The Effects of Microgravity on Bone Regeneration in Mice

Barte Ziliukaite / Vilnius University
barte.ziliukaite@gmail.com

ABSTRACT

The Rodent Research-10 (RR-10) mission investigated how microgravity affects bone regeneration in mice. During this experiment, mice were sent to the International Space Station (ISS), where they spent 30 days in microgravity conditions. In spaceflight, the absence of gravitational loading can enhance osteoclast-driven bone resorption and impair new bone formation, leading to significant bone tissue loss. This study focused on identifying structural changes in the bone lacuno-canalicular network resulting from microgravity and mechanical loading. To visualize and quantify these changes, we employed advanced imaging techniques, including micro-computed tomography (micro-CT) and confocal microscopy. Our findings will contribute to a deeper understanding of skeletal adaptation in space and may inform future research aimed at preserving tissue regenerative health when sending astronauts on long duration space missions.

INTRODUCTION

- This research is part of Rodent Research-10 (RR-10), which was launched to the ISS in December 2020.
- The primary aim of the mission is to investigate the *Cdkn1a* gene, which encodes the CDKN1A/P21 protein (P21). P21 plays an important role in DNA damage response.
- Another goal of this study is to understand how microgravity changes the structure of bone, leading to a better understanding of how astronauts are affected during spaceflight.
- In RR-10, two strains of mice were used: Wildtype (WT) and *Cdkn1a* knockout (P21), mice without the gene.
- In our research we have investigated three groups from this mission: Ground Control (GC), Flight (FL), and Running Wheel (RW).
- The duration of the experiment was 30 days.

BONE STRUCTURE

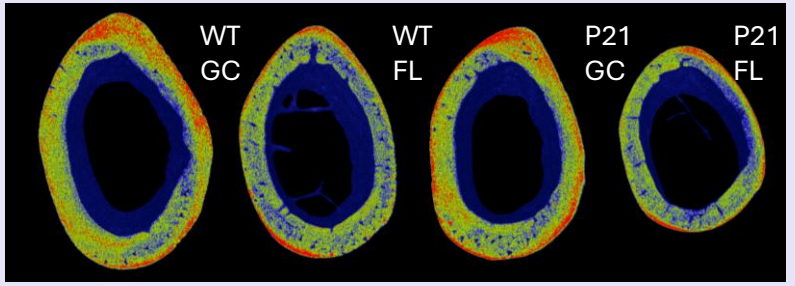
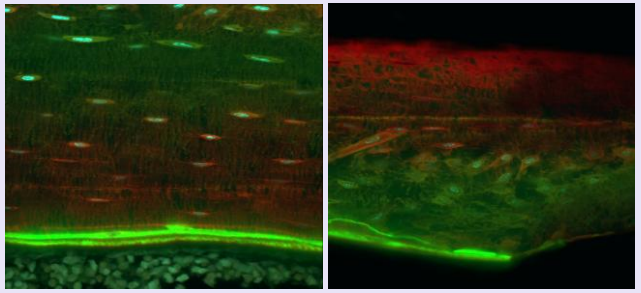


Figure 1. Bone porosity of Wild Type and P21 Flight and Ground Control samples.



WT GC **WT FL**

Figure 2. Confocal images of Wild Type Ground Control and Flight samples.

Data from micro-CT shows that spaceflight mice lose a rigid bone (red), surrounding the perimeter of the bone, that is observed in ground control samples (Fig. 1). In addition, bone formation was more active in ground control mice (red color represents bone, green – newly formed bone during the last week of the spaceflight) (Fig. 2).

REFERENCES

Keller EE. (2024). Rodent Research-10 SpaceX-21 – NASA. WWW document 5 April 2024: https://www.nasa.gov/ames/space-biosciences/rodent-research-10-spacex-21/. Accessed 9 May 2025.

Blaber EA, Dvorchkin N, Lee C, Alwood JS, Yousuf R, Pianetta P, Globus RK, Burns BP, Almeida EAC. (2013). Microgravity Induces Pelvic Bone Loss through Osteoclastic Activity, Osteocytic Osteolysis, and Osteoblastic Cell Cycle Inhibition by CDKN1A/P21. PLOS ONE 8: e61372.

Acknowledgements

I would like to thank Dr. Eduardo Almeida (NASA Ames Research Center) for his mentorship throughout the course of the spring semester, as well as my colleague Josephine Maglio (Uppsala University).