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 impair task performance during long-duration space missions and planetary exploration. High-intensity free weight (FW) and constant mass, inertial force (ARED) resistance training has been shown to prevent atrophy during long-term space flight using NASA's International Space Station (ISS) research facilities. However, it is unknown whether muscle function can be maintained in ambulatory subjects after deploying ARED on the ISS. METHODS: Twenty untrained subjects were assigned to either the ARED (8 males, 3 females) or FW (6 males, 3 females) group and muscle groups in ambulatory subjects prior to deploying ARED on the ISS. Both groups performed 4 days of training per week consisting of squat (SQ), hip raise (HR), and deadlift (DL) exercises 3 d·wk⁻¹ for 16 wks. SQ, HR, and DL muscle strength (1RM) was measured before, after 8 wks, and after 16 wks of training to provide exercise and muscle strength information. All subjects performed the same exercises and used the same specific hardware for each exercise before training and after 8 weeks of training. FW and ARED 1RM were measured pre- and post-training for all three exercises. Subject groups were not different in age (ARED: 36 ± 7; FW: 32 ± 4 yrs), height (ARED: 171 ± 11; FW: 171 ± 7 cm), or body mass (ARED: 79 ± 14; FW: 75 ± 11 kg). RESULTS: Both groups increased muscle volume in the V (FW: 13±2%, ARED: 10±2%), H (FW: 3±1%, ARED: 3±1 %), ADD (FW: 15±2%, ARED: 10±1%), LG (FW: 7±2%, ARED: 4±1%), MG (FW: 7±2%, ARED: 5±2%), and DP (FW: 2±1%; ARED: 2±1%) after training. There were no between-group differences in muscle strength or volume differences before training. All subjects performed the same exercises and used the same specific hardware for each exercise before training and after 8 weeks of training. RESULTS: Both groups increased muscle volume in the V (FW: 13±2%, ARED: 10±2%), H (FW: 3±1%, ARED: 3±1 %), ADD (FW: 15±2%, ARED: 10±1%), LG (FW: 7±2%, ARED: 4±1%), MG (FW: 7±2%, ARED: 5±2%), and DP (FW: 2±1%; ARED: 2±1%) after training. There were no between-group differences in muscle strength or volume differences before training. All subjects performed the same exercises and used the same specific hardware for each exercise before training and after 8 weeks of training. Significant improvements in muscle strength and volume were observed in all muscles except the RF and ALC after training. Also, there were no between-group differences in muscle strength or volume differences before training. All subjects performed the same exercises and used the same specific hardware for each exercise before training and after 8 weeks of training. The training effects similar to FW and a positive but weak effect, ARED likely will prevent against muscle atrophy, respectively. CONCLUSIONS: The increase in muscle volume and strength following ARED training is not different than FW training. With the training effect similar to FW and a positive but weak effect, ARED likely will prevent against muscle atrophy, respectively.

Introduction

• Muscle atrophy and reduced muscle strength have been observed following long-duration space flight (Caffaro, 2000; Trappe, 2000).
• 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 core performance and mission success during long duration missions and planetary exploration.
• The interim Resistive Exercise Device (iRED) has been utilized since the first International Space Station (ISS) mission as a countermeasure to disuse-induced bone loss.
• ARED has been developed by NASA to address iRED's limitations (variable loading, focusing on the other muscle groups).

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.

Results

• Subject groups were not different in age (AGED: 36 ± 7; PW: 32 ± 4 yrs), height (AGED: 171 ± 1 cm), and body mass (AGED: 79 ± 14; PW: 75 ± 11 kg).
• There were no between-group differences in strength gains in squat, heel raise, and deadlift (Lehr, 2008).
• Muscle volume significantly increased in the V, ADD, LG, MG, and DP but did not in RF and ALC after training. Also, there were no between-group differences (p > 0.05).
• 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).

Overall Study Design

• Twenty volunteers (14 men, 6 women) consented to participate in this study and were assigned to either a 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, heel raise, and deadlift exercises 3 d·wk⁻¹ for 16 weeks using a periodized resistive exercise training program. Each group performed 4 sets of maximum strength measurements (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 and ARED 1RM were measured pre- and post-training for all three exercises.
• Magnetic Resonance images (MRI) were acquired pre- and post-training.
• Data were analyzed using a training group × time repeated-measures ANOVA (p < 0.05) and a muscle group × time ANOVA (p < 0.05). Taking a post hoc test was used to determine pair-wise differences when a significant F score was found.

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References