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MEASUREMENT OF EXERCISE GROUND REACTION FORCES UNDER APPROPRIATE CONDITIONS FOR THE DESIGN OF VIBRATION ISOLATION SYSTEMS

Abstract

Future exploration exercise devices (EEDs) will be countermeasures for bone loss, muscle loss, and decreased aerobic capacity, among other health issues which arise from prolonged exposure to the microgravity environment. Prospective EEDs are compact, cable-driven systems which support resistive and aerobic exercises such as squats and rowing. An EED will likely require a Vibration Isolation System (VIS) to prevent harmful vibrations, attributed to cyclic loading during exercise, from being transmitted to the space vehicle. The configuration of such a VIS may include a platform to which the crew member and exercise device are secured. One of the major stages in VIS design work is determining expected input forces to the platform due to various exercises and the frequencies at which they occur. Current analyses use force readings from static ground measurements of exercises. However, these measurements may be conservative. A VIS provides its function through motion, meaning that the ground relative to the crew member is dynamic rather than static. It was considered that this could affect exercise form and, in turn, ground reaction force profiles, magnitudes, and frequencies. Hence, it may be more appropriate to include force readings from exercising on a dynamic platform. This research aimed to collect these measurements, providing new insight into human-VIS interaction. Human subject testing was conducted at the Center for Assistive, Rehabilitation, and Robotics Technologies at the University of South Florida. The six degree of freedom (DOF) motion platform of the Computer Assisted Rehabilitation Environment (CAREN) (Motekforce Link, Amsterdam, Netherlands) was used in this research to simulate prospective VIS motion. A sinusoidal platform response was implemented in heave and pitch directions. These DOFs were selected to match the primary DOFs of excitation for squat and row exercises. Various frequencies were tested, selected based on target exercise frequencies as well as structural resonances of the International Space Station. Results showed that differences do exist in the ground reaction force profiles between static and dynamic test conditions which were at comparable frequencies. Hence, testing with a dynamic platform is warranted for VIS design work. Also, knee range of motion was well-maintained between conditions, suggesting that target components exercise form is obtainable. Finding parameters which satisfy requirements for the human-EED-VIS system as a whole is essential and deserves further discussion.