A Third-Generation Evidence Base for Human Spaceflight Risks

Aerospace Medical Association
85th Annual Meeting

Craig E. Kundrot, PhD
Sarah Lumpkins, PhD
Jennifer Steil
Neal Pellis, PhD
John Charles, PhD

12 May 2014
I have no financial relationships to disclose.

I will not discuss off-label use and/or investigational use in my presentation.
The goal of HRP is to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration.
HRP Risks

1. Risk Factor of Inadequate Nutrition
2. Risk of Acute and Late Central Nervous System Effects from Radiation Exposure
3. Risk of Acute Radiation Syndromes Due to Solar Particle Events (SPES)
4. Risk of Adverse Behavioral Conditions and Psychiatric Disorders
5. Risk of Adverse Health Effects Due to Alterations in Host-Microorganism Interactions
6. Risk of Adverse Health Effects of Exposure to Dust and Volatiles During Exploration of Celestial Bodies
7. Risk of an Incompatible Vehicle/Habitat Design
8. Risk of Bone Fracture
9. Risk of Cardiac Rhythm Problems
10. Risk of Clinically Relevant Unpredicted Effects of Medication
11. Risk of Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems
12. Risk of Crew Adverse Health Event Due to Altered Immune Response
13. Risk of Decompression Sickness
14. Risk Of Degenerative Tissue Or Other Health Effects From Radiation Exposure
15. Risk Of Early Onset Osteoporosis Due To Spaceflight
16. Risk of Impaired Control of Spacecraft, Associated Systems and Immediate Vehicle Egress Due to Vestibular/Sensorimotor Alterations Associated with Space Flight
17. Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance
18. Risk of Inadequate Critical Task Design
19. Risk of Inadequate Design of Human and Automation/Robotic Integration
20. Risk of Inadequate Human-Computer Interaction
21. Risk of Injury from Dynamic Loads
22. Risk of Intervertebral Disk Damage
23. Risk of Orthostatic Intolerance During Re-Exposure to Gravity
24. Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System
25. Risk of Performance Decrement Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team
26. Risk of Performance Errors Due to Fatigue Resulting from Sleep Loss, Circadian Desynchronization, Extended Wakefulness, and Work Overload
27. Risk of Performance Errors Due to Training Deficiencies
28. Risk of Radiation Carcinogenesis
29. Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity
30. Risk of Renal Stone Formation
31. Risk of Spaceflight-Induced Intracranial Hypertension/Vision Alterations
32. Risk of Unacceptable Health and Mission Outcomes Due to Limitations of In-flight Medical Capabilities
Program Architecture

- Evidence
  - Risks
    - Gaps
      - Tasks
        - Deliverables
First Generation Evidence Base

• 2008 Evidence Book
  - One volume
  - One chapter for each HRP risk
  - Review paper format
    • Aimed at scientifically-educated, non-specialist reader
    • Current state of knowledge from both research and operations
  - Authors
    • Human Research Program
    • National Space Biomedical Research Institute

• Chapters linked to their risk on HRP website
  - humanresearchroadmap.nasa.gov/Evidence/
• The February 2008 versions of the Evidence-Based Risk Reports were reviewed by members of a committee on NASA’s Research on Human Health Risks, established by the Institute of Medicine.


  humanresearchroadmap.nasa.gov/reviews/IOM%20Review.pdf

• This review also offered excellent suggestions to improve public access to the information in these reports.
Limitations of the 1GEB

- Limited authorship
  - NASA and NSBRI
  - Missing ISS international partners
  - Missing researchers studying related terrestrial issues

- Laborious update process
  - Resulting in “all or none” updates

- Infrequent updates

Note: Some Evidence Reports have been supplemented by a bibliography or additional report
The Second Generation Evidence Base - Wikipedia

• The Gene Wiki precedent
  - Enable the creation of a collaboratively written, continuously updated, high quality review article for all (~25,000) human genes.
  - Wikipedia
    • “Stub” articles for each gene in standardized format
    • Users add and refine content
    • en.wikipedia.org/wiki/Gene_Wiki

• The HRP implementation
  - Portal page in Wikipedia
  - Main article for each Risk
    • Subarticles as needed
    • Links to related Wikipedia content
    • Summary of HRP-approved Evidence Report

A review article for every gene is powerful

The Gene Wiki project – 2010 stats

- 10,300 articles
- 1.2 million words
- 67MB text
  • (about 1,000 journal articles)
- 3,500 editors
- 17,000 edits
- 55 million page views

12 May 2014
The HRP Portal

Visual impairment due to intracranial pressure

From Wikipedia, the free encyclopedia

(Redirected from IOP)

Spaceflight induced visual impairment is hypothesized to be a result of increased intracranial pressure. The study of visual changes and intracranial pressure (ICP) in astronauts on long-duration flights is a relatively recent topic of interest to Space Medicine professionals. Although reported signs and symptoms have not appeared to be severe enough to cause blindness in the near term, long-term consequences of chronically elevated intracranial pressure are unknown.7

NASA has reported that fifteen long-duration male astronauts (45–55 years of age) have experienced confirmed visual and anatomical changes during or after long-duration flights. Optic disc edema, globe flattening, choroidal folds, hyperopic shifts and an increased intracranial pressure have been documented in these astronauts. Some individuals experienced transient changes post-flight while others have reported persistent changes with varying degrees of severity.8

Although the exact cause is not known at this time, it is suspected that microgravity-induced cephalad fluid shift and comparable physiological changes play a significant role in these changes. Other contributing factors may include pockets of increased CO₂ and an increase in sodium intake. It seems unlikely that resistive or aerobic exercise are contributing factors, but they may be potential countermeasures to reduce intracranial pressure (ICP) or intracranial pressure (ICP) in-flight.9

### Contents

- [1 Causes and current studies](#)
  - 1.1 CO₂
  - 1.2 Sodium Intake
  - 1.3 Exercise
  - 1.4 Biomarkers
  - 1.5 One-Carbon Metabolism (Homocysteine)
  - 1.6 Space Obstructive Syndrome
- [2 Current ICP and IOP Measurement](#)
  - 2.1 ICP Measurement
  - 2.2 IOP Measurement
- [3 Existing Long-Duration Flight Occurrences](#)
- [4 Case Definition and Clinical Practice Guidelines](#)
  - 4.1 Causes
  - 4.2 Stages
- [5 Risk Factors and Recommendations](#)
  - 5.1 Immediate Actions
  - 5.2 Near and Long Term Actions
- [6 Benefits to Earth](#)
- [7 See also](#)
- [8 External links](#)
- [9 References](#)

STS-61 crew members conduct Detailed (O2) 473

Intracranial Pressure on the middeck of Discovery, Orbiter Vehicle (OV) 103.

Mission Specialist (MS) Williams M. Shepherd rests his head on the stabilized headrest while Pilot Robert D. Cabana, holding Shepherd's eye open, prepares to measure Shepherd's intracranial pressure using a tono pen (in his right hand).
Strengths of the Wikipedia approach

- Extremely accessible
  - Reading
  - Contributing
- Many “hits”
Weaknesses of the Wikipedia approach

• Wikipedia rules for content
  - Cannot copy Evidence Reports
  - Must summarize Evidence Reports
    • The resulting article is a summary of a review
• Few contributions
  - Net loss of content
  - Workload to maintain thriving articles is unknown

<table>
<thead>
<tr>
<th>Metric</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unique contributors</td>
<td>85</td>
</tr>
<tr>
<td>Total contributions</td>
<td>146</td>
</tr>
<tr>
<td>Minor contributions</td>
<td>80</td>
</tr>
</tbody>
</table>
The Third Generation Evidence Base

• **Advantages**
  - Wiki-based
  - Editorially controlled
  - Verbatim copy of full Evidence Report

• **Implementation plan**
  - Contributions will be added:
    • Directly by pre-approved contributors and
    • Indirectly by other individuals using an email link at the top of each Evidence Report page
  - Each HRP Element will have an Editorial Board, which will review contributions before they are made publicly available
Risk of Adverse Behavioral Conditions and Psychiatric Disorders

Risk of Adverse Behavioral Conditions and Psychiatric Disorders

Behavioral issues are inevitable among groups of people, no matter how well selected and trained. Spaceflight demands can heighten these issues. The Institute of Medicine ([IOM]) Safe Passage, notes that Earth analog studies show an incidence rate of behavioral problems ranging from 3-13 percent per person per year. The report transposes these figures to person crews on a 3-year mission to determine that there is a significant likelihood of behavioral conditions and psychiatric disorders emerging. Impacts of behavioral issues are minimized if they are identified and addressed early. The HRP must provide the best measures and tools to monitor and assess mood and to predict risk for an effective management of behavioral and psychiatric conditions prior, during and following spaceflight.}

An iconic photograph of Russian cosmonaut Valery Poliakov, who has clearly demonstrated his capacity for long-duration space flight, having completed two tours of duty on the Russian space station Mir, including one that lasted 438 days, thus setting a record that remains unbroken to this day. Current International Space Station missions involve crew stays of up to 6 months, with provision of an effective set of psychosocial countermeasures to aid crew morale and team cohesion.
Conclusion

• NASA’s Human Research Program seeks to understand and mitigate risks to crew health and performance in exploration missions
• HRP’s evidence base consists of an Evidence Report for each HRP risk
• Three generations of Evidence Reports
  1) Review articles
     + Good content
     - Limited authorship, infrequent updates
  2) Wikipedia articles
     + Viewed often, very open to contributions
     - Summary of reviews, very few contributions
  3) HRP-controlled wiki articles
     + Incremental additions to review articles with editorial control
     - ?

humanresearchroadmap.nasa.gov/Evidence