**ABSTRACT**

The current exercise countermeasures have not fully protected astronauts’ pre-flight aerobic and muscular fitness levels during international space station missions prompting a need to optimize the exercise prescription to improve or maintain astronaut’s ability to perform critical tasks and eventually extend the duration of missions. **Purpose:** To test the hypothesis that an integrated resistance and aerobic exercise prescription performed with exercise equipment similar to that on the ISS can be tolerated and maintain cardiovascular and muscular fitness during 14 days of exposure to a model of microgravity. **Methods:** Subjects (N = 9) participated in 14-21 days of pre-bed rest training and familiarization, 14 days of bed rest + iRAT exercise, and 7 days of ambulatory recovery. Peak aerobic capacity (VO2peak), ventilatory threshold (VT), isokinetic and leg press tests were performed pre- and post-bed rest to evaluate cardiovascular and muscle function. Muscle cross-sectional area (CSA) was determined pre, mid, and post-bed rest using magnetic resonance imaging (MRI). **Results:** Improvements from pre- to post-bed rest were observed in VO2peak (2.8 ± 0.2 to 3.2 ± 0.2 L•min⁻¹), ventilatory threshold (1.9 ± 0.2 to 2.1 ± 0.2 L•min⁻¹), leg power (1592 ± 317 to 1740 ± 359 W), and muscle CSA of the grouped vasti muscles (67.5 ± 8.4 to 68.9 ± 8.3 mm²). Muscle strength and total CSA of the upper and lower legs were not different from pre to post-bed rest. **Conclusions:** This is the first report of an exercise being completed for the prevention of cardiovascular and skeletal muscle deconditioning during strict bed rest using exercise equipment similar to that on the ISS. This was accomplished with high subject compliance.

**INTRODUCTION**

The lack of mechanical loading characteristic of long-duration space flight causes dramatic loss in aerobic fitness and muscle strength. Daily aerobic and exercise resistances are performed on the International Space Station (ISS) to maintain fitness, but have not been fully effective. There is considerable variability among crew with some experiencing no loss whatsoever and others more than 30% decline in aerobic and/or muscular fitness. In an effort to optimize in-flight exercise prescriptions and better understand the complex relationship between strict unloading and high intensity exercise, a series of ISS flight and ground-based bed rest studies are underway.

**METHODS**

- Approved by NASA and UTMB IRB
- **Subjects:** Healthy young males and females (N=9; 8 men, 1 woman)
- Bed rest (BR): 14 days horizontal
- Diet: Strictly controlled and isenergetic
- Macronutrient distribution: 55% carbohydrate, 30% fat, 15% protein
- Testing: 21 days of familiarization with exercise testing and training
- Pre and post-testing
  - Strength assessment: Isokinetic dynamometry knee and ankle, leg press, isotonic strength
  - Aerobic capacity (VO2peak).

**RESULTS**

Integrated Resistance and Aerobic Exercise Protects Fitness during Bed Rest

**DI SCUS SION**

This is the first report of complete preservation of aerobic and muscular fitness during 14 days of bed rest using exercise alone. These data demonstrate, for the first time that it is possible to alleviate the deconditioning effects of strict bed rest for 2 weeks with approximately one hour of exercise per day. It is important to know that once or twice daily exercise sessions can compensate for the drastic unloading observed during strict bed rest. It is likely that the intensity of the exercise was a major contributor to the success of the program. Exercise Is Medicine is an American College of Sports Medicine initiative to “make physical activity and exercise a standard part of a disease prevention and treatment medical paradigm.” The above research highlights the importance of exercise from a unique perspective. Strict bed rest is a potent stimulus for deconditioning, not only in controlled research subjects such as this study but even more importantly for those hospitalized for medical purposes. Hospital associated deconditioning and functional decline are common problems with a paucity of research or clinical recommendation examining prevention, functional recovery or reconditioning. The current study illustrates the unique capability of exercise alone to prevent deconditioning associated with strict bed rest. Subjects spent less than one hour per day, with some days as little as 15 minutes performing exercise, and were able to preserve muscle size, strength and aerobic capacity during 24 days of strict bed rest in which they were not allowed to sit up even for a moment. All toiletting, showering, eating and personal hygiene were performed while lying in a hospital bed. While this is a dramatic experimental paradigm to induce deconditioning, it provides a unique context to clearly illustrate the potent effect of exercise as medicine. No other form of treatment including any known drug has such the capability to prevent deconditioning and maintain functional capacity.