National Aeronautics and Space Administration

U.S. Countermeasure Operations

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Preflight Exercise

- Goal
  - Maximize increases in muscle, bone and aerobic fitness
  - Familiarize astronauts with in-flight exercise prescription and hardware operation
- Schedule
  - Crewmember assigned about 2 yr before mission
  - Each crewmember is scheduled PT 4 hrs/wk

Preflight Exercise (con't)

- Exercise Program
  - Aerobic Exercise Prescription
    - Crew performs on own
  - Resistance Exercise Prescription
    - Program written by ASCR
    - General fitness using free-weights
    - Emphasize in-flight exercises

Preflight Exercise (con't)

- In-Flight Hardware
  - Crew receives 2 CMS Ops Classes
    - Covers hardware usage, maintenance, inspection, etc.
  - Our class focuses on usage, exercise technique, establishing exercise speeds/loads, and safe hardware operation
  - ARED: 16 training sessions over 2 yr (time taken out of PT)
    - Considered training class and is therefore hard scheduled and tracked
  - T2: encourage crew to come during PT time to practice T2 operations

Preflight Challenges

- Training schedule tight making pre-flight training inconsistent
  - Limit on number of work hours in a week
  - PT usually the first thing moved or deleted from training schedule based on priority
  - If moved usually placed extremely early or late
- International travel
  - Multiple facilities, different equipment, various times in country, time in training schedule while in that country
  - Difficult to establish a routine

In-flight Exercise

- Overall concept
  - Body adapts to the surrounding environment
  - Program variation key to mitigate adaptation to 0 G
  - If the body cannot predict the environmental stimuli, more likely to preserve functionality
- Goal
  - Minimize losses in muscle, bone and aerobic conditioning
  - Protect performance and functionality
  - Maximize hardware utilization
- Schedule
  - 2.5 hours exercise 6 d/wk
  - 1.5 hr Resistive
  - 1 hr Aerobic
  - Most exercise 7d/wk

In-flight Exercise (con't)

- ARED:
  - Vary Load:
    - Lower body - Heavy (4x6), Light (4x12), Medium (4x8)
    - Upper Body - All 3x10
  - Vary Exercises: 3 distinct exercise routines/days
    - Primary exercises are lower body/triple extension movements
  - Vary Order: Each routine or day rotates so each gets a heavy, light, medium day.
  - Vary Exercise Techniques: Use a variety of squat and deadlift techniques and stances.
  - 2 distinct macrocycles; % of load lifted increases week to week
  - Loads determined using pre-flight ARED training sessions
  - Lower Body: Calculate 6, 8 and 12 RM using 10 RM
  - Add 75% BW to all squat and heel raise exercise
  - Next Step: Evaluate high velocity exercises

In-flight Exercise (con't)

- CEVIS/T2 :
  - Try to accommodate crew preference
    - Recommend 3/3
    - End of mission 2/4
  - For CEVIS and T2 we prescribe steady state and various interval protocols
  - Difficulty increases as increment progresses
    - CEVIS – Watts
    - T2 – Speed/Load
  - Recommend at least 5 min of passive walking/running as a warm-up
  - Treadmill Load
    - Starts at 50-60% of preflight body weight
    - Increase load throughout the mission
  - CEVIS protocols based on preflight VO2 maximal cycle aerobic test

In-flight Challenges

- Broken hardware/hardware not performing as expected
- In-flight operations can restrict exercise time
  - e.g. experiments sensitive to vibration, maintenance activities, EVA
- Communication
  - Takes time to adjust program through email
  - Limited individual talk time with crew
- Injury
- Schedule
  - 6 crew + 1.5 hr ARED time = 9 hr; crew work day = 8 hr
- Treadmill
  - Loading on treadmill dictated by harness comfort
  - Limited understanding of load x speed interaction
    - How to create prescriptions to maximize aerobic fitness
- Exercise program affects multiple systems
  - Limited exercise time
  - Maximize prescriptions to maximize use of crew time
- Crew preference/effort
  - Ground: Underestimate loads/speeds for in-flight prescription
  - In-flight: Crew adherence - may deviate or alter program due to preference

Postflight Reconditioning

- All crewmembers have issues to some degree
  - Neurovestibular, orthostatic, back/neck, coordination, balance/agility, aerobic, strength, endurance, power and flexibility
  - All crewmembers progress at different rates
- Goal
  - Return to preflight status as quickly as possible
- Schedule
  - Lasts 45 days starting R+1
  - 2 hr every day, including weekends
- Every day
  - Aerobic Exercise
  - Dynamic Stretching and Warm-up
  - Core Exercise
  - Static Stretching
- Every other day
  - Resistance Training
  - General Performance Skills

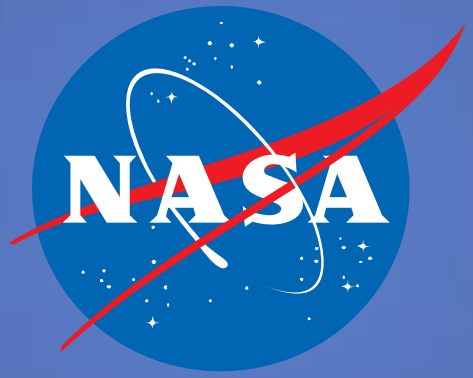
Postflight Reconitioning (con't)

- Every day
  - Aerobic Exercise
    - 20–30 min
    - HR ≥ 75–80% age predicted max
    - Progression: Recumbent Bike → Upright Bike/Rower/Elliptical → Treadmill → Outdoor
  - Dynamic Stretching and Warm-up
    - Done everyday starting at R+0
    - Objectives
      - Primary – warm-up and dynamic stretching
      - Secondary benefits – balance, coordination, orthostatic and neurovestibular
  - Core Exercises
    - Done everyday starting at R+1 and progressing as needed
    - Objectives- develop and work core muscle strength and endurance in all planes of motion
      - Primary – muscle strength and muscle endurance
      - Secondary benefits – reduced back and neck stiffness and neurovestibular
  - Static Stretching
    - Done everyday starting at R+0
    - Objectives – increase flexibility around all joints
      - Primary – flexibility

- Every Other Day
  - Resistance Exercise
    - Perform exercises similar to those performed during flight
    - Progressively push load to preflight levels
  - General Performance Skills
    - Mobialanception
      - Start at R+1. As crewmember improves tasks become more challenging
      - Objectives
        - » Primary – mobility, balance, proprioception
        - » Secondary benefits – neurovestibular and orthostatic
    - Medicine Ball
      - Starts at R+1 and becomes progressively harder as the crewmember improves
      - Objectives – power in multiple planes of motion
        - » Primary – power and back
        - » Secondary benefits – muscle endurance, coordination, balance, strength, neurovestibular
    - Ladder and Cone Drills
      - Start around R+7; after our first functional fitness exam.
      - Objectives – agility, coordination and balance while moving in multiple planes of motion
        - » Primary – agility, coordination and balance
        - » Secondary benefits – neurovestibular, reduced foot and calf soreness
    - Jumping Drills
      - Start no sooner than R+21
      - Objectives – power, coordination and balance while moving in multiple planes of motion
        - » Primary – power, agility, coordination and balance
        - » Secondary benefits – reduced foot and calf soreness

Postflight Challenges

- Progression
  - Crew initial ability / functionality
    - In-flight program adherence
  - Adherence / attendance
    - Family obligations
  - Desire to return to normal activities
    - Crew push too hard, risking injury
- Schedule
  - Don’t always get 2 full hours
- Fatigue
  - Family / friends
  - Fighting gravity
  - Return to work / normal activities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Back-up Slides

ARED Exercise Prescription

%	Heavy	Light	Medium	Heavy	Light	Medium		**Session 1**
70	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		Squat
75	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		Heel Raise
80	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		Deadlift
85	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		RDL
90	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		Shoulder Press
95	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		Bent-over Row
100	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		
105	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		**Session 2**
110	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		Sumo Squat
115	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		Heel Raise
120	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		Deadlift
125	4 x 6	4 x 12	4 x 8	4 x 6	4 x 12	4 x 8		Shrug
								Bench
70	1	2	3	2	3	1		Tricep
75	3	1	2	1	2	3		
80	2	3	1	3	1	2		**Session 3**
85	1	2	3	2	3	1		SL Squat
90	3	1	2	1	2	3		Sumo Deadlift
95	2	3	1	3	1	2		RDL
100	1	2	3	2	3	1		Upright Row
105	3	1	2	1	2	3		Bicep Curl
110	2	3	1	3	1	2		Single Arm Row
115	1	2	3	2	3	1		
120	3	1	2	1	2	3		
125	2	3	1	3	1	2		

Sample Protocols

CEVIS

Simple Ride Protocol					
Elapsed Time	Stage Time	% VO2	VO2 (L/min)	Watts	HR
3	3	55	1.90	104	113
28	25	80	2.76	172	137
31	3	55	1.90	104	113

Two Minute Interval					
Elapsed Time	Stage Time	% VO2	VO2 (L/min)	Watts	HR
5	5	55	1.90	104	113
7	2	80	2.76	172	137
9	2	60	2.07	118	118
11	2	85	2.94	185	142
13	2	60	2.07	118	118
15	2	85	2.94	185	142
17	2	60	2.07	118	118
19	2	85	2.94	185	142
21	2	60	2.07	118	118
23	2	85	2.94	185	142
25	2	60	2.07	118	118
27	2	85	2.94	185	142
29	2	60	2.07	118	118
31	2	80	2.76	172	137
36	5	55	1.90	104	113

T2

2 Min Protocol	Stage #	Time (min)	Speed
	1	5	6
	2	2	7
	3	2	6
	4	2	8
	5	2	6
	6	2	9
	7	2	6
	8	2	9
	9	2	6
	10	2	8
	11	2	6
	12	2	7
	13	5	6

5 Min Protocol	Stage #	Time (min)	Speed
	1	5	6
	2	5	7
	3	5	8
	4	5	8
	5	5	7
	6	5	6