Muscle Adaptations Following Short-Duration Bed Rest with Integrated Resistance, Interval, and Aerobic Exercise

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Unloading of the musculoskeletal system during space flight results in deconditioning that may impair mission-related task performance in astronauts. Exercise countermeasures have been frequently tested during bed rest (BR) and limb suspension; however, high-intensity, short-duration exercise prescriptions have not been fully explored. **PURPOSE:** To determine if a high intensity resistance, interval, and aerobic exercise program could protect against muscle atrophy and dysfunction when performed during short duration BR. **METHODS:** Nine subjects (1 female, 8 male) performed a combination of supine exercises during 2 weeks of horizontal BR. Resistance exercise (3 d · wk^{-1}) consisted of squat, leg press, hamstring curl, and heel raise exercises (3 sets, 12 repetitions). Aerobic (6 d · wk^{-1}) sessions alternated continuous (75% VO_2 peak) and interval exercise (30 s, 2 min, and 4 min) and were completed on a supine cycle ergometer and vertical treadmill, respectively. Muscle volumes of the upper leg were calculated pre, mid, and post-BR using magnetic resonance imaging. Maximal isometric force (MIF), rate of force development (RFD), and peak power of the lower body extensors were measured twice before BR (averaged to represent pre) and once post BR. ANOVA with repeated measures and *a priori* planned contrasts were used to test for differences. **RESULTS:** There were no changes to quadriceps, hamstring, and adductor muscle volumes at mid and post BR time points compared to pre BR (Table 1). Peak power increased significantly from 1614 ± 372 W to 1739 ± 359 W post BR (+7.7%, $p = 0.035$). Neither MIF (pre: 1676 ± 320 N vs. post: 1711 ± 250 N, +2.1%, $p = 0.333$) nor RFD (pre: 7534 ± 1265 $N \cdot ms^{-1}$ vs. post: 6951 ± 1241 $N \cdot ms^{-1}$, -7.7%, $p = 0.136$) were significantly impaired post BR.

Table 1. Muscle volumes with bed rest and integrated exercise countermeasures

Muscle Group	Pre	Mid	Post	% change (Pre vs. Post)	p- value†
Quadriceps (mL)	974 ± 104	989 ± 104	992 ± 109	+1.84%	0.083
Hamstrings (mL)	466 ± 76	468 ± 82	471 ± 83	+1.07%	0.662
Adductors (mL)	386 ± 57	382 ± 67	377 ± 63	- 1.03%	0.321

Mean ± SD;†ANOVA time effect

CONCLUSION: A combination of high intensity, short duration exercise countermeasures performed during 2 weeks of BR increased concentric power and protected muscle from unloading induced atrophy and dysfunction.