SPACE LIFE SCIENCES SYMPOSIUM (A1)
Human Physiology in Space (2)

Author: Mrs. Ana Diaz
Massachusetts Institute of Technology (MIT), United States, anadiaz@mit.edu

Mr. Chris Trigg
Massachusetts Institute of Technology (MIT), United States, ctrigg@mit.edu
Dr. Laurence R. Young
Massachusetts Institute of Technology (MIT), United States, lry@mit.edu

COMBINING ERGOMETER EXERCISE AND ARTIFICIAL GRAVITY

Abstract

Humans suffer physiological deconditioning during space missions, primarily due to the weightlessness. Some of these adverse consequences include bone loss, muscle atrophy, sensory-motor deconditioning, and cardiovascular adaptation, which may lead to orthostatic intolerance when astronauts return to Earth. In order to mitigate these negative effects several countermeasures are currently in place such as very intensive exercise protocols or the intake of nutrition supplements. However, despite all these countermeasures, astronaut physiological deconditioning may still persist, highlighting the need for new approaches to maintain the astronauts' physiological state within acceptable limits.

Artificial gravity could provide a comprehensive countermeasure capable of challenging all the physiological systems at once, therefore maintaining overall health during extended weightlessness. Several ground studies using short-radius centrifugation, in conjunction with head down bed-rest, have shown that exposure to intermittent artificial gravity combined with ergometer exercise is effective in preventing physiological deconditioning. However, the numerous confounding factors between the studies (including centrifuge configuration, gravity level, and use/intensity of exercise) make it very difficult to draw clear conclusions about the parameters needed to maintain physiological conditioning in space.

The objective of our current research effort is to analyze the effects of different artificial gravity levels (0g, 1g, and 1.4 g at the feet) and ergometer exercise intensities (moderate and vigorous) on musculoskeletal and cardiovascular functions, as well as motion sickness and comfort. Human experiments will employ a new configuration of the MIT Compact-Radius Centrifuge (CRC). The centrifuge has been constrained to a radius of 1.4 meters, the upper radial limit for a centrifuge to fit within an ISS module without extensive structural alterations. In addition, a cycle ergometer has been added for exercise during centrifugation, as well as mechanical and physiological sensors such as foot forces, heart rate, blood pressure, and EMG measurements. Some of these experimental measurements will be used to validate a new computational model that captures the short-term cardiovascular response to exercise in a high gravity gradient environment. Preliminary results and conclusions will be shown and discussed.

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