Research Enabled by the Lunar Environment

Session 4

Challenges in Human Physiology and Performance

PENNSTATE

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Some Apollo “firsts”

- First documented US cases of space adaptation syndrome
- First ambulation on another planetary body
- First documented stress-associated cardiac arrhythmia in space

Agenda

- 8:30 The Musculoskeletal System
  Peter Cavanagh, PhD, Cleveland Clinic
- 8:50 The Cardiovascular System
  Ben Levine, MD, University of Texas Southwestern Medical Center
- 9:10 Sensory and Motor Systems
  Jim Lackner, PhD, Brandeis University
- 9:30 Behavior and Performance
  Larry Palinkas, PhD, University of Southern California
- 9:50 Open Discussion
  Joan Vernikos, PhD

Key Questions (1/2)

1. What are the most essential experiments in a lunar station that will enable future exploration of Mars? What advantages would lunar research offer (e.g., fractional-g, resources) that the terrestrial environment or the ISS would not?
2. Are there unique features of the lunar environment that make it an important research priority? In other words, is it a destination unto itself, or a stepping stone (figuratively) to other locales?

Key Questions (2/2)

3. What lunar *in situ* measurements or processing of biological material might be necessary to reduce the return mass without sacrificing the quality of research?
4. What features of lunar exploration constitute the greatest risks to the health and safety of astronauts? Is research necessary to mitigate these risks to acceptable levels? If so, what type of research and end-products would you anticipate?

Common themes from presenters (1/4)

- The lunar environment may differ from free-fall in that the latter eliminates gravitational stress, the former requires adaptation/recalibration to a different gravitational field.
- Adaptation to the lunar environment is expected and should equal or exceed that anticipated for Mars (i.e., the Moon is a more challenging test bed for fractional gravity). However, at this level of reduced g the extent of adaptation is *not* expected to be similar across systems.

    A lunar fractional gravity lab (centrifuge) may be desirable to characterize non-linear responses to fractional g.

Common themes from presenters (2/4)

- Variability of responses in all systems is documented and is expected for the moon (i.e., “adapters” vs. “non-adapters”). This variability should be assessed, and appropriate preventative or restorative countermeasures must be personalized. EVA alone should *not* be considered an efficacious countermeasure.
- Preflight screening of potential lunar colonists is essential. Forward work is needed to refine and validate tests of
  - Behavioral health
  - Sensitivity to psychological stress
  - Compatibility with other team members
  - Susceptibility to motion sickness and/or altered sensory environments
  - Potential for sudden cardiovascular events
  - Potential for renal stones, osteoporosis

Common themes from presenters (3/4)

- Possible points of convergence for exercise device(s) and regimen(s) that:
  - Provide relatively high loading to much of the musculoskeletal and cardiovascular system
  - Accommodate a wide variety of crew
  - Can be stowed
  - Require little or no power
  - Maximize crew time

- Direct sample return is not obligatory but *in situ* measurement techniques are essential
  - Blood borne markers
  - Imaging techniques

What's Missing? (4/4)

- Understanding of all biological systems and the radiation/lighting environment
- Efficacy and dose-response relationships for pharmacological and non-pharmacological (exercise) countermeasures in a reduced g-environment
- Characterization of metabolic and thermal environment
- Characterization of real task demands for lunar EVA and lunar ambulation