Simulated space radiation and weightlessness: vascular-bone coupling mechanisms to preserve skeletal health

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INTRODUCTION

Spaceflight, bone and oxidative stress
- Astronauts may develop bone loss in space as a result of environmental challenges, such as exposure to both weightlessness and ionizing radiation.
- Oxidative stress results from an imbalance between production of free radicals and the ability of cells to counteract their harmful effects at the molecular level.

Endogenous ROS/RNS signaling for adaptive responses

HYPOTHESES

Weightlessness and radiation together cause oxidative stress, adversely affecting both bone and the blood vessels that feed muscle and bone.

METHODS

Animals: Adult (4 mo old at start), male C56Bl/6J mice
- Hindlimb unloading by tail traction to simulate weightlessness
- Irradiation with either 137Cs, Protons, or 56Fe

Experimental design

RESULTS

Late effects of HZE, but not transient HU, on vasodilation (via NO signaling mechanism) at 6 to 7 months post-treatment

PurposE OF THE STUDIES

To define the mechanisms and risks of bone loss in space and to help develop effective ways to prevent that bone loss.

Radiation and HU as single factors invoke similar pro-osteoclastogenic and antioxidant responses in bone marrow. HU and IR combined do not result in additive effects.

Mice were irradiated with 137Cs (2Gy). At one day post-IR, mice were euthanized and bone marrow cells were collected for analysis of gene expression by qPCR. Y-axis values indicate relative expression levels of gene of interest normalized to Gapdh using the ΔΔct method. Data shown are mean ± S.D. (n=5-6/group) and analyzed by 1-factor ANOVA. *p<0.05 compared to NL by Dunnett’s post-hoc test.

CONCLUSION

Radiation exposure and simulated weightlessness cause persistent antioxidant responses in marrow, decrements in bone microarchitectre and altered vasodilation properties of associated vasculature.

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