



Human Adaptation to Space: Space Physiology and Countermeasures

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Acknowledgements

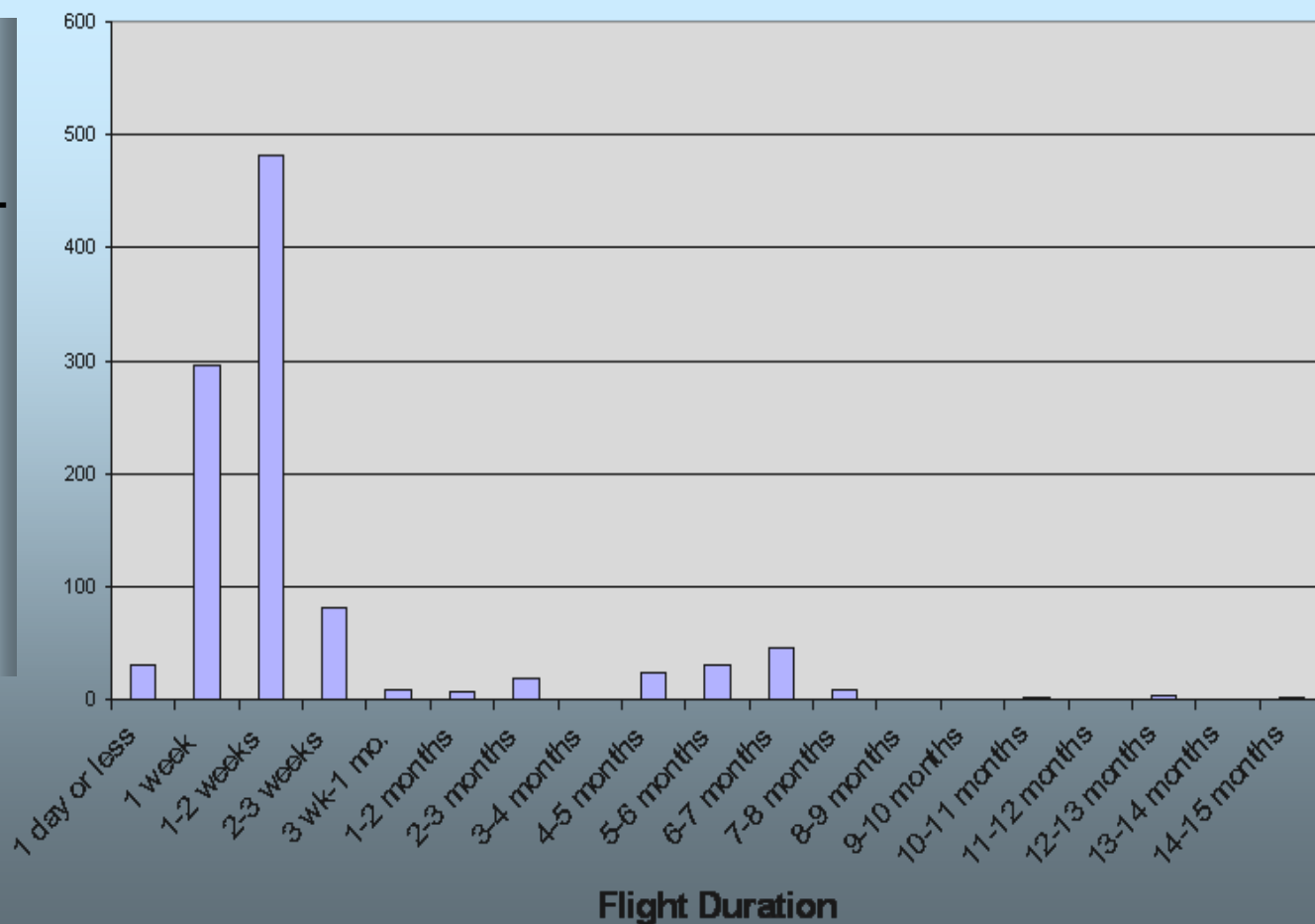
The following presentation is the product of on-going work by The NASA, Johnson Space Center, Space Life Sciences Directorate (SLSD)

Laboratories, researchers, clinicians, and analysts from each division, Habitability and Environmental Factors; Human Adaptation and Countermeasures; and Space Medicine, within SLSD have contributed to the work presented here.



Human Spaceflight Experience

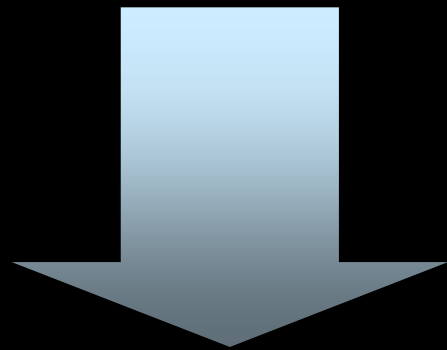
Number of individual exposures





Human Response to Spaceflight

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**

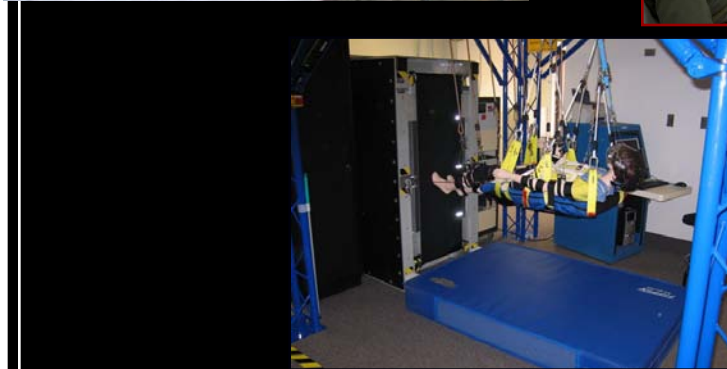


Transitioning Data/Technology/Solutions to Operations

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

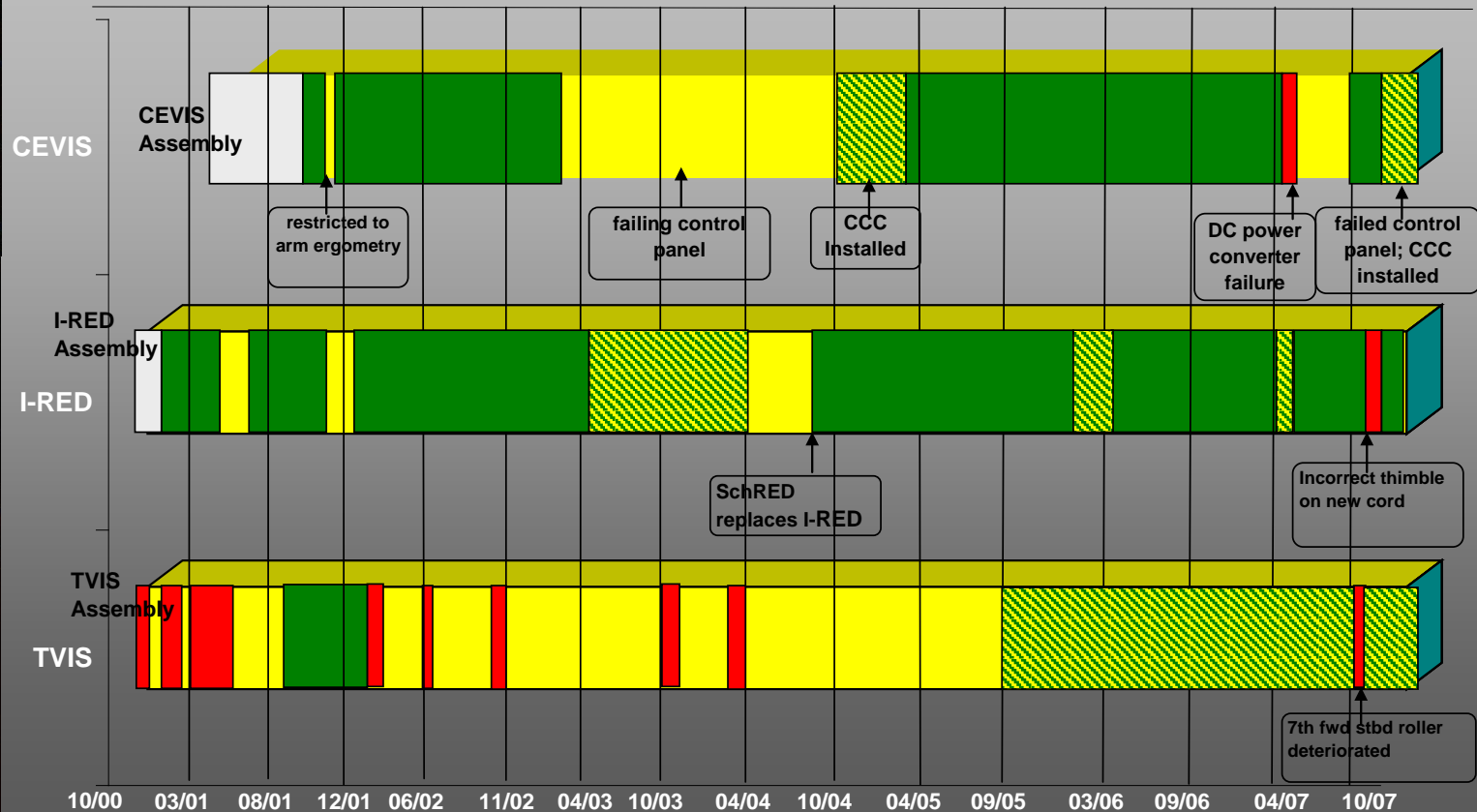
This integrated system supports crew capability for normal and contingency ops. There is limited redundancy and crossover between the elements of the CMS system.



Exercise Device Availability

ISS Exercise Hardware Availability Timeline

EXP1 EXP2 EXP3 EXP4 EXP5 EXP6 EXP7 EXP8 EXP9 EXP10 EXP11 EXP12 EXP13 EXP14 EXP15 EXP16



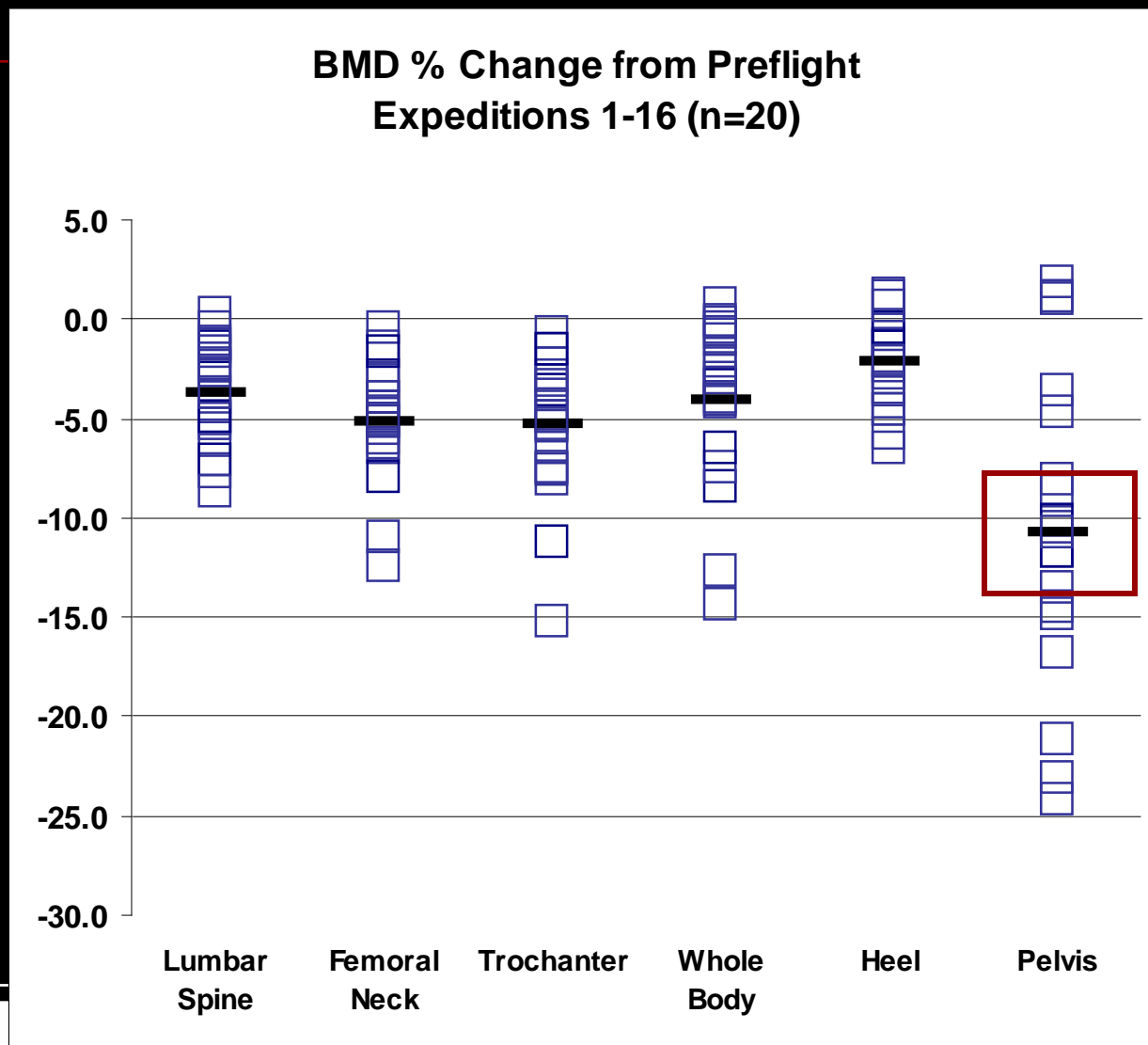


Biomedical Data

- Data Collected via Medical Requirements
- Assessments of:
 - Bone
 - Aerobic Fitness
 - Functional Fitness



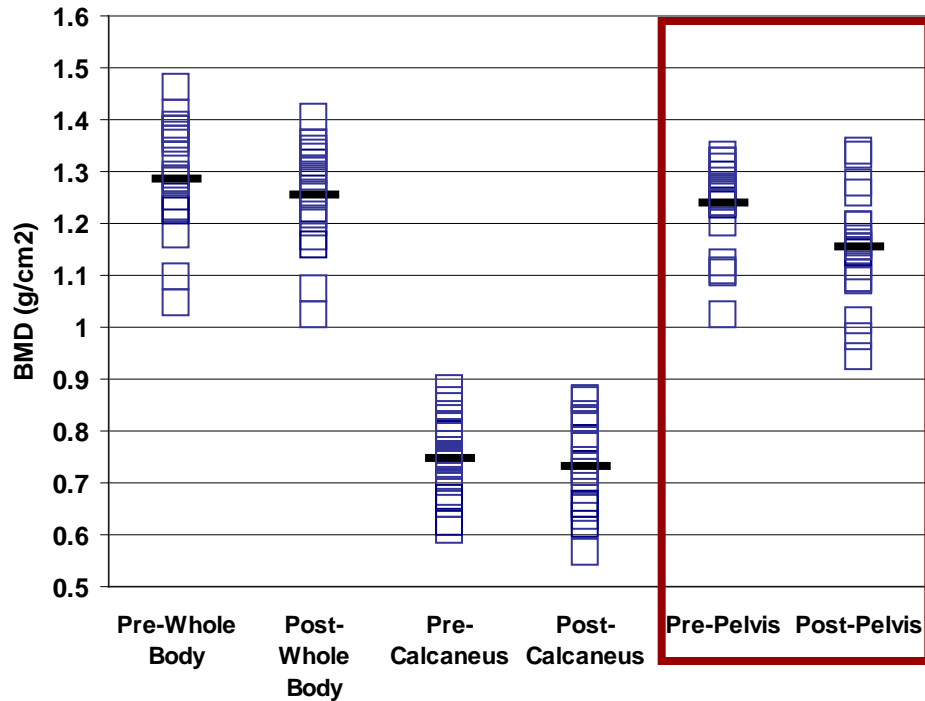
Decreased Bone Mineral Density



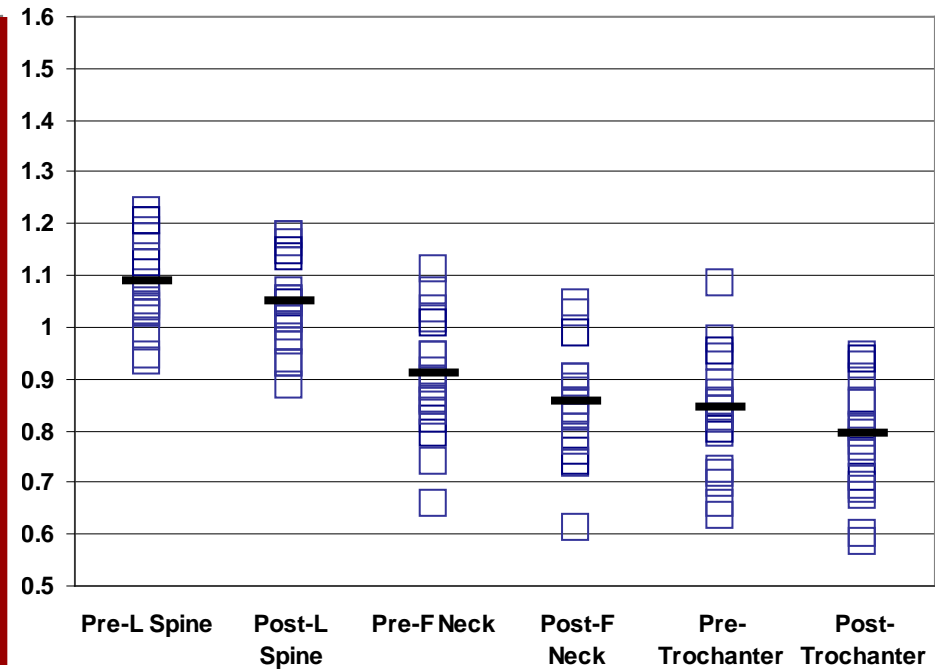


Decreased Bone Mineral Density

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



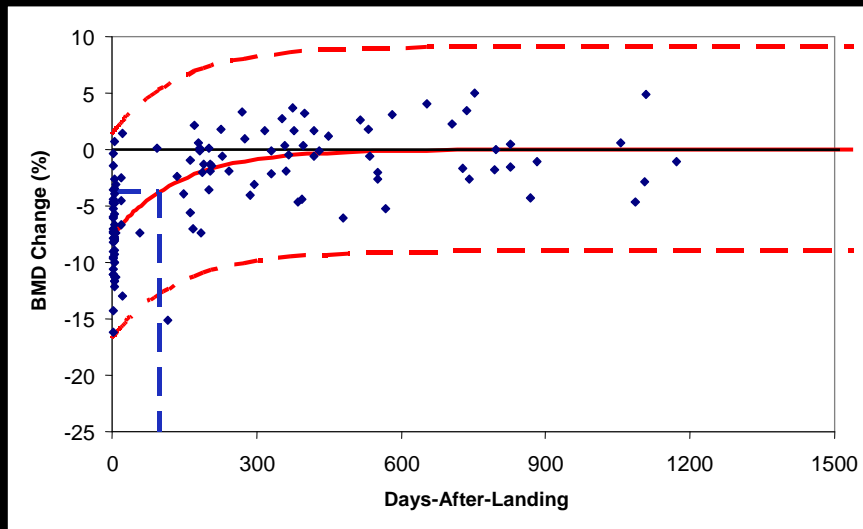
Pre and Post Bone Mineral Density- I
Expeditions 1-16 (n=20)



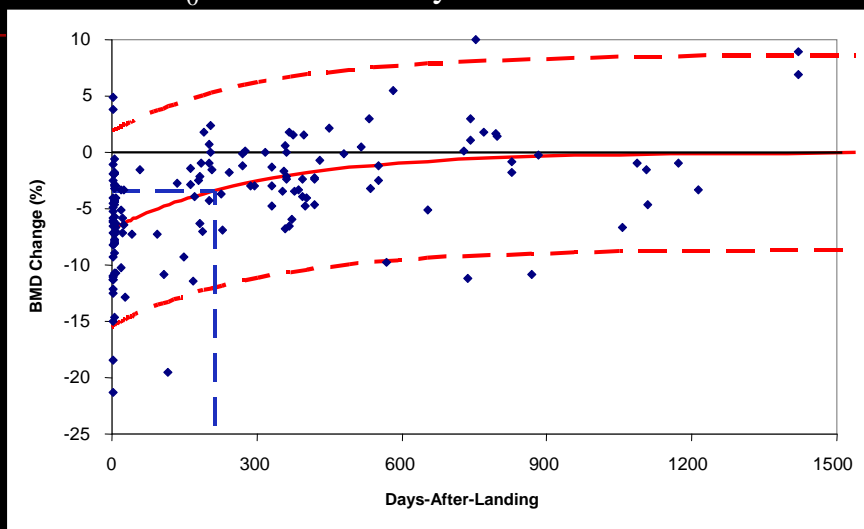


Bone Mineral Density Recovery

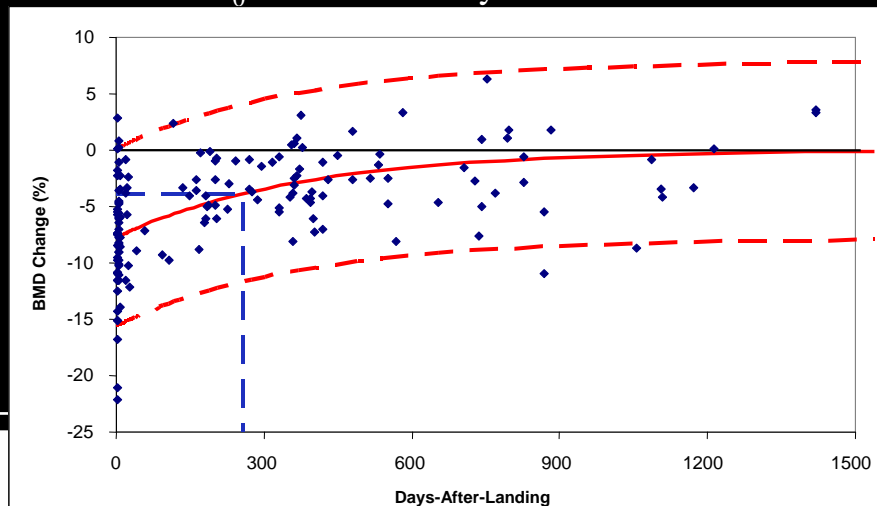
Pelvis
Loss₀=7.7% Recovery Half-life=97 d



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



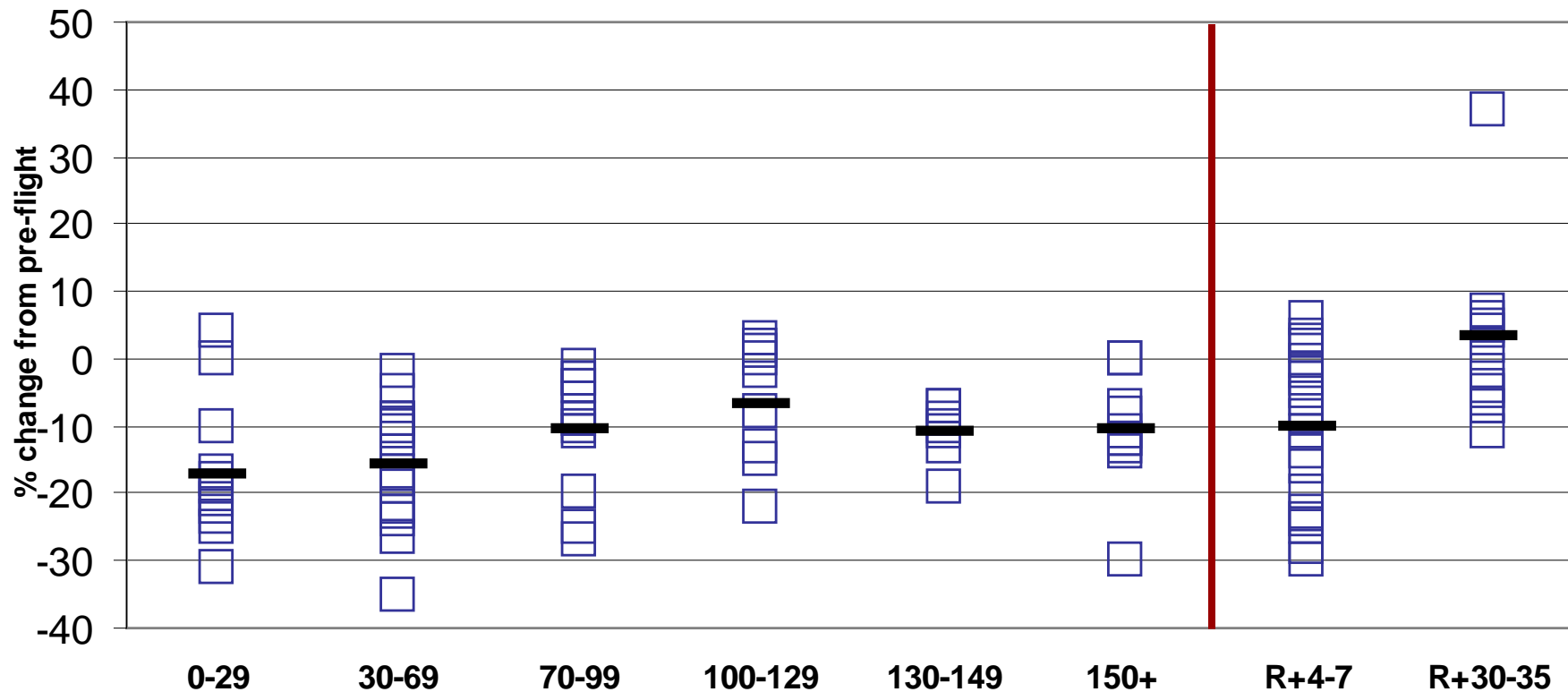
Trochanter
Loss₀=7.8% Recovery Half-life=255 d





Estimated In-flight and Post-flight Aerobic Capacity

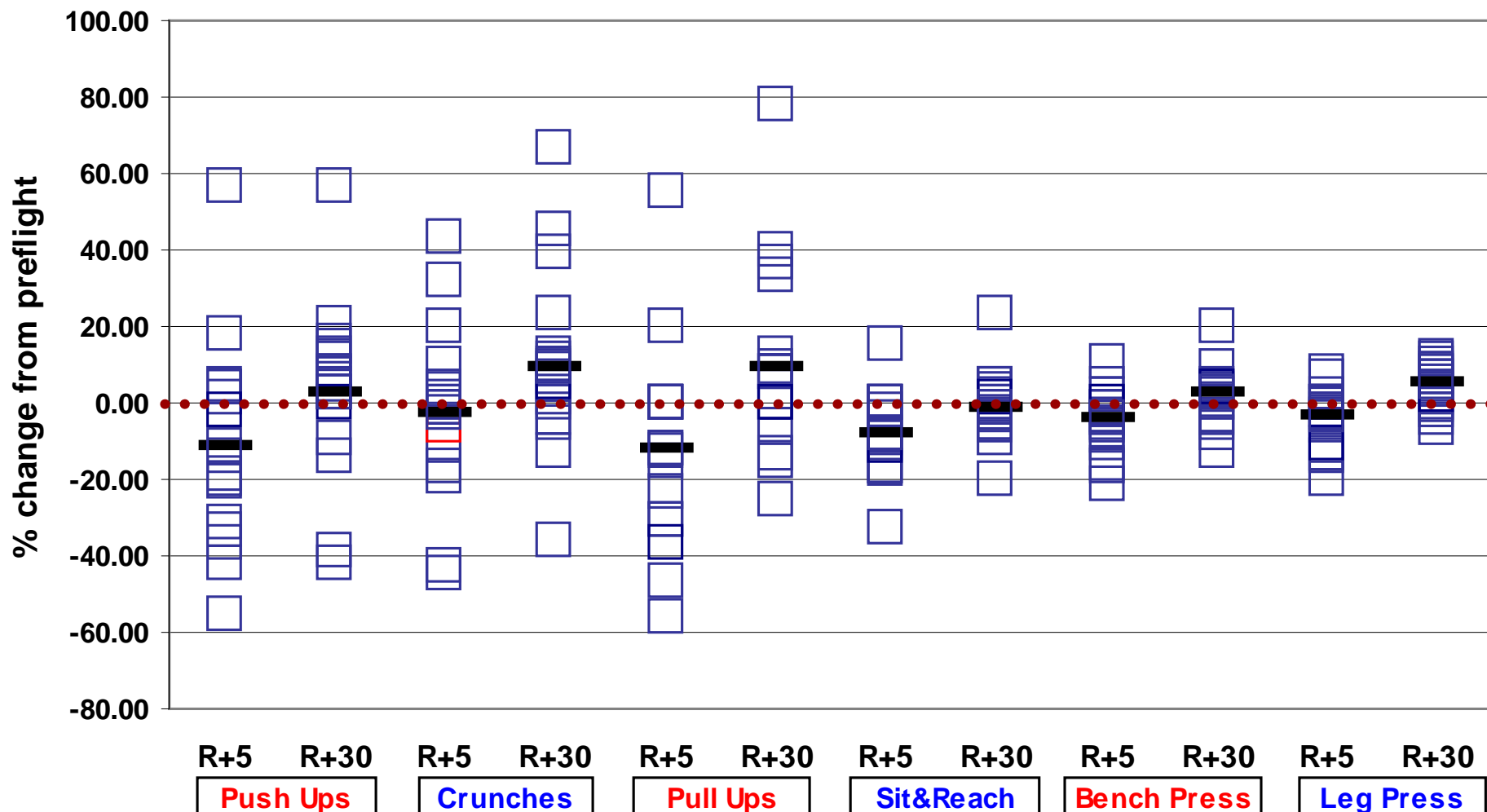
Percent Change in Estimated VO₂ Index from Pre-Flight Expeditions 1-16 (n=20)





Recovery of Functional Fitness

Postflight Functional Fitness Expeditions 1-16 (n=20)





Back Up Slides



Biomedical Results of ISS Expeditions 1-16

Summary Slide

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.