EFFECTS OF REPLACING TREADMILL RUNNING WITH ALTERNATIVE EXERCISE COUNTERMEASURES DURING LONG-DURATION SPACEFLIGHT

A.N. Varanoske[1], B.J. Prejean[1], N.C. Strock[1], D. Conly[1], B.T. Peters[1], E.S. Morant[1], J.D. Sibonga[2], S.M. Smith[2], S.R. Zwart[3], E.R. Spector[1], R.S. Fincke[2], M. Young, & K. Marshall-Goebel[2]
[1]KBR, Houston, TX, USA; [2]NASA Johnson Space Center, Houston, TX, USA; [3]University of Texas Medical Branch, Galveston, TX, USA

INTRODUCTION: Current exercise countermeasures on the International Space Station (ISS) include treadmill running, cycle ergometry, and resistive exercise, which are used to protect crewmember health and performance during long-duration spaceflight. However, exploration vehicles for Artemis and beyond will have volume and power restrictions, requiring exercise hardware to have a smaller footprint and use fewer resources. Thus, recent efforts have focused on developing exercise devices (such as the European Enhanced Exploration Exercise Device [E4D]) that provide both aerobic and resistive training on one platform without including a treadmill. It is critical to validate the efficacy of exploration-focused exercise modalities to preserve muscle strength, aerobic fitness, bone density, and sensorimotor performance. Thus, the aim of this study is to determine the physiological effects of spaceflight that occur with nominal ISS exercise prescriptions compared to exploration-forward exercise modalities to determine if a treadmill is required to maintain current levels of protection during long-duration missions.

METHODS: Crewmembers will be assigned to one of three groups: 1) Control Group ($n \geq 40$), who will partake in nominal exercise on the ISS, including running on the Treadmill with Vibration Isolation and Stabilization 2 (T2), ergometry on the Cycle Ergometer with Vibration Isolation and Stabilization (CEVIS) device, and strength training on the Advanced Resistive Exercise Device (ARED); 2) Active Group 1, who will partake in CEVIS and ARED exercise only ($n = 8$); and 3) Active Group 2, who will partake in aerobic and resistive exercise on the E4D only ($n = 8$). For Active Group 1, nominal aerobic exercise on T2 will be replaced with corresponding exercise on CEVIS. For Active Group 2, a dedicated exercise prescription will be designed to maximize the capabilities of the E4D to include resistive exercise, cycle ergometry, rowing, and rope pulling. Crewmembers in both active groups will not be permitted to perform treadmill exercise. Health and performance markers including bone mineral density (dual-energy x-ray absorptiometry [DXA]), body composition (DXA), cardiovascular fitness (cycle VO2peak), muscle strength and endurance (isometric/isokinetic testing, power endurance testing), sensorimotor performance (sit-to-stand, obstacle course), postural control (computerized dynamic posturography), and blood and urine biochemical markers of bone metabolism will be assessed before, during, and following spaceflight.

RESULTS: Thirteen subjects (3 Active [CEVIS + ARED], 10 Control) have been recruited for this study. Data collection is currently in progress.

CONCLUSIONS: This study will assess the efficacy of exploration exercise modalities, including the effects of removing the treadmill exercise capability or of exclusively using the E4D, compared to nominal ISS exercise across an entire mission on bone, muscle, aerobic, and sensorimotor health and performance. Findings from this study will help provide a recommendation on whether these exploration exercise modalities can sufficiently protect against physiological deconditioning during spaceflight or whether a treadmill may be required to maintain current levels of protection during future exploration class spaceflight missions.

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