# TWELVE WEEKS OF PROGRESSIVE ARTIFICIAL GRAVITY RESISTANCE TRAINING: PRELIMINARY RESULTS FROM THE PROGRESS STUDY

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## Introduction

Artificial gravity (AG) resistance training (RT)has been proposed as a promising countermeasure to mitigate musculoskeletal deconditioning during long-duration space missions by providing enhanced mechanical loading and a gravitational gradient along the body's longitudinal axis. While AG-based exercise has been incorporated into NASA's Human Research Roadmap, optimal training load and modalities for long-term application remain unclear. The ProGress study aims to evaluate the feasibility, tolerability, and efficacy of high-intensity lower-body resistance training performed under AG using a short-arm human centrifuge (SAHC), compared to conventional resistance training under Earth gravity (1g).

## Methods

We plan to include 20 healthy, recreationally active male and female participants, who will be assigned to either AG-based resistance training (RT) on a SAHC or conventional resistance training in a standard gym environment (n = 10 per group). Over a 12-week intervention period, participants will complete 36 RT sessions (thrice per week). Each RT session lasts approximately 20 minutes and consists of squats, single-leg calf raises, and deep squats (three sets of 8–10 repetitions). Individual RT intensity is based on a three-repetition maximum (3RM) test and ratings of perceived exertion (Borg scale). In the centrifuge group, RT intensity is adjusted by increasing rotational speed to modulate gravitational load, while gym-based RT load is adjusted by external load. All centrifuge RT sessions are medically supervised. At baseline and post-intervention, quadriceps muscle volume (MRI), lower-body strength (3RM, isometric and isokinetic maximum voluntary contraction (Isomed2000)), $VO_2$max (cycle ergometry), functional performance (countermovement jumps and hopping tasks), and selected metabolic and tissue-level markers are assessed.

## Results

Given the currently small sample size, the present analyses are descriptive in nature, and no inferential statistical testing has been performed at this stage. To date, five participants have completed the AG-based intervention. Mean gravitational load at the center of mass increased from 1.3 ± 0.1 g to 1.7 ± 0.1 g across the training period. Average perceived exertion during training was 15.7 ± 1.2. Mean cardiovascular responses at the end of RT sessions were heart rate 136.90 ± 26.25 bpm, diastolic blood pressure 79.02 ± 13.52 mmHg, and systolic blood pressure 158.79 ± 13.47 mmHg. Preliminary analyses indicate an approximately 10% increase in muscle volume, primarily in the vastus lateralis, vastus medialis, and gastrocnemius muscles. Mean 3RM strength increased from 86.0 ± 30.5 kg to 133.0 ± 28.6 kg, and $VO_2$max increased by 5 ± 1.2 $ml \cdot kg^{-1} \cdot min^{-1}$.

## Conclusion

Preliminary findings suggest that short-duration, high-intensity resistance training under artificial gravity is feasible, well tolerated, and capable of inducing adaptations of strength and muscle mass as well as aerobic capacity.