the affects of muscle atrophy. Astronauts today participate in a planned exercise program to help counteract the effects of a weightless environment. Flight doctors now recommend 15 minutes of exercise daily for a 7- to 14-day mission and 30 minutes of exercise daily for a 30-day mission. This exercise will also help the astronauts adjust better to the gravity of the earth when they return home. The results of additional research in these same areas are currently being conducted.

Significance and Interpretation of Results

From a physical therapy standpoint, I feel that results from musculoskeletal experiments and those including exercise in space can lead way for huge developments in the future of space flight. A more detailed understanding of the process in which muscle loss occurs, the time line in which this loss occurs and the groups of muscles most likely affected could lead researchers to new interventions for the future. Perhaps rubber or latex bands can be used at different resistances to provide progressive weight bearing forces for the muscles. At the same time, these bands can provide the astronauts with a resistive exercise in different planes of motion that we use every day on earth. Space suits lined with similar resistive forces could also be worn even while the astronaut is not working out, and would still mimic that of a weight-bearing environment. I hope that with ongoing studies and knowledge, researchers can reach a turning point in their musculoskeletal investigation and in the development of interventions for the astronauts in the future.

References

1. Exercising Astronauts. (1995, September 22). Liftoff.msfc.nasa. Retrieved October 13, 2002: http://liftoff.msfc.nasa.gov/academy/astronauts/exercise.html
2. Maintaining Strength in Space: Bone, Muscle, and Metabolic Studies. (1998, September). Spaceflight.nasa. Retrieved November 29, 2003: http://spaceflight.nasa.gov/shuttle/archives/sts-95/factsheets/fs1998_09_009jsc.html
3. Muscle and Bone Loss in Space. (2002, October). Discovery. Retrieved November 29, 2003: http://www.discovery.ca/ISS/MedicalDangers.cfm
4. Musculoskeletal Experiments. (1996, May 3). Liftoff.msfc.nasa. Retrieved October 17, 2003: http://liftoff.msfc.nasa.gov/shuttle/lms/overview/mus.html