Effects of voluntary resistance exercise training during recovery from hindlimb unloading on rat gastrocnemius muscle

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ABSTRACT

As research continues to examine the deleterious impact of long-duration spaceflight on human muscle mass and function, there remain gaps in our knowledge of muscle physiology, especially in examining how muscle's ability to recover or rehabilitate from unloading may alter the results of multiple exposures to microgravity followed by 1g recovery. The purpose of this study was to analyze the effects of resistance exercise training of gastrocnemius muscle mass and anabolism during the initial recovery period immediately following a bout of unloading, as well as to examine the role that exercise may have on a subsequent period of weightlessness. This was achieved in rodent models of simulated spaceflight (0g), recovery (1g), and resistance training (>1g) using male Sprague-Dawley (6 mo) rats randomly assigned to the following groups: 28d hindlimb unloading (HU), 28d HU followed by a 56d recovery period of normal cage ambulation at 1g (1HU+REC), 2 cycles of 28d HU with a 56d recovery period between unloading (2HU), 2HU followed by an additional 56d recovery at 1g (2HU+REC), or an age- and housing-matched control group (CON). In addition, following the initial 28d HU period, two groups of animals were given 7d recovery at 1g followed by a 7wk (3 sessions/wk) moderate-intensity, moderate-volume voluntary resistance exercise program (EX) in which the animals were trained to perform a squat-like motion with full extension of the lower limb and resistance was applied incrementally by weighted pouches over the scapula to ~65% bodyweight. At the conclusion of the experiments, gastrocnemius muscles were carefully excised, weighed, and evaluated for cumulative (24h) rates of protein synthesis (FSR). Values of both muscle mass and FSR were lower than control during periods of unloading ($p<0.05$), but with recovery, control values were reached for mass and surpassed for FSR. Interestingly, there was no significant difference between the mass of 2HU and 2HU+EX ($p>0.05$), and both were diminished in comparison to control animals, suggesting that benefits of exercise during periods of ambulatory reloading after disuse/microgravity may not be additive. In conclusion, our data suggest that given adequate recovery, microgravity-induced losses of muscle mass can be fully restored to control values, and this adaptational response persists even with multiple exposures. These findings may have important implications not only for career astronauts, but also for individuals who have been subjected to casting of a limb or a period of bed rest following severe injury or illness.