Murine Spine Composition and Mechanics are Maintained After 30-Days of Spaceflight

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As NASA prepares to send astronauts on long-term deep space missions, understanding the detrimental effects of spaceflight on the human body is imperative. Spaceflight is known to negatively affect the spine, with astronauts experiencing systemic bone loss and increased post-flight risk of intervertebral disc herniation.

Space investigations with rodent models have characterized some of the effects of spaceflight on the mammalian body, but highly variable microgravity experimental conditions have made it difficult to cohesively interpret results. These conditions include animal housing, flight duration, and for the spine specifically, anatomical location of study. Thus, the objective of this study was to comprehensively characterize the effects of spaceflight on the bulk properties of the murine lumbar spine. To do this, we examined the lumbar spine of mice flown on the NASA Rodent Research 10 (RR-10) mission and analyzed disc biochemical content, disc joint material properties, lumbar vertebral body microarchitecture, and proximal tibia microarchitecture. Finally, we qualitatively examined bone growth in the vertebral bodies using confocal microscopy and on-orbit injections of calcein for bone labeling.

Contrary to prior results, we found very little to no effect of spaceflight on lumbar spine properties. Spaceflight, however, did negatively affect both cortical and trabecular bone properties of the proximal tibia load-bearing site. We hypothesize that this may be due to loading associated with increased physical activity in the second half of the mission, observed on in-flight videos, that reload the lumbar spine as mice utilize quadruped ambulation. This increased activity occurs after an initial period of relative inactivity in microgravity. In support of this hypothesis, we observed new L5 bone formation in the last seven days of spaceflight, suggesting that current 30-day experimental flight conditions may not be as effective at lumbar spine unloading as previous shorter flights.