Human Adaptation to Space: Space Physiology and Countermeasures

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Human Spaceflight Experience

The graph shows the number of individual exposures for different flight durations. The x-axis represents the flight duration in months, while the y-axis represents the number of individual exposures. The highest number of exposures is for flights lasting 2-3 weeks, followed by shorter durations like 1-2 weeks. The number of exposures decreases significantly for longer durations.
Astronauts experience a spectrum of adaptations in flight and postflight.

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

• 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
Exercise Countermeasures System Elements

Resistive Exercise
- SchRED
  - Axial Bone loading, Muscle Strength, & Joint protection

Treadmill
- TVIS
  - Bone impact loading, Sensorimotor & Cardio

Cycle Ergometry
- CEVIS
  - Cardio & muscle

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
- I-RED Assembly: failing control panel
- CCC Installed
- DC power converter failure
- Failed control panel; CCC installed
- SchRED replaces I-RED
- Incorrect thimble on new cord
- 7th fwd stbd roller deteriorated

Exercise Device Availability
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

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

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

Pre and Post Bone Mineral Density - II
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)

% change from preflight

Push Ups  Crunches  Pull Ups  Sit&Reach  Bench Press  Leg Press
Back Up Slides
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.