Human Research Program

Human Health Countermeasures

Element Overview

Peter Norsk, MD

HHC Element Scientist
Who am I?

M.D., University of Copenhagen 1982
Dr. med. (Ph.D) same place 1989
Manager of DAMEC Research A/S 1989 – 2002
Consultant, Dept. of Aerospace Medicine 2002-03
Associate Professor, University of Copenhagen 2003 -06
Professor, same place, Gravitational & Space Physiology 2006 -11
HHC Element Scientist, USRA/NASA, JSC 2011 –

Research:
Using gravity and anti-gravity models to understand BP regulation
13 inflight studies (shuttle, Mir, ISS).
Environmental hazards:
Environmental hazards:

• Weightlessness
• Radiation
• Oxidative stress
Weightlessness – what is it?
Weightlessness
Weightlessness
Weightlessness = free fall condition
SOLAR WIND
- Low hazard and continuous
- Low energy protons, electrons, and other particles travelling at about $5 \times 10^5 \text{ m/s}$

SOLAR FLARE
- Very hazardous
- Intermittent and lasting for 1 to 2 days
- High energy protons traveling at the speed of light ($3 \times 10^8 \text{ m/s}$)

GALACTIC COSMIC RAYS
- Hazardous and continuous
- Composed primarily of gamma rays
Oxidative stress:

Hyperoxia
Hypoxia
Stress
Etc.
Tired people?
Tired people?

No, back from space
Tired people?

- Blood pressure reflexes
- Blood volume
- Sensori-motor function
- Bone
- Muscle
- Immune system

No, back from space
Introduction to HHC

• Provides the biomedical expertise for the development and assessment of:
  • medical standards.
  • vehicle and spacesuit requirements dictated by human physiologic needs.
  • a validated and integrated suite of countermeasures that ensure the maintenance of crew health during all phases of exploration missions.

• Targets human physiologic and performance capabilities at risk from spaceflight missions at each stage of mission performance.
  • Pre flight countermeasures involve physical fitness and exercise, and physiologic adaptation training.
  • In-flight countermeasures cover physiologic and nutritional health, physical fitness, and mission performance.
  • Post flight countermeasures target rehabilitation strategies and long term crew health.
Within HRP, the Human Health Countermeasures (HHC) Element focuses on:

- Defining, understanding and mitigating the untoward physiological changes associated with human spaceflight.
- Providing optimized countermeasures that use a minimum of flight resources.
- Defining standards for human health and performance.
- Defining requirements for mission operations and hardware design.
An example:

Orthostatic intolerance:

Mitigated by:

- Oral salt and fluid loading
- Antigravity garment
- Additional clinical treatment
Bed rest, flight analog for 0 G
Parabolic flight – shortterm 0 G
The Human System Risk Board (HSRB) determines the appropriate risk action and determines risk disposition, mitigation or monitoring strategy.
Human Health Countermeasures

Manager – David Baumann
Element Scientist – Peter Norsk, M.D.
Deputy Element Scientist – Lauren Merkle, Ed.D.

- Bone (4 Risks)
- Muscle (2 Risks)
- Cardio (2 Risks)
- Immune (1 Risk)
- Neuro (1 Risk)
- Pharm (1 Risk)
- DCs (1 Risk)
- Nutrition (1 Risk Factor)
- VIIP (1 Risk)
- Occupant Protection (1 Risk)
- (1 Risk)
HHC Disciplines

- 10 disciplines in HHC examining 15 Risks
  - Bone (4 risks)
  - Muscle (2 risks)
  - Cardiovascular (2 risks)
  - Immune (1 risk)
  - Pharmacology (1 risk)
  - Sensorimotor (1 risk)
  - Occupant Protection (1 risk)
  - Decompression Sickness (1 risk)
  - Nutrition (1 risk factor)
  - Visual Impairment and Intracranial Pressure (1 risk)
HHC Risks

- Risk Factor of Inadequate Nutrition
- Risk of Bone Fracture
- Risk of Cardiac Rhythm Problems
- Risk of Adverse Health Event Due to Altered Immune Response
- Risk of Intervertebral Disc Damage
- Risk of Renal Stone Formation
- **Risk of Therapeutic Failure Due to Ineffectiveness of Medication**
  - Risk of Impaired Control of Spacecraft, Associated Systems, and Immediate Vehicle Egress Due to Vestibular/Sensorimotor Alterations Associated with Spaceflight
  - Risk of Impaired Performance Due to Reduced Muscle Mass, Strength, and Endurance
  - Risk of Orthostatic Intolerance During Re-Exposure to Gravity
  - Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity
  - Risk of Early Onset Osteoporosis
  - Risk of Injury Due to Dynamic Loads
  - Risk of Decompression Sickness
  - Risk of Microgravity-Induced Visual Alterations/ICP
Human Health Countermeasures Element Structure

Manager – David Baumann
Element Scientist – Peter Norsk, MD
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Digital Astronaut
Exercise Physiology and Countermeasures
VIIP
Non-Exercise Physiological Countermeasures
Flight Analogs
Projects directly supporting Risk Mitigation
Human Health Countermeasures Element Structure

Human Health Countermeasures
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Enabling Projects - Infrastructure
## HHC Scorecard of Evidence

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Risk</th>
<th>Evidence/Data</th>
<th>Knowledge of Mechanism</th>
<th>Countermeasure (CM) required?</th>
<th>Maturity of CM</th>
<th>Technology Development</th>
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<tbody>
<tr>
<td>Bone</td>
<td>Risk of Accelerated Osteoporosis</td>
<td>Green</td>
<td>Green</td>
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<td>Risk of Renal Stone Formation</td>
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<td>Cardiovascular</td>
<td>Risk of Cardiac Rhythm Problems</td>
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<td>UKN</td>
<td>N/A</td>
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<td>Risk of Orthostatic Intolerance during Re-Exposure to Gravity</td>
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<td>EVA</td>
<td>Risk of Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems</td>
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<td>Exercise/Muscle</td>
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<td>Risk of Crew Adverse Health Event Due To Altered Immune Response</td>
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<td>Nutrition</td>
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<td>Sensorimotor</td>
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Green = no additional evidence/data needed
Yellow = incomplete evidence/data
Red = little or no evidence/data
Grey = not applicable (N/A), need is unknown (UKN), or to be determined (TBD)
## Study Areas

<table>
<thead>
<tr>
<th>Discipline / Risk</th>
<th>Evidence/Data</th>
<th>Ground Analogues</th>
<th>Pre/Post-flight</th>
<th>In-flight</th>
<th>Performance</th>
<th>Mechanistic Studies</th>
<th>CM Studies</th>
<th>Technology Development</th>
<th>Informing Operations</th>
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p = IRP planned work
Ideal HHC Countermeasure Validation
(Renal Stone Risk: Potassium Citrate Example)

Definition of renal stone risk


Ground-based development of countermeasures


Countermeasure validated in flight experiment


Risk Mitigation

- OCHMO approval for transition to medical practice and operational readiness

HSRB

HSRB
Types of Deliverables

- Information for Standards
- Recommended Standard Update
- Informing Mission Operations
- Countermeasures
- Information to Other Elements
- Requirements to Other Programs
- Updates to Human System Risk Forum
Thank you
Questions?