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 lower extremity muscles, may impact task performance during long-duration space missions and planetary exploration. High intensity free weight (FW) resistance exercise training has been shown to prevent postural muscle atrophy in space flight using NASA’s International Space Station (ISS) Advanced Resistive Exercise Device (ARED). However, whether FW and ARED training elicit comparable increases in muscle mass and strength is unknown. The present study compared the efficacy of ARED and FW training to induce muscle volume increases in ambulatory untrained subjects prior to deploying ARED on the ISS. METHODS: Twenty untrained males and females (8 males, 3 females) were assigned to either the ARED (8 males, 3 females) or FW (6 males, 3 females) group and performed 16 weeks of training. Each group performed twice-weekly resistive exercise training at 80% of 1 repetition maximum for 1 hour. Force and displacement were recorded in each exercise for both groups prior to and after training. Muscle cross-sectional area (CSA) was measured in the Rectus Femoris (RF), vasti group (V), Hamstring group (H), Anterolateral Compartment (ALC), Lateral Gastrocnemius (LG), and Medial Gastrocnemius (MG) muscles in vivo using MRI. RESULTS: The ARED and FW groups increased muscle volume in the RF (ARED: 10±2%, FW: 8±2%), V (ARED: 31±4%, FW: 18±2%), and H (ARED: 23±3%, FW: 16±2%) muscle groups. Both groups increased muscle volume in the RF, V, and H muscle groups. CONCLUSIONS: The ARED and FW training regimens are effective in increasing muscle mass and strength following 16 weeks of training. The muscle volume increases following ARED training are similar to those following FW training.

Thigh Muscle Volume

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Vasti Group</th>
<th>Hamstring Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARED</td>
<td>10±2%</td>
<td>23±3%</td>
</tr>
<tr>
<td>FW</td>
<td>18±2%</td>
<td>16±2%</td>
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</table>

Calf Muscle Volume

<table>
<thead>
<tr>
<th>Exercise</th>
<th>ALC Group</th>
<th>MG Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARED</td>
<td>6±1%</td>
<td>9±1%</td>
</tr>
<tr>
<td>FW</td>
<td>5±1%</td>
<td>8±1%</td>
</tr>
</tbody>
</table>

Conclusions

ARED training elicited increases in muscle volume and strength that were not different than those elicited by FW training. MRI Methods

• Subjects had a mean age of 45.5 years and a mean height of 1.78 m. MRI scans were acquired at the Johnson Space Center's MRI facility in Houston, Texas. Subjects were instructed to refrain from any strenuous physical activity for 24 hours prior to the MRI scan. MRI scans were acquired using a 3T MRI scanner (Signa HDx, GE Healthcare, Waukesha, WI). Scan parameters included a T1-weighted spin-echo sequence with a TR of 600 ms, a TE of 10 ms, and a flip angle of 90°. The Field of View was 350 x 350 mm, the matrix size was 256 x 256, and 128 slices were acquired. The slice thickness was 3 mm with an interslice gap of 1 mm. The number of signal averages was 4, and the acquisition time was approximately 12 minutes per slice. Changes in muscle volume were calculated using the ImageJ software (ImageJ, National Institutes of Health, Bethesda, MD). Results were analyzed using a mixed-effects model with subject as a random effect and time (baseline, post-training) and group (ARED, FW) as fixed effects. Overall, the ARED and FW groups showed similar increases in muscle volume and strength following 16 weeks of training. The results of this study indicate that ARED training is an effective countermeasure to disuse-induced bone loss in spaceflight and planetary exploration. References


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 missions and planetary exploration. The Advanced Resistive Exercise Device (ARED) is a countermeasure to disuse-induced bone loss in spaceflight and planetary exploration. ARED is designed to provide resistive exercise at similar levels of intensity, with constant load, low eccentric forces) to that which may have decreased in efficacy. ARED, recently deployed on ISS during Expedition 18, was used to provide 24 kg of resistance using 2 vacuum cylinders (constant load), 20 vehicles to stimulate the in vivo component of free weight (FW) exercise, and provides an eccentric load of greater than 90% for loads greater than 40 kg.

Conclusions

• Subject groups were not different in age (AGED 36 ± 7, FW: 32 ± 4 years), height (AGED 177 ± 10 cm), or body mass (AGED 93 ± 14, FW: 78 ± 11 kg).
• There were no between-group differences in strength gains in squat, heel raise, or deadlift (Loehr, 2008).
• 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).