Medical problems in human space flight and space medicine research

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Contents

1. Medical problems in space flight
2. Space medicine research
3. Outreach & public participation
Flight schedule of JAXA’s Astronaut

- Completed the five long duration flight on ISS.
- Prepare next two long duration ISS flight (Yui and Onishi).

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<thead>
<tr>
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<tbody>
<tr>
<td>#1 Exp 18-20</td>
<td>#2 Exp 22-23</td>
<td>#5</td>
<td>#6</td>
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<tr>
<td>Koichi WAKATA</td>
<td>Soichi NOGUCHI</td>
<td>Exp 38-39</td>
<td>Exp 44-45</td>
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<td>#3 Exp 28-29</td>
<td>#4 Exp 32-33</td>
<td>Koichi WAKATA (CDR) Completed</td>
<td>Kimiya YUI</td>
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<tr>
<td>Satoshi FURUKAWA</td>
<td>Akihiko HOSHIDE</td>
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<td>Takuya ONISHI</td>
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Medical Problems in Human Space Flight

1. Bone Loss & Muscle Atrophy
2. Fluid shift & Orthostatic Intolerance
3. Space motion sickness
4. Psychological Problem
5. Space radiation
Bone Loss in space flight and osteoporosis

Osteoporosis

- 13 Million Japanese suffered
- Bone loss rate (femoral neck)
  Senile, Post-menopausal
  DXA: $-1 \sim 2\%$/year

Bone loss in space flight

- Bone loss rate (femoral neck)
  DXA: $-1.5\%/Month = -9\%/6 Months$
  qCT: $-2.5\%/Month = -15\%/6 Months$
- 10 times rapid

Change in qCT BMD after ISS flight ($n=14$)

Data published by T. Lang 2004
Muscle atrophy

Muscle atrophy in space flight
- More severe in anti-gravity muscles such as back and calf muscles
- Calf muscle atrophy rate: $1\%$/ day during 1~2 weeks space flight
- 10~20% decrease after ISS flight

Muscle atrophy rate in bed rest
- $1\%$/ 2 days

Muscle atrophy rate in aging
- After 60 years old: $2.0\%$/ year

(c)NASA
JAXA
Fluid shift

Early stage in μG

After adapted in μG

At landing 1G

Before Flight 1G

Orthostatic Hypotension

Edema, Headache

in Space

on Earth
Space Motion Sickness

1. Vomiting, headache, and nausea
2. 60 to 70% suffered in first flight
3. Occur intermittently during 1-2 days
Psycho-social problems in isolated environment

Psychological support
Private psychological counseling
Periodic family conference

- different nationalities
- confined living space for 6 months
- tight schedule

- psychological stress
- damage individual and team performance
- alone, quarrel, hostility
Space radiation

Type of space Radiation

1) Galactic
2) Solar-particle
3) Geomagnetically trapped

Radiation exposure in ISS
0.5~1.0 mSv/d

To minimize the exposure of space radiation
1) Predict space radiation environment
2) Monitor exposure level with personal dosimeter
3) Evacuate in shelter room and consider return to earth
Contents

1. Medical problems in space flight
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3. Outreach & public participation
Space medicine research

1) Develop health care technology to reduce the medical risks and to improve crew performance

2) Perform high quality medical science

3) Provide general public with the benefits obtained from human space flight
Five Research Areas of JAXA’s Space Medicine

- Physiological Countermeasure
- Psychological Support
- Health care for Radiation
- Medical System
- Environmental Medicine
1. Purpose
Prophylactic use of bisphosphonate to preventing space flight induced bone loss and renal stones

2. Method
Medication: In flight weekly Alendronate(70mg) or pre flight I.V. Zoledronate(4mg)
Measurements: BMD, qCT, Bone marker, Renal stone parameter, ultrasound

3. Scientists
Toshio Matsumoto, JAXA PI
(Tokushima Univ.)
Hiroshi Ohshima (JAXA)
Adrian LeBlanc, NASA PI
(USRA)
Jeff Jones (NASA)

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**Bisphosphonate**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Effect</th>
<th>Side effects</th>
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<tr>
<td>Analogous to Pyrophosphate</td>
<td>Increase in BMD 5%/ year Decrease in fracture occurrence</td>
<td>Upper GI lesion</td>
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<tr>
<td>Suppress bone resorption</td>
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**Merit:** Inhibits bone resorption
**Demerit:** Upper GI irritation

oral weekly pill or I.V.
Result of Bisphosphonate Study

%Change in DXA BMD (g/cm²)
ISS Controls (n = 14) vs. Bisphosphonate Subjects (n = 5)

<table>
<thead>
<tr>
<th>Bone Site</th>
<th>Controls</th>
<th>Bisphosphonate</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td>Femoral Neck</td>
<td>p = 0.001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trochanter</td>
<td>p = 0.019*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Hip</td>
<td>p = 0.001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumbar Spine</td>
<td>p &lt; 0.001*</td>
<td></td>
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*p value statistically significant when Holm correction for multiple comparisons is applied

A2. The effect of long-term microgravity exposure on cardiac autonomic function by analyzing echocardiogram – JAXA Holter –

**Experiment**

(1) Equipment  
Digital Holter ECG FM-180 (FUKUDA DENSII)  
65(W)x18(D)x62(H)mm, 78g

(2) Data Collection  
24-hour ECG (Pre, Inflight, Post flight)

(3) PI: Mukai C (JAXA)  
CI: Ohtsuka K (TWMC)

(4) Background  
Holter ECG data represents not only cardiac function by its waveforms, but also autonomic function by analyzing inter-beat intervals.

**Progress Status**

- Eight astronauts completed data collections  
- Result paper is in press.

Experiment

(1) Data Collection
   Microorganisms Samples collection from nasal cavity, pharynx, and skin(Pre/In/Post flight)
(2) PI: Mukai (JAXA)
   CI: Makimura (Teikyo U.), Sugita (Meiji Pharm. U.)
(3) Purpose
   To evaluate the microorganisms inhalation and skin adhesion during the stay in the ISS.

Progress Status

• Complete: data collections.
• Analyzing data and making paper.
A4. Biomedical analyses of human hair exposed to long-term space flight -HAIR-

**Experiment**

1. **Data collection**
   - Hair shaft with hair root sampling at Pre, In, and Post flight

2. **Analysis**
   - Hair Shaft: Mineral content
   - Hair Root: Gene expression

3. **PI:** Mukai (JAXA)
   - **CI:** Majima (Kagoshima U.)

4. **Purpose**
   - To examine the effect of space flight on gene expression and mineral content in hair.

**Progress Status**

- Complete: data collections
- Analyzing data and making paper

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A5. Space Radiation Health Care Activities

(1) JAXA personal dosimeter

JAXA Personal dosimeter is used as medical operation.

(2) JAXA Biological Dosimeter Study

- Complete: Flight validation study
- We will start JAXA Biological Dosimeter as medical operation from next JAXA’s flight.
A6. Onboard Diagnostic Kit

Integrated medical system, PC with various medical equipment in JEM was performed by medical astronauts in 2011. The non-MD validation study completed in Inc. 31/32.

Pulse Dosimeter  USB Camera  Stethoscope

Digital Holter ECG  EEG

Added for the second phase study

Digital BP  Thermometer  Myodynamometer
A7. Effect of the Hybrid Training Method on the disuse atrophy of the musculoskeletal system — Hybrid Exercise—

1. Concept
   • Electrical muscle stimulation of antagonist to resist the volitional agonist
   • Dumbbell-like exercise is possible in microgravity

2. PI
   Prof. Shiba N (Kurume University)

3. Experiments.
   • Flight experiment completed in Inc. 37/38
Contents

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Outreach Activities

B1. Mission X in Japan for children

Masson-X events are performed to educate children based on the concept train like an astronauts

B2. Health promotion enlightenment for general public

JAXA made leaflets about tips for health promotion for general public.
B3. Challenge to Space Medicine

1. JAXA planned to acquire video images related to space medicine proposed by general public.

2. General public could participate in ISS utilization, and they could get answers from astronaut directly.

3. It was beneficial for general public to understand space physiology easily, and it can provide them with educational materials of space medicine.
(1) Neutral Position

Procedure
Take a picture of upright and relax postures in space.

Results
When you relax in space, your back, hip, knee, and elbow joints were bent involuntarily.
Learned Physiology

On earth, posture is adjusted so the body doesn’t collapse from gravity and the arms hang vertically, drawn by gravity.

In space, when you relax your body, the joints bend as a result of the extensor and flexor muscle tensile balance and this unconsciously becomes the neutral posture.
(2) Blood pressure measurement

Procedure

Measure blood pressure values of upper and lower limbs in ISS and compare with those on Earth.

Results

On the ground, systolic blood pressure was found to be 10-40 mmHg greater in lower limbs than that of upper limbs.

In contrast, the systolic blood pressures for upper and lower limbs were equal in space.
Learned Physiology

On the ground, hydrostatic pressure, exerted by gravity, raises the systolic blood pressure of lower limb to exceed that of upper limbs.

In a micro gravitational environment, there exists no hydrostatic pressure, so there is no difference of systolic pressure between the upper and lower limb in
## Acknowledgements

### Space Medicine Research
- Mukai C (JAXA)
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- Ishida S (JAXA)
- Aiba T (JAXA)

### Medical Operation
- Ogata K (JAXA)
- Miki T (JAXA)
- Matsumoto A (JAXA)
- Kikuchi T (JAXA)

### Bone Loss CM
- Matsumoto T (Tokushima U.)
- Nakamura T (UOEH U.)
- Kohri K (Nagoya C.U.)

### Biological Rythmus
- Ohtsuka K (Tokyo W. U.)
- Yamamoto N (Tokyo W. U.)

### JAXA Station Astronauts
- Wakata K (JAXA)
- Noguchi S (JAXA)
- Furukawa S (JAXA)
- Hoshide A (JAXA)
Thank you for your attention