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Author: Mr. Rahul Goel
Univ of Houston, United States

Mr. Justin Kaderka
Massachusetts Institute of Technology (MIT), United States
Prof. Dava Newman
Massachusetts Institute of Technology (MIT), United States

ENHANCING THE BENEFITS OF AN ARTIFICIAL GRAVITY COUNTERMEASURE COUPLED WITH EXERCISE AND VIBRATION

Abstract

Artificial gravity (AG) produced by short radius centrifugation has been hypothesized as an effective countermeasure because it reintroduces an acceleration field in space. A novel combination of AG coupled with one-legged squats on a vibrating platform may preserve muscle and bone in the lower limbs to a greater extent than the current exercise paradigm. The current, system specific countermeasures have had limited success in preventing musculoskeletal deconditioning in long duration missions. A numerical model was developed to analytically analyze the benefits of the proposed countermeasure. Ground reaction force data and motion data was collected using a motion capture system (VICON) while performing one-legged and two-legged squats in 1-G. In order to determine the muscle and reaction forces of lower limb joints, the motion was modeled in OpenSim (Stanford, CA, USA) and inverse dynamics were applied. Vibration stimulus was modeled by adding a 20 Hz sinusoidal force of 0.5 body weight to the force plate data. Without vibration, the collected ground reaction forces for two-legged squats were over 40% higher than maximally produced while performing two-legged squats using the Interim Resistive Exercise Device (iRED) in parabolic flight. Comparable one-legged ground reaction force data on iRED is not available. From the numerical model in a 1-G acceleration field, hip, ankle and knee torques increased substantially for one-legged squats with vibration compared to one- or two-legged squats without vibration. Additionally, muscle forces of the hip flexors for one-legged squats with vibration were increased by up to 266% as compared to two-legged squats. Higher muscle forces and joint reaction forces would help stimulate muscle activation and bone modeling and in turn might reduce musculoskeletal deconditioning. These results indicate that the proposed countermeasure might surpass the performance of the iRED and should be pursued as a method of mitigating musculoskeletal deconditioning.