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DEVELOPMENT AND EXPERIMENTAL EVALUATION OF THE ENHANCED DYNAMIC LOAD SENSOR FOR THE INTERNATIONAL SPACE STATION (EDLS-ISS)

Abstract

The evidence that prolonged exposure to the microgravity (μG) environment of space results in a reduction in bone and muscle mass is well documented. As a result, vigorous exercise protocols have been implemented on the International Space Station (ISS) to mitigate musculoskeletal deconditioning among crewmembers. Despite such efforts however, continued bone loss and muscle atrophy is observed even when countermeasures are in effect. These exercise countermeasure systems currently do not provide a means for on-orbit biomechanical data collection and analysis. In an attempt to improve the understanding of astronaut joint loading during resistive exercise in μG a self-contained load sensing system, the Enhanced Dynamic Load Sensor for the International Space Station (EDLS-ISS) was developed. Such a system may provide real time loading feedback to the exercising crewmember as well as 6 degrees of freedom force, moment and center of pressure data for use by researchers on Earth. The aim of this research effort was to evaluate the performance of the EDLS-ISS system in its operational environment, i.e. microgravity. A reduced gravity flight campaign was completed at NASA's Ellington Field in Houston, Texas, to assess the system's overall usability, calibration accuracy and to evaluate differences in the exercising subject's posture, load distribution and technique when comparing μG to 1G-loading. The study involved 7 subjects (3 female and 4 male), each who performed deadlift and squat exercises as prescribed on ISS at 3 self-selected loads (heavy, medium and light). Exercises were performed in micro-, lunar- and earth gravity. The results from this study are presented and the findings discussed – both in the light of ongoing earth-based research and on-orbit exercise optimization. Data obtained through the EDLS-ISS system is used to characterize astronaut joint loading, optimize exercise protocols to mitigate musculoskeletal deconditioning and may lead to the design of improved, lightweight exercise equipment for use during long-duration spaceflight, including future missions to Mars and beyond.