Human Adaptation to Space: Space Physiology and Countermeasures

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Astronauts experience a spectrum of adaptations in flight and postflight.

- **Balance disorders**
- **Cardiovascular deconditioning**
- **Decreased immune function**
- **Muscle atrophy**
- **Bone loss**

**Human Response to Spaceflight**

- **Neurovestibular**
- **Cardiovascular**
  - Bone
  - Muscle
- **Immunology**
  - Nutrition
- **Behavior**
Space Adaptation Syndrome (SAS)

- approximately 70% of all astronauts traveling into space experience SAS symptoms, which range from nausea and light headedness to vomiting. The exact cause of SAS is unknown, but it is believed that it is caused by conflicting sensory inputs from the vestibular organ (inner ear) and the eyes. SAS symptoms normally last only for a day or two and can be treated by medication.
Space Adaptation Syndrome (SAS)

- Space Motion Sickness (SMS)
- Headache
- Back Pain
- Insomnia
- Nasal Congestion
- Constipation
- Nosebleed
- Urinary Retention
- Urinary Incontinence
Transitioning Data/Technology/Solutions to Operations

Research

Operational
ISS Expeditions 1-16

- 20 Astronauts on ISS
  - 17 males
  - 3 females
- Average age 47.2 years young
- Average length of mission 174.2 days
  - Longest mission 215 days
  - Shortest mission 133 days
Countermeasure

- an action, process, device, or system that can prevent, or mitigate (negate or offset) the effects of threats to a human; a threat is a potential or actual adverse event that may be malicious or incidental, and that can compromise the health and/or performance of an individual and the integrity of mission
This integrated system supports crew capability for normal and contingency ops. There is limited redundancy and crossover between the elements of the CMS system.
Exercise Device Availability

ISS Exercise Hardware Availability Timeline

CEVIS Assembly: restricted to arm ergometry
CEVIS: 09/05

I-RED Assembly: failing control panel
I-RED: 10/03

TVIS Assembly: TVIS
TVIS: 10/00

CCS Installed: 04/05

DC power converter failure: 03/06

Incorrect thimble on new cord: 09/06

7th fwd stbd roller deteriorated: 10/07

SchRED replaces I-RED: 03/01

Failed control panel: 04/03

Installed: 04/04

Failed control panel: 04/04

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Biomedical Data

Data Collected via Medical Requirements

Assessments of:

- Bone
- Aerobic Fitness
- Functional Fitness
Decreased Bone Mineral Density

BMD % Change from Preflight Expeditions 1-16 (n=20)

-30.0 -25.0 -20.0 -15.0 -10.0 -5.0 0.0 5.0 10.0 15.0 20.0 25.0 30.0

Lumbar Spine, Femoral Neck, Trochanter, Whole Body, Heel, Pelvis
Decreased Bone Mineral Density

Pre and Post Bone Mineral Density- II
Expeditions 1-16 (n=20)

Pre and Post Bone Mineral Density- I
Expeditions 1-16 (n=20)
Bone Mineral Density Recovery

Pelvis
Loss$_0$=7.7%  Recovery Half-life=97 d

Femoral Neck
Loss$_0$=6.8%  Recovery Half-life=211 d

Trochanter
Loss$_0$=7.8%  Recovery Half-life=255 d
Estimated In-flight and Post-flight Aerobic Capacity

Percent Change in Estimated VO2 Index from Pre-Flight Expeditions 1-16 (n=20)
Recovery of Functional Fitness

Postflight Functional Fitness Expeditions 1-16 (n=20)
Purpose: Highlight the biomedical data captured during International Space Station expeditions 1 - 16 via the medical requirements testing.

Content: Graphic assessments of physiological and performance. The physiological parameters assessed include skeletal and cardiovascular. Performance parameters assessed include aerobic capacity, strength, flexibility, and endurance measurements.