Human Adaptation to Space: Space Physiology and Countermeasures

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Human Spaceflight Experience

Number of individual exposures vs. Flight Duration
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
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
- I-RED
  - SchRED replaces I-RED
  - DC power converter failure
  - failed control panel; CCC installed
- TVIS Assembly
  - Incorrect thimble on new cord
  - 7th fwd stbd roller deteriorated

Timeline:
- EXP1 01/10
- EXP2 03/01
- EXP3 08/01
- EXP4 12/01
- EXP5 06/02
- EXP6 11/02
- EXP7 04/03
- EXP8 10/03
- EXP9 04/04
- EXP10 04/05
- EXP11 09/05
- EXP12 03/06
- EXP13 09/06
- EXP14 04/07
- EXP15 10/07
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)

BMD (g/cm²)

Pre-L Spine Post-L Spine Pre-F Neck Post-F Neck Pre-Trochanter Post-Trochanter

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

BMD (g/cm²)

Pre-Whole Body Post-Whole Body Pre-Calcaneus Post-Calcaneus Pre-Pelvis Post-Pelvis

BMD (g/cm²) vs Pre-Post
Bone Mineral Density Recovery

Pelvis
Loss₀=7.7%  Recovery Half-life=97 d

Femoral Neck
Loss₀=6.8%  Recovery Half-life=211 d

Trochanter
Loss₀=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
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.