Suborbital Flight – Life Science Opportunities

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Microgravity Exposures

- Jumping (2-10 sec)

Hannah Kearny winning Olympic Gold in Freestyle/Moguls

Simon Ammann winning Olympic Gold in Ski Jumping

- Parabolic flight (18-22 sec)

Zero-G Corporation parabolic flights

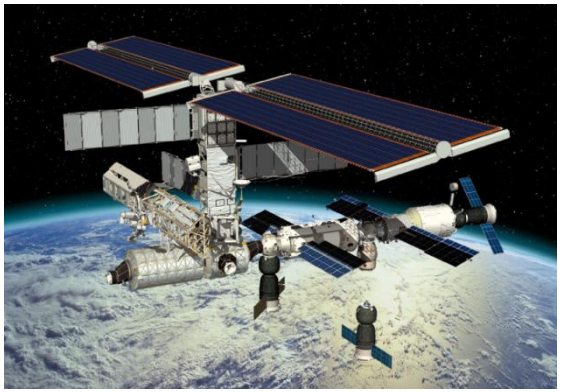
Microgravity Exposures

- Suborbital flight

SpaceShipOne and White Knight vehicles

SpaceShipOne suborbital flight
Courtesy of X PRIZE foundation

- Orbital flight



International Space Station (ISS) on orbit

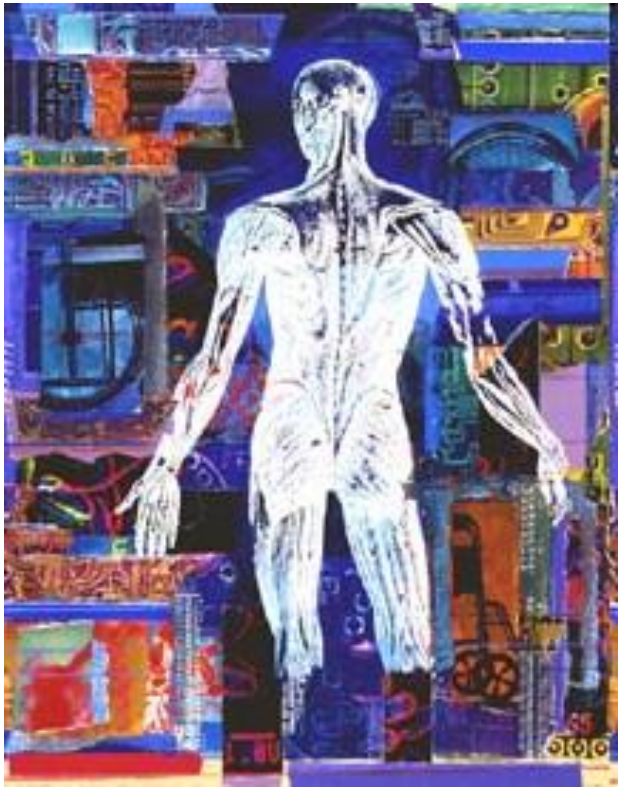
Astronaut Ed Lu eating food on the ISS

Attractive Features of Sub-Orbital Flight

- Low Cost
- Multiple subjects, including repeat flier crews
- Sufficient time to see early micro-g effects
- Opportunity to explore hypogravity (0-1 g) effects

Major Human Research Issues

- Radiation
- Bone
- Muscle
- Cardiovascular
- Neuromuscular
- Psychosocial



One Example: Prisk's Proposal for Suborbital Study of Particle Retention in Lungs

- Reduced sedimentation in low gravity
- Particles that normally are deposited in the large and medium-sized airways in 1G remain in suspension
- Subsequently transported deeper into the lung where they eventually deposit, beyond the reach of the mucociliary clearance system
- Dr. Kim Prisk, UCSD. Proposal to NASA, 2009

Basic Methodology

- Breathe bolus of particles containing short half-life radioactive tracers
- Use Gamma-Ray imaging to localize parts of lung where the particles are retained/cleared
- Compare zero-g to one g and hypergravity

Why Use Suborbital Flight?

- Parabolic flight is too brief for the movement of particles that have been deposited to be imaged (30 sec images)
- Space flight would not accommodate the large amount of short half-life (6 minute) radioactive tracer material
- Suborbital flight would allow several minutes for inhalation, particle deposit, and multiple images.

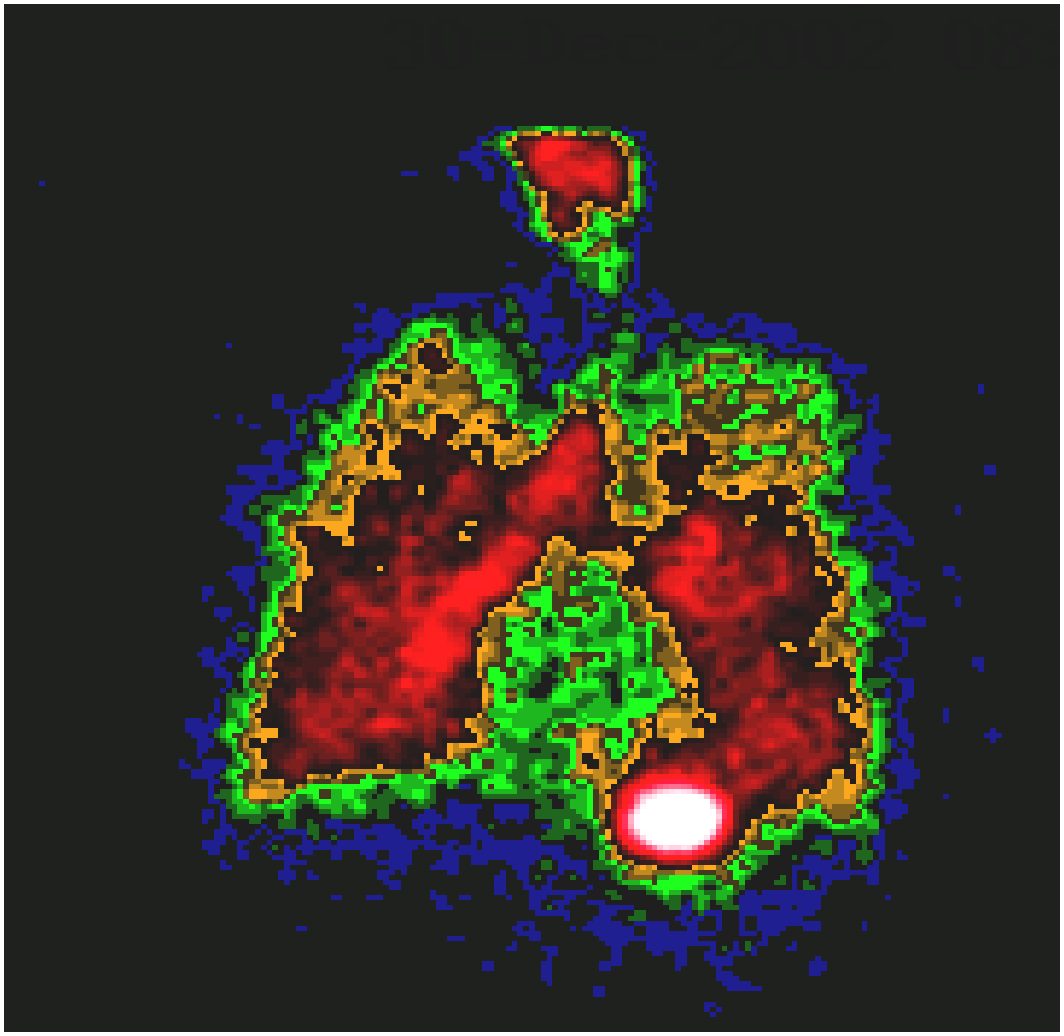
Prisk's Methodology

- Directly measure the rate of mucociliary clearance in the central airways of humans in sustained periods of reduced gravity available **in sub-orbital flight.**
- Compare the rate of clearance in reduced gravity with clearance rates in **earthnormal gravity (1G) and in hypergravity (centrifuge) in the same subjects.**

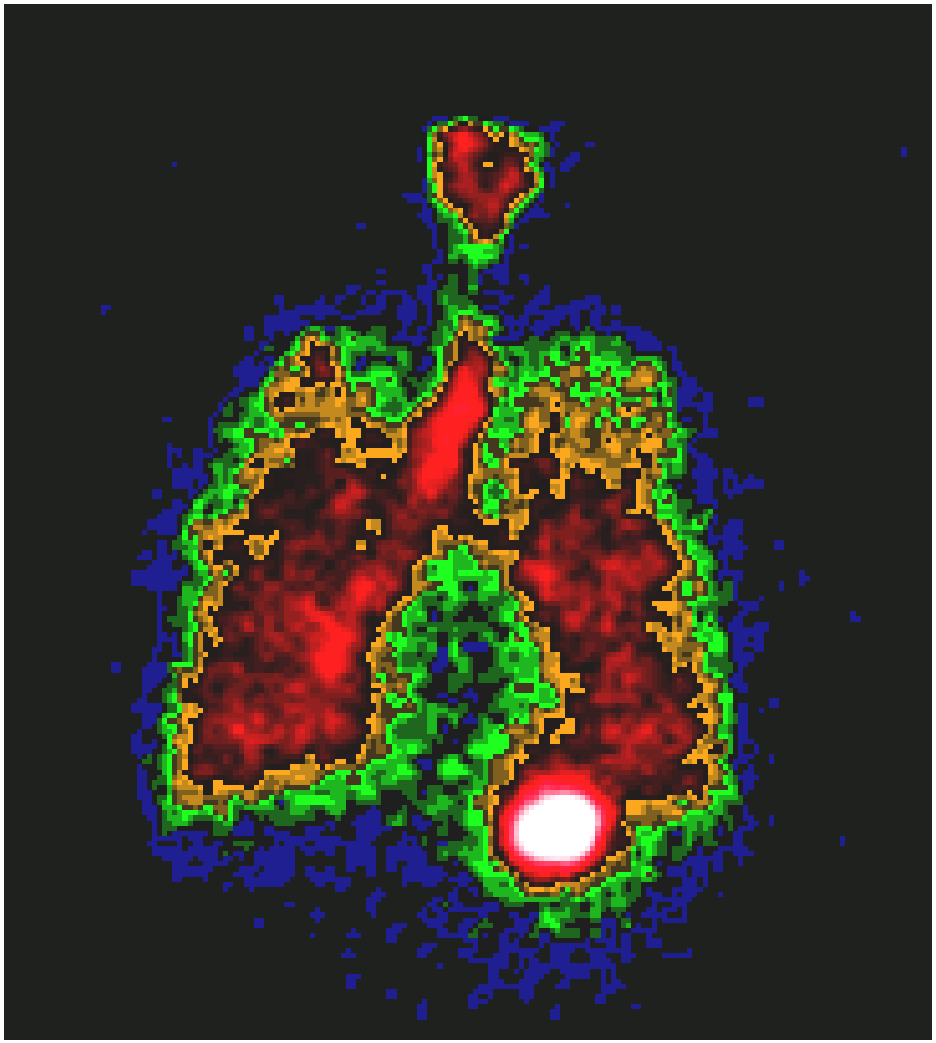
Prisk's Hypothesis

- That mucociliary clearance in the central airways in humans is more rapid in low gravity
- Leads to decreased residence time of inhaled and deposited particulate matter
- The result is that standards for exposure to Lunar Dust are overly conservative

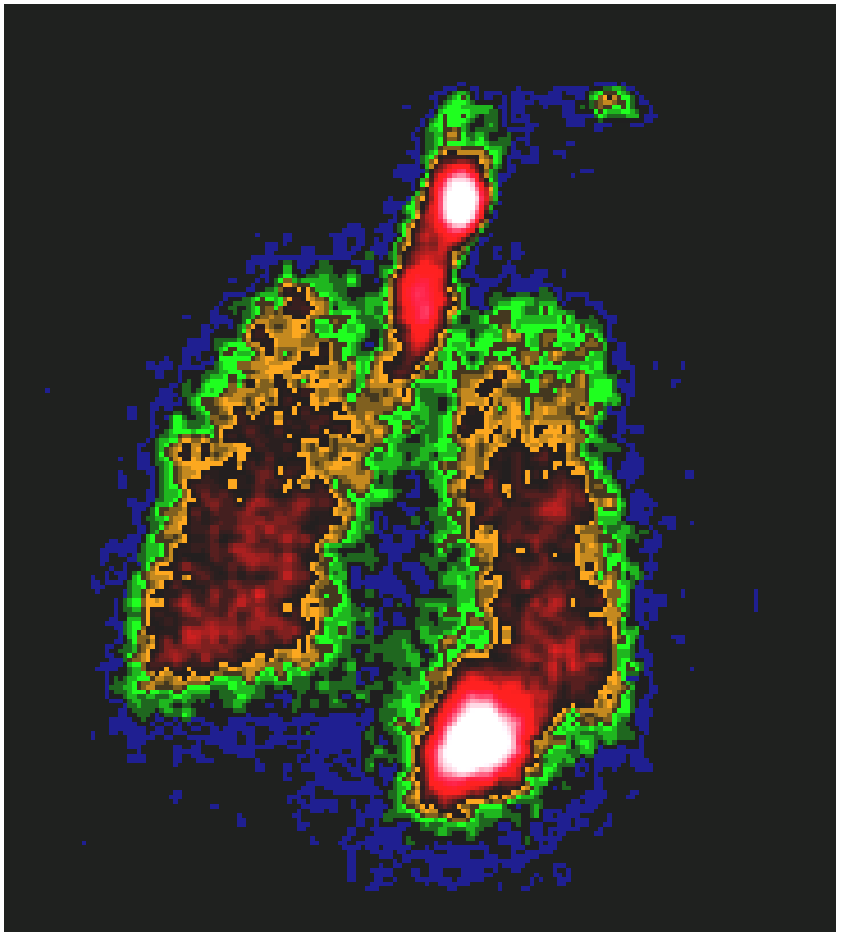
Gamma Ray Image of Particles Just after Inhalation



20 Minutes Later



And After 45 Minutes

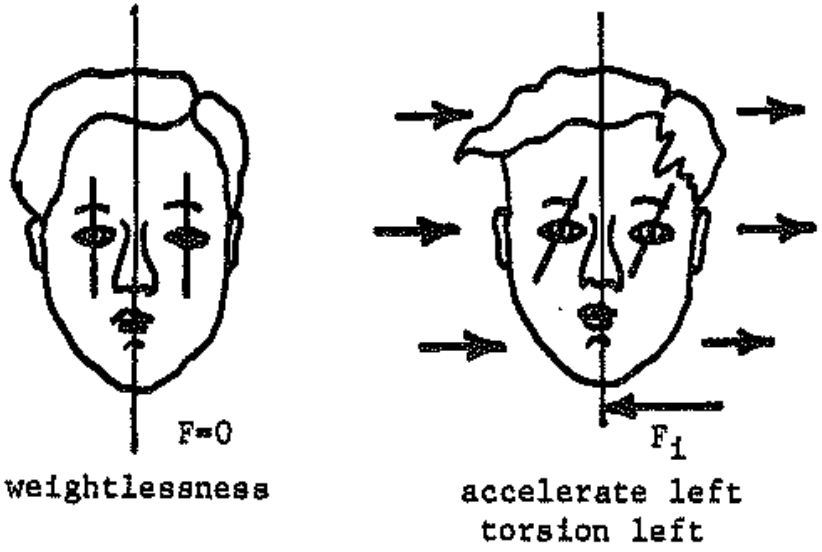


Significance for Lunar Dust Inhalation

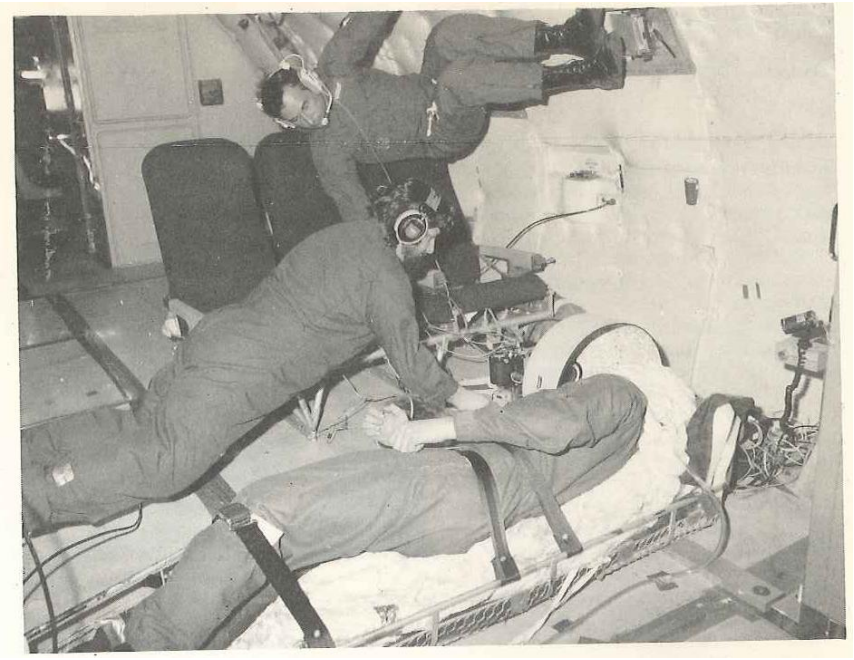
- Mucociliary clearance is rapid in large airways
- Particle deposits in small airways my be gravity dependent
- Standards and Countermeasures for Dust Inhalation may be g-sensitive

Another Example: Ocular Torsion (0-1.8 G stimulus)

- Ocular torsion on earth and in weightlessness
  - Laurence Young, Byron Lichtenberg, Anthony Arrott, Troy Crites, Charles Oman, Edelman
  - Annals of the New York Academy of Sciences Volume 374 Pages 80-92 November 6, 1981 28522



Ocular Torsion Example



Ocular Torsion Example

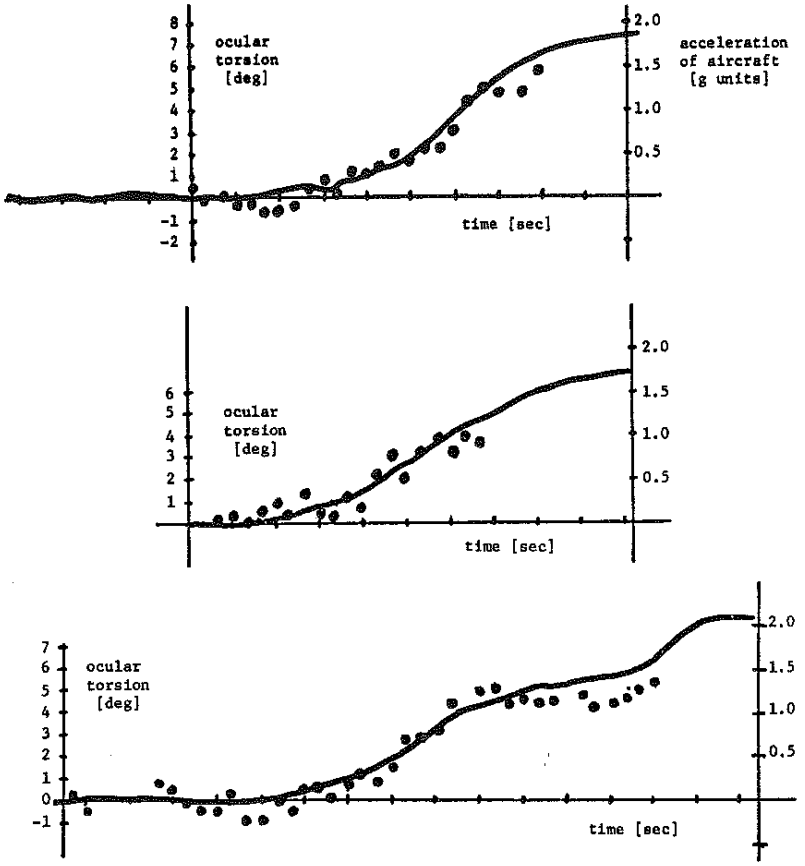


FIGURE 11. Three examples of ocular torsion (counterclockwise positive) induced by the onset of gravitoinertial force following approximately 30 seconds of weightlessness. Subjects were positioned such that the force was exerted in a lateral direction (y-axis). Solid line indicates acceleration of aircraft. Solid circles indicate angle of torsion measured in each frame of photographic data.

Conclusions

Sub-Orbital Research Could be Our

- ***Field of Dreams***

- For Space Life Sciences