Characterizing the Effects of Radiation on Muscle Cells

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**Recommended Citation**

Caldwell, Lori; Harding, Charles; Hanson, Eryn; Dennison, JR; and Vargis, Elizabeth, "Characterizing the Effects of Radiation on Muscle Cells" (2018). IBE. *Presentations*. Paper 189.  
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Characterizing the Effects of Radiation on Muscle Cells

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Muscle Atrophy Occurs in Space

Muscle loss

180 days

-40%

leaving

arriving

-12% in 10 days [3]

[1]https://m1.behance.net/rendition/modules/46869501/disp/e31f45fa96b406c2edd5f105dd023744.png
Caused by Reactive Oxygen Species

Sources of ROS
- UV radiation
- Ionizing radiation
- Increased incidence under microgravity
  - Decreased muscle loading


http://www.biotek.com/assets/tech_resources/10592/figure1.jpg
Rigorous Astronaut Training

- Minimize effects of muscle loss
  - Send physically fit astronauts to space
Rigorous Astronaut Training

- Minimize effects of muscle loss
  - Send physically fit astronauts to space
  - In space, undergo continued exercise
Rigorous Astronaut Training
Reactive Oxygen Species

Sources of ROS
- UV radiation
- Ionizing radiation
- Increased incidence in microgravity
  - Decreased muscle loading

Utah State University’s Space Environment Test Facility

Heated cell chamber (37°C, 1 atm)

Strontium 90 radiation source

Vacuum chamber

Sample port
Modeling Radiation

- 21.5 cm source-to-sample distance
- Dosage rate: 0.71 Gy/hr
Dosage Calculation

- Dosage outside Earth’s geomagnetic sphere = $48.1 \pm 0.81 \mu\text{Gy/day}$
- Flight duration to Mars one way = 180 days
- Dosage on Mars’ surface = $22.9 \pm 0.44 \mu\text{Gy/day}$
- Experimental stay on Mars = 365 days

- Total mission length = 725 days
- **Total mission radiation dosage** = $0.66 \pm 0.12 \text{ Gy}$

- 10 year colonizing mission dosage = $3.84 \pm 0.15 \text{ Gy}$
- 3-5 Gy at once could kill person
Preliminary Work

- How does radiation affect cell pellet?
- Mouse skeletal muscle cells (C2C12)
Utah State University’s Space Environment Test Facility

- Strontium 90 radiation source
- Vacuum chamber
- Heated cell chamber (37°C, 1 atm)

- Undifferentiated C2C12 mouse skeletal muscle cells

(Not even close to normal, \textit{in vivo} cells)
Undifferentiated C2C12 Cell Viability

![Graph showing the relationship between radiation dose (Gy) and percent viability. The graph indicates a decrease in viability with increasing radiation dose. The data points for Day 0 and Day 7 are shown with error bars.]
C2C12 Morphology – 7 Day post radiation
Differentiated, Normal Control
C2C12 Morphology – 7 Day post radiation

7.2 Gy
14.6 Gy
36.8 Gy
Monolayer Radiation Exposure

- Strontium 90 radiation source
- Atmospheric pressure

C2C12 skeletal muscle
CRL-1999 aortic smooth muscle
C2C12 Cellular Monolayer Viability

* = p < 0.05
CRL-1999 Cellular Monolayer Viability

* = p < 0.05
C2C12 Morphology – 7 Day post radiation

7.2 Gy

14.6 Gy

36.8 Gy
Caused by Reactive Oxygen Species

Sources of ROS
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http://www.biotek.com/assets/tech_resources/10592/figure1.jpg
Ground-based Models

- **Animal Models**
  - Nerve blocking
  - Casting
  - Hindlimb unloading

- **Cell Culture Models**
  - Clinostat
  - Rotary cell culture system

Rotating Cell Culture System (RCCS)

- Simulated microgravity using a rotating vessel maintaining cells at their terminal settling velocity
- Normal gravity using ultra low attachment flasks
Combining Radiation with Microgravity Simulations

- Preliminary work with cesium disks did not deliver adequate levels of radiation to cells within RCCS
Custom RCCS compatible with Space Survivability Test Chamber

- Constructed from stainless steel and polycarbonate
- 6 rotary vessels controlled by one motor
Combining Radiation and Microgravity

- Custom RCCS built for compatibility with Space Survivability Test Chamber
- Constructed from stainless steel and polycarbonate
- 6 rotary vessels controlled by one motor
Combined Effects

Sample port
Summary and Ongoing Work

- Radiation chamber effective at delivering radiation to muscle cells
  - Advantages: close to our cell culture lab, tunable, accessible
  - Disadvantages: \(\beta\) not \(\gamma\) radiation
- Combining radiation and simulated microgravity ongoing
- Future work: how can changes to muscle tissue be mitigated?
  - Anti-oxidants
  - Anti-inflammatory therapeutics
Acknowledgments
Spontaneous contractions of C2C12 cells in vitro

questions?

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