Muscle Volume Increases Following 16 Weeks of Resistive Exercise Training with the Advanced Resistive Exercise Device (ARED) and Free Weights

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Abstract

Space flight-induced muscle atrophy, particularly in the postural and locomotory muscles, may impact task performance during long-duration space mission and planetary exploration. High intensity free weight (FW) resistive exercise training has been shown to prevent atrophy during long-term space flight (Shackelford, 2004). The Advanced Resistive Exercise Device (ARED) is a portable, compact exercise device that requires less equipment and reduces costs compared to FW. ARED training elicited increases in muscle volume and strength that were not different than training with FW at the Johnson Space Center, National Aeronautics Space Administration (NASA). Increased muscle function may impact crew performance and mission success during long duration missions and planetary exploration. The increases in muscle volume and strength following ARED training is not different than FW training. With the training regimen similar to FW and a 23% load capacity, ARED training will provide resistance to muscle atrophy in microgravity.

Purpose

The purpose of this study was to compare the efficacy of ARED and FW training to induce hypertrophy in specific muscle groups in ambulatory subjects.

Introduction

• Muscle atrophy and reduced muscle strength have been observed following long-duration space flight (LaForce, 2000; Trappe, 2008).
• Decreased muscle performance is considered a human health and performance risk by the Human Research Project at the Johnson Space Center, National Aeronautics and Space Administration (NASA).
• Decreased muscle function may impact crew performance and mission success during long duration missions and planetary exploration.
• The Interresistive Exercise Device (IRED) has been utilized since the first International Space Station (ISS) mission as a countermeasure for stress losses and muscle atrophy, but did not prove to be completely protective (Lee, 2004).
• ARED was developed by NASA to address IRED's limitations in loading capacity. 1.36 kg of maximal resistance, limited range of motion, and lower eccentric forces that may have decreased in efficacy.
• ARED, recently deployed on ISS during Expedition 18, provides up to 272 kg of assistance of the Exercise Physiology Laboratory members for their hard work and dedication to this project.  A special thank you to the test crew members.

Methods

Twenty volunteers (14 men, 6 women) consented to participate in this study and were assigned to either the FW or ARED training group. The study protocol was reviewed and approved by the Johnson Space Center’s Committee for the Protection of Human Subjects.

• Subjects performed squat belt mini, and deadlift exercises 4 days/week for 16 weeks using a periodized resistive exercise training program.
• Each subject performed a maximum resistance strength measurement (1RM) on both the ARED and FW. Training loads were prescribed from the 1RM acquired on the training specific hardware for each exercise before training and after 8 weeks of training.
• FW & ARED 1RM were measured pre-, mid-, and post-training for all three exercises.
• Magnetic Resonance Imaging (MRI) was acquired pre- and post-training.
• Data were analyzed using a training group x time repeated-measures ANOVA (p<0.05) and a muscle group x time ANOVA (p<0.05). Tukey’s post hoc test was used to determine pair-wise differences when a significant F Score was found.

MRI Methods

• Subjects laid supine for 15 minutes to equilibrate fluid distribution.
• Cross-sectional images (8 mm slices with a 2 mm gap) were acquired using a 1.5T MRI system (Signa, GE Healthcare).
• Cross-sectional area (CSA) was calculated within each slice of the Rectus Femoris (RF), the Vasti group (V), the Hamstring group (H), and the Adductor group (Add). The increases in the V, Add, LG, and MG over the rest of the muscle groups in the thigh and the Anterolateral Compartment (ALC), Lateral Gastrocnemius (LG), Medial Gastrocnemius (MG), and the Deep Posterior group (DP) in the calf.
• CSA = (# of pixels) (sum of slice thickness and interslice gap).

Results

• Subject groups were not different in age (AGED: 31 ± 5 yr; FW: 32 ± 4 yr), height (AGED: 179 ± 8 cm; FW: 171 ± 7 cm), or body mass (AGED: 79 ± 14 kg; FW: 75 ± 11 kg).
• There were no between-group differences in strength gains in squat, bench press, or deadlift.

• Muscle volume increases were greater in the V and Add than the RF and H in the thigh (P<0.05). In the calf LG and MG muscle volume increases were greater than the ALC and DP (P<0.05).

• CSA = (# of pixels) (sum of slice thickness and interslice gap).

Conclusions

• ARED training elicited increases in muscle volume and strength that were not different than those elicited by FW training.
• Some subjects during bed rest tolerated loads as high as 254 kg during their exercise training to prevent muscle atrophy and bone demineralization (Shackelford, 2004). By providing the capability to perform resistive exercise at similar levels of intensity, with eccentric loading, we suspect that muscle and bone will be better protected than previously observed (Lee, 2004; Trappe, 2009).
• The increase in the V,A, Add, LG, and MG over the rest of the muscle groups indicates a possible need to revisit either the primary exercises themselves (squat, bench press, and deadlift) or the kinematics or potentially add other exercise focusing on the other muscle groups.

Acknowledgments

This work was sponsored by NASA Johnson Space Center’s Office of Mission Operations. The authors kindly acknowledge the support of the Science Physiology Laboratory members for their dedication and dedication to the project. A special thank you to the test crew members.

References