Summary of
International Space Station
Exercise Countermeasures
### ISS Exercise Countermeasures

<table>
<thead>
<tr>
<th>Pre-flight</th>
<th>Optimization of Muscle and Bone</th>
</tr>
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<tbody>
<tr>
<td>Training Program</td>
<td></td>
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<tr>
<td>In-flight</td>
<td></td>
</tr>
<tr>
<td>- Treadmill Vibration Isolation System (TVIS)</td>
<td>Preserve anaerobic function</td>
</tr>
<tr>
<td>- Cycle Ergometer Vibration Isolation System (CEVIS)</td>
<td>Preserve aerobic capacity</td>
</tr>
<tr>
<td>- interim Resistive Exercise Device (iRED)</td>
<td>Preserve strength &amp; bone mineral</td>
</tr>
<tr>
<td>- Handgrip equipment</td>
<td>Preserve hand strength for EVAs</td>
</tr>
<tr>
<td>Post-flight</td>
<td></td>
</tr>
<tr>
<td>Rehabilitation Program</td>
<td>Progressive build up of body loss areas</td>
</tr>
<tr>
<td>Phase return to duty</td>
<td>Minimize injury/accident risk</td>
</tr>
</tbody>
</table>
In-flight Exercise Countermeasures Hardware

Exercise Countermeasure Equipment is part of the Crew Health Care System (CHeCS)

- Functional performance requirements for this equipment is documented in SSP 50470, CHeCS GFE Specification
  - iRED, Section 3.7.16.1
  - CEVIS, Section 3.7.11
  - TVIS, Section 3.7.25
- CHeCS equipment is managed by the Government Furnished Equipment Office (Code OX) within the ISS Program
  - Developed under NAS9-97029 to Wyle Laboratories
# ISS Exercise Countermeasures

<table>
<thead>
<tr>
<th>Exercise Countermeasure</th>
<th>TVIS</th>
<th>iRED</th>
<th>CEVIS</th>
<th>EVA HW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic/anaerobic training</td>
<td>XXX</td>
<td>X</td>
<td>XXX</td>
<td></td>
</tr>
<tr>
<td>Neuromotor conditioning (coordination, muscle tone)</td>
<td>XXX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axial high-impact skeletal loading</td>
<td>XXX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength/endurance training of postural muscles</td>
<td>XX</td>
<td>XXX</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Skeletal muscle strength/endurance training</td>
<td>X</td>
<td>XXX</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Axial high-strain skeletal loading</td>
<td>XXX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVA arm exercise training</td>
<td>XX</td>
<td>XXX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVA handgrip strength training</td>
<td></td>
<td></td>
<td>XXX</td>
<td></td>
</tr>
<tr>
<td>EVA 2-hr prebreathe exercise countermeasure</td>
<td></td>
<td></td>
<td>XXX</td>
<td></td>
</tr>
<tr>
<td>Aerobic/Anaerobic fitness assessment</td>
<td>X</td>
<td></td>
<td>XXX</td>
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<tr>
<td>EVA arm ergometry assessment</td>
<td></td>
<td></td>
<td>XXX</td>
<td></td>
</tr>
</tbody>
</table>

Requirements documented in SSP 50260: ISS Medical Operations Requirements Document
## Nominal In-flight Exercise Prescription

**Aerobic Conditioning**
- 2 days/wk
- 1 TVIS, 1 CEVIS
- 1 hour each session

**Interval Training**
- 4 days/wk
- 3 TVIS, 1 CEVIS
- 3 protocols
- 1 hour each session

**Resistive Training**
- 6 days/wk
- 6 protocols
- 1 hour each session

**Additional EVA training**
- arm ergometry
- hand exercises
TVIS

• As a Countermeasure
  – Ambulation trainer (neuromuscular patterning)
  – Endurance exercise of postural musculature
  – Axial, high impact skeletal loading (bone maintenance)
  – Aerobic exercise

• For Fitness Evaluation
  – Backup for the CEVIS and Velo-ergometer (CEVIS nominal, Velo. 1st backup device) for 30-day Physical Fitness Evaluation

• Contingency Option: CEVIS or Velo-ergometer
  – Provide aerobic/anaerobic exercise countermeasure
  – Does not provide ambulation training
  – Does not provide axial skeletal loading
  – Does not provide endurance exercise for trunk postural muscles
TVIS
(Treadmill with Vibration Isolation System)
TVIS
(Treadmill with Vibration Isolation System)
CEVIS

• As a Countermeasure
  – Aerobic/anaerobic exercise countermeasure
  – Maintenance of lower body muscular endurance
  – EVA arm exercise training
  – EVA 2-hr pre-breathe exercise countermeasure

• As an Assessment Tool
  – 30-day Physical Fitness Evaluation
  – EVA Arm ergometry assessment test

• Contingency Option: Russian provided Velo-Ergometer
  – Provide aerobic/anaerobic exercise countermeasure
  – Provide muscular endurance countermeasure
  – Not appropriate for PFE
    » Low setting too high for PFE protocol
    » Inappropriate exercise intensity resolution
  – Not appropriate for EVA pre-breathe exercise
    » Low settings too high for ramping protocol
    » Inappropriate exercise intensity resolution
CEVIS
(Cycle Ergometer with Vibration Isolation System)
iRED
(interim Resistive Exercise Device)

• **As a Countermeasure**
  – training for muscle strength and endurance of all major muscle groups
  – Core exercises emphasize strength and endurance of postural muscles
  – Maintenance of skeletal muscle mass and volume
  – High-strain skeletal loading (bone maintenance)

• **Contingency Option: CRES (contingency resistive exercise system), Russian expanders**
  – Does not provide sufficient force during axial loading for bone maintenance
  – Reduced range of motion against resistance compared to iRED
Resistive Exercise Daily Workout

iRED

This program is written with the intent to perform lower body exercises everyday. It also is written to minimize the iRED reconfiguration time for the crewmember.

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 3</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>deadlift</td>
<td>squat</td>
<td>deadlift</td>
</tr>
<tr>
<td>bent over rows</td>
<td>heel raises</td>
<td>bent over rows</td>
</tr>
<tr>
<td>straight leg deadlift</td>
<td>straight leg deadlift</td>
<td>straight leg deadlift</td>
</tr>
<tr>
<td>squat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>heel raises</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 2</th>
<th>Day 4</th>
<th>Day 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>shoulder press</td>
<td>bicep curls</td>
<td>shoulder press</td>
</tr>
<tr>
<td>rear raises</td>
<td>tricep kickbacks</td>
<td>lateral raises</td>
</tr>
<tr>
<td>front raises</td>
<td>upright rows</td>
<td>front raises</td>
</tr>
<tr>
<td>hip abduction</td>
<td>hip flexion</td>
<td>hip abduction</td>
</tr>
<tr>
<td>hip adduction</td>
<td>hip extension</td>
<td>hip adduction</td>
</tr>
</tbody>
</table>
Resistive Exercise Daily Workout

(Proposed Length of ISS Increment 1 is approximately 4 months.)

6 weeks  Hypertrophy  12-15 reps/2-3 sets to failure
4 weeks  strength endurance  8-10 reps/2-3 sets
4 weeks  strength  6-8 reps/2-3 sets
2 weeks  power  4-6 reps/2-3 sets

This model is mainly for the core (multi-jt.) exercises (Days 1,3,5). The single joint exercises (Days 2,4,6) could stay at 6/8 to 10/12 repetitions.
iRED
(interim Resistive Exercise Device)
Contingency Resistive Exercise System