Integrated Resistance and Aerobic Training Maintains Cardiovascular and Skeletal Muscle Fitness During 14 Days of Bed Rest

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Background: Known incompatibilities exist between resistance and aerobic training. Of particular importance are findings that concurrent resistance and aerobic training reduces the effectiveness of the resistance training and limits skeletal muscle adaptations (example: Dudley & Djamil, 1985). Numerous unloading studies have documented the effectiveness of resistance training alone for the maintenance of skeletal muscle size and strength. However the practical applications of those studies are limited because long-duration crew members perform both aerobic and resistance exercise throughout missions/spaceflight. To date, such integrated training on the International Space Station (ISS) has not been fully effective in the maintenance of skeletal muscle function.

Purpose: The purpose of this study was to evaluate the efficacy of high intensity concurrent resistance and aerobic training for the maintenance of cardiovascular fitness and skeletal muscle strength, power and endurance over 14 days of strict bed rest.

Methods: 9 subjects (8 male and 1 female; 34.5 ± 8.2 years) underwent 14 days of bed rest with concurrent training. Resistance and aerobic training were integrated as shown in table 1. Days that included 2 exercise sessions had a 4-8 hour rest between exercise bouts. The resistance training consisted of 3 sets of 12 repetitions of squat, heel raise, leg press and hamstring curl exercise. Aerobic exercise consisted of periodized interval training that included 30 sec, 2 min and 4 min intervals alternating by day with continuous aerobic exercise.

Table 1. Integration of Aerobic and Resistance Showing Time Spent Exercising

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Resistance	35-60 min		35-60 min		35-60 min		
Aerobic Interval		32 min		15 min		35 min	
Aerobic Continuous	30 min		30 min		30 min		

Subjects were tested before and after bed rest for leg press muscle power and endurance, isokinetic strength, calf and thigh muscle cross-sectional area (MRI), maximal aerobic power (VO_2max), and ventilatory threshold (VT).

Results: VO_2max (3.0 to 3.2 L/min; p>0,05) and VT were maintained (2.5 to 2.4 L/min; p>0.05) when comparing pre-bed rest to immediately post bed rest. There was a small increase in vasti muscle CSA (pre: 74.3 cm^2, post 75.6 cm^2; p<0.05) and no significant changes (p>0.05) in any other muscle CSA (hamstring, adductor, medial and lateral gastroncnemius, total lower leg). There were no changes or slight increases in leg press maximal isometric force, peak power and endurance following bed rest. Isokinetic strength of the knee extensors and plantar flexors also showed maintenance of muscle function (p>0.05).

Conclusion: The integrated resistance and aerobic training used in this study preserves cardiovascular fitness and muscle function. Given the challenges associated with concurrent training these findings are particularly encouraging. Future work will focus on exercise prescription over longer durations of bed rest, provide additional measurements and comparisons with long duration bed rest controls and be used to optimize exercise programs on ISS.