The Effects of Long-Term Recovery from Simulated Microgravity and Deep Space Radiation on the Rat Coronary Structure and Biochemical Properties

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Background

Human travel into space exposes them to the spaceflight environment, which includes:

- Extreme temperature variations
- Exposure to deep-space radiation
- Effects of weightlessness (e.g. microgravity)

Physiological adaptations occur when exposed to these different environmental stimuli, also increasing the crew's risk of developing medical conditions. Some of these risks include cardiovascular deconditioning. To assess these risks, we conducted a study of the long-term single and combined effects of deep space radiation and microgravity exposure on rats.

Our hypothesis includes studying changes in blood vessel structure and function resulting from simulated spaceflight exposure.

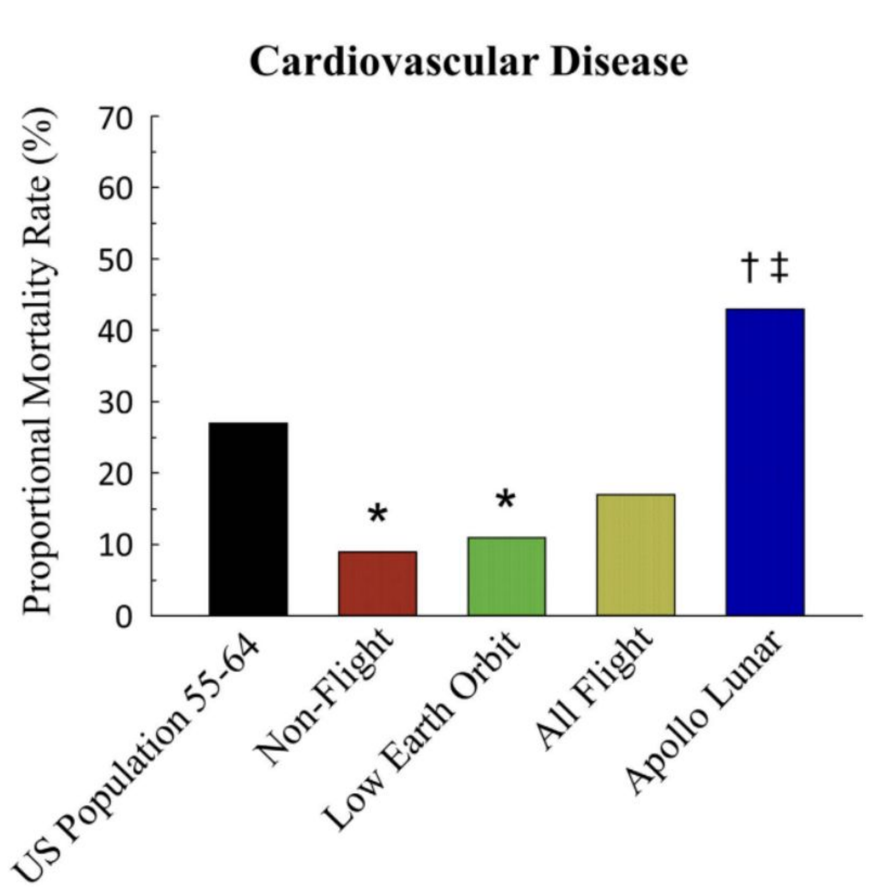


Figure 1: Astronaut mortality rate from sapceflight exposure due to cardiovascular disease. (See reference 1).

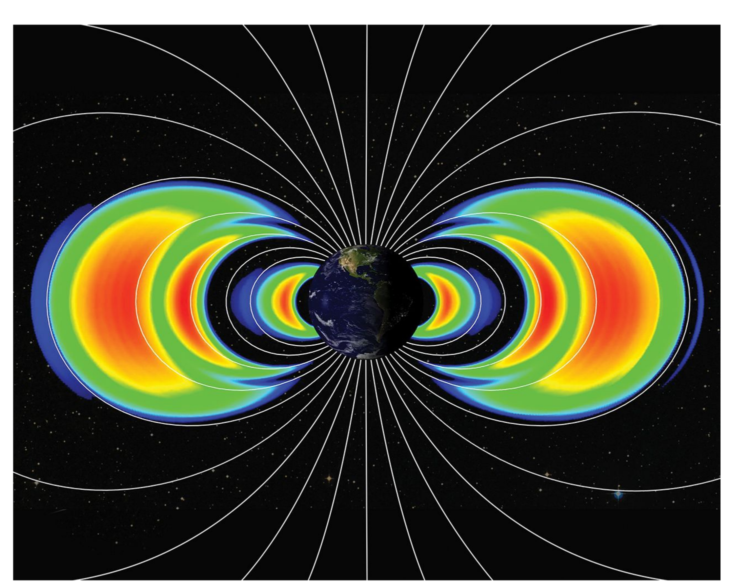


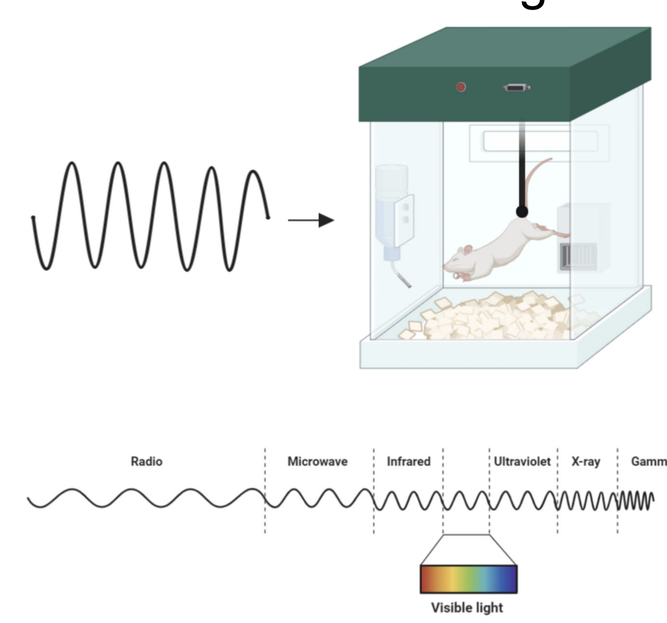
Figure 2. Van Allen Belts, *NASA's Goddard Space Flight Center/Johns Hopkins University, Applied Physics Laboratory*

Figure 3. Brookhaven National Laboratory

Methods

Biospecimen samples were collected and processed from the following groups.

Figure 4. Simulated radiation and hindlimb unloading



EXPERIMENTAL GROUPS	Rats/Group
Sham Irradiation	18
Hindlimb Unloading (HLU)	18
Space Radiation - 0.75 Gy	18
Space Radiation - 1.5Gy	18
HLU+Space Radiation, 0.75 Gy	18
HLU + Space Radiation, 1.5 Gy	18
Total Animals	108

Rat coronary arteries were cryostat sectioned and stained, via immunofluorescence, to quantify structure.

Figure 5. Example image of a cryostat sectioned sample

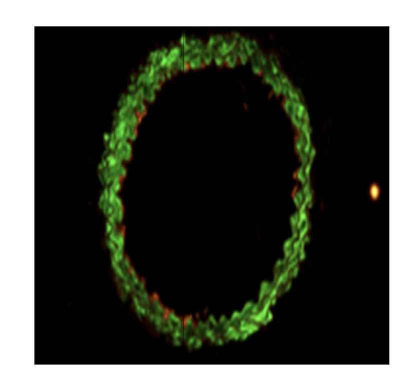


Figure 6: Example immunofluorescence image for quantifying structure

Results

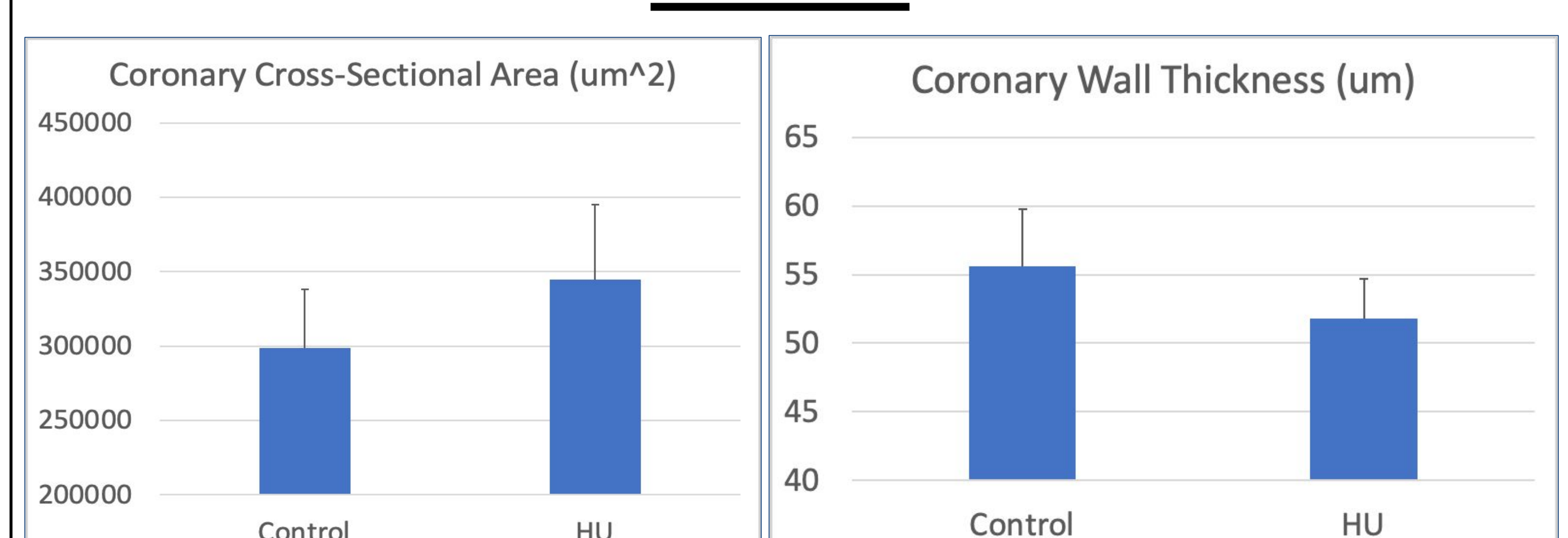


Figure 6. Effects of simulated microgravity on coronary artery structure. From simulated microgravity exposure, there are suggestions of artery structural remodeling, including increases in cross sectional area and decreases in wall thickness. These may be due to vessel relaxation from decreased blood pressure and consequent wall thinning. These observations were not statistically different.

Discussion

Our exploration of space now includes more people traveling and residing in space; thus, there is increasing rationale to understand the effects of spaceflight on human physiology.

As a model organism for studying human adaptations to the spaceflight environment, we studied rats exposed to simulated spaceflight conditions.

Here we see the residual effects of simulated deep space radiation and/or microgravity exposure leading to specific cardiovascular structural adaptations. Our results here suggest long-term adaptations of the coronary artery that may be relevant for the various health adaptations astronauts may experience caused by their travel into space.

Future Directions

We have on-going and future studies measuring biochemical and physiological adaptations of the coronary artery, and more components of the cardiovascular system, including vascular (e.g. endothelial nitric oxide synthase) and oxidative stress (e.g. superoxide dismutase) pathways.

References

1. Delp MD, Charvat JM, Limoli CL, Globus RK, Ghosh P. Apollo lunar astronauts show higher cardiovascular disease mortality: possible deep space radiation effects on the vascular endothelium. Scientific reports. 2016 Jul 28;6(1):1-1.

Acknowledgements

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