



Canadian Space Agency  
Agence spatiale  
canadienne



# Exercise Countermeasures Support

Natalie Hirsch  
Canadian Space Agency

ICWG Workshop, 19 June 2010



# Background

- ISS medical operations support
  - Requirements and implementation of medical operations support developed through consensus between International Partners

## ISS MMOP Countermeasures Working Group Representatives

NASA	M. Rapley
RSA	I. Kozlovskaya
ESA	F. Castrucci N. Petersen
JAXA	H. Ohshima
CSA	N. Hirsch



# Background

- First Canadian ISS Expedition crewmember – 2009
- CSA astronauts fly under ISS-US Operating System
- ISS medical operations support for CSA astronauts
  - in collaboration with NASA
  - in coordination with International Partners



# Exercise Prescription

## Pre-flight

- Launch-365 days to Launch
- Objectives:
  - Ensure general physical preparedness
    - adequate level of fitness to conduct mission operations safely and effectively
    - sufficient reserve to help offset the deconditioning effect of space flight.
  - Crewmembers are trained and familiar with in-flight equipment, exercise technique and protocols



# Exercise Prescription

## Pre-flight

- General Physical Preparedness - Fitness Guidelines
  - Cardiorespiratory:
    - maximum aerobic capacity ( $VO_{2max}$ ) at or above the mean for their age and gender (American College of Sports Medicine Guidelines)
      - based on NASA-STD-3001, Volume 1
  - Musculoskeletal:
    - Pre-flight musculoskeletal fitness within or above *Very Good* health benefit zone for age and gender matched norms (Canadian Physical Activity, Fitness and Lifestyle Approach (CPAFLA))
    - Hand grip, push-ups, partial curl-ups, sit and reach, vertical jump



# Exercise Prescription

## Pre-flight

### Resistance training

- Phase 1 – Stabilization (muscular endurance, joint stability)
- Phase 2 – Strength (strength endurance, hypertrophy)
- Phase 3 – Undulating periodization – (alternate between stabilization, strength endurance, power)
  
- flexibility, balance and agility exercises in all phases
- 3 days/week



# Exercise Prescription

## Pre-flight

### Cardiorespiratory conditioning

- Cycling; running; elliptical
  - 3-5 days/week
  - Steady and interval stimulus
- Include exercises that will be performed in-flight
    - squats, deadlifts, presses, CR protocols
    - Pre-flight resistance loads to estimate in-flight loads



# Exercise Prescription

## Pre-flight - Implementation

- CSA astronauts physically based in Houston but travel frequently
- Face-to-face sessions with crewmember on regular basis
- Exercise activity captured with heart rate monitor and electronic notes/journal
- Exercise prescriptions updated via email



# Exercise Prescription

## Pre-flight - Implementation

- In-flight countermeasures hardware training sessions performed at NASA-JSC
  - Capture in-flight hardware settings
- Pre-flight exercise related evaluations conducted at NASA-JSC
  - VO<sub>2</sub>, Isokinetic, DEXA, Functional fitness test



# Exercise Prescription In-flight

- Launch to Landing
- Objectives:
  - mitigate deleterious effects of microgravity to ensure operational effectiveness and decrease time required for post-flight reconditioning.
    - Muscular atrophy, bone loss, cardiovascular and neurosensory deconditioning
- Resistance and cardiorespiratory training
  - 6 days/week + 1 active rest day
  - Resistance: 1 hr/day
  - Cardiorespiratory: 30-45 min/day



# Exercise Prescription In-flight

## Resistance

### Phase 1 – Acclimatization

- 3 workouts
- Each workout composed of:
  - Warm-up set (1 x 15 reps; 1 x 8 reps)
  - 2-3 sets x 10 reps
  - Emphasis on lower body (squats, deadlifts, heel raises)





# Exercise Prescription

## In-flight

### Resistance

#### Phase 2 –

- 3 workouts & 3 variations for reps/load
- 9 day cycle
  - Warm-up set (1 x 8 reps)
  - 4 sets of 6 reps or 3 sets x 8 or 12 reps
- Each workout composed of 6-7 exercises
  - Emphasis on lower body
- Progress load by 5% every third cycle, if first 2 cycles completed as prescribed.



# Exercise Prescriptions In-flight

## Cardiorespiratory program:

- Aerobic fitness maintained at or above 75 percent of the pre-flight value (NASA-STD-3001, Volume 1)

## Cycle ergometer (CEVIS)

- Set of individualized protocols developed by NASA Exercise Physiology Lab
  - steady state protocol (20 min @ 80%  $VO_{2max}$ )
  - interval protocols (2 min stages, 40 or 50%  $VO_{2max}$  rest; stimulus stages range from 60-90%  $VO_{2max}$ )

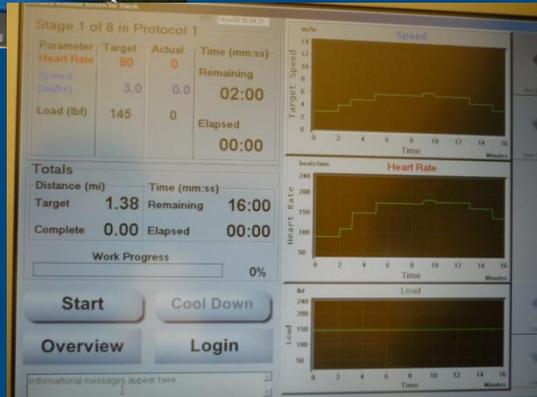




# Exercise Prescriptions In-flight



T2 & Facebook display



## Treadmill (TVIS & T2)

- Loading as high as feasible
- 75-90% HRmax (ground)
- At least one interval protocol/week
- Passive walking at end of session
- Cycle ergometer and treadmill data received weekly
- Periodic Fitness Evaluation
- Recommendations provided as needed



# Exercise Prescriptions

## Post-flight

- Landing to Landing + 45 days
- Objectives:
  - Crewmember obtains pre-flight physical fitness
- 2 hour reconditioning session, 6-7 days/week
- Based on NASA standardized post-flight protocol
  - Flexibility
  - Balance, agility, coordination
  - Muscular strength, endurance
  - Cardiorespiratory
- Progression based on crewmember's condition & post-flight data



# Exercise Hardware

- Pre-flight & Post-flight:
  - Commercially available
  - Heart rate monitors (with GPS)
  - Strength and conditioning equipment
- In-flight:
  - Resistance: ARED (iRED)
  - Cardiovascular: Treadmill - T2 (TVIS) and Cycle-ergometer – CEVIS (velo)
- At this time, CSA is not involved in the development of in-flight exercise countermeasures hardware.



# Current Challenges

- 1) Minimum fitness standards to be maintained in-flight is unknown.
  - Impact on response to hardware contingency situations / availability.
  - Forward work at ISS Countermeasures Working Group



# Operational Considerations

- 1) Pre-flight crewmembers have full training and travel schedule
- 2) Crewmember's exercise technique may be different in micro-g
- 3) Hardware and software issues



Canadian Space Agency  
Agence spatiale  
canadienne



# Questions?