Training Firefighters
Considerations for Improving Health, Safety, and Performance

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Outline

• Training firefighters to improve performance & health
  – How do we maximize physiological adaptations while minimizing occupational fatigue?
    • Which program is best?
    • What are appropriate training parameters on- vs. off-duty?
  – How can we enhance recovery?
  – How much exercise is needed for health outcomes?
  – How can we make training safer?
Exercise Programming

Which program is best?

Firefighter Fitness Continuum

- Strength
- Power
- Speed
- Endurance
- Power-endurance
- Muscle endurance
- Anaerobic threshold
- Aerobic threshold

Training Strategies

- Linear periodization
- Nonlinear periodization
- Block periodization
- Circuit training
Training Strategies

• Linear periodization
• Nonlinear periodization
• Block periodization
• Circuit training

Nonlinear Periodization

Volume

Intensity

Time

Linear vs. Nonlinear Periodization

Peterson et al., 2008
Training Strategies

• Linear periodization
• Nonlinear periodization
• Block periodization
• Circuit training

Block Periodization

• Accumulation phase
  – Similar to General Preparatory Phase
  – Improve general aerobic endurance, muscular endurance & basic coordination
  – High volume
  – Low intensity
  – 2-6 weeks

Figure 5: Present improvements for swim and track performance variables. These percent improvements represent performance changes of BMI, V̇O2max, and MINS. Score at the end of the block period was assessed against the final performance that was not used in the current block period. The value training group increased significantly group improvements (p ≤ 0.05).
Block Periodization

• Transmutation phase
  – Focused on task-specific abilities
    • Aerobic-anaerobic endurance, glycolytic endurance, strength endurance, proper technique
  – Intensity: Mod-high; Volume: moderate
  – Most exhausting training cycle
  – 2-4 weeks

• Aerobic-anaerobic endurance, glycolytic endurance, strength endurance, proper technique

Intensity: Mod-high; Volume: moderate

Most exhausting training cycle

2-4 weeks

Realization phase

• Restoration / tapering
  – Drills that mimic occupational tasks
  – Intensity: High; Volume: Low
  – Allows quick, active recovery b/t sessions
  – 1-2 weeks

Intensity: High; Volume: Low

Allows quick, active recovery b/t sessions

1-2 weeks

Linear Periodization

Strength / Power

Endurance

Load

Time

Stimulating

Retaining

Detraining

Block Periodization

Endurance

Stimulating

Retaining

Detraining

Load

Time

Stimulating

Retaining

Detraining

Zatsiorsky, 1995

Load

Time
Summary

- Block Periodization
  - Focus on single outcome
  - Maximize multiple fitness outcomes throughout year = accommodate unpredictable nature of fire emergencies
  - Frequent evaluation / adjustments
Circuit Training

**EVALUATION OF CIRCUIT-TRAINING INTENSITY FOR FIREFIGHTERS**

<table>
<thead>
<tr>
<th></th>
<th>Circuit Training</th>
<th>Smoke Diving</th>
<th>Fire Suppression</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aerobic Intensity</strong></td>
<td>79%</td>
<td>79%</td>
<td>88%</td>
</tr>
<tr>
<td><strong>Anaerobic Intensity</strong></td>
<td>12 mmol L⁻¹</td>
<td>13 mmol L⁻¹</td>
<td></td>
</tr>
</tbody>
</table>

*Values represent % of HRmax.

Abel et al., 2011

Training On-Duty

How much is too much?
Training On-Duty

Advantages
- Improved performance outcomes
- Enhanced exercise compliance
- Exercise supervision
- Team unity

Disadvantages
- Exercise-induced fatigue

Exercise Fatigue

Table 1. Comparison of STPT task times at baseline and after an exercise session in a 12 trained firefighters (n = 12).

<table>
<thead>
<tr>
<th>Task</th>
<th>Baseline STPT</th>
<th>Exercise STPT</th>
<th>% Change</th>
<th>p Value</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total SPOT (s)</td>
<td>386.5 ± 18.4</td>
<td>428.5 ± 27.1</td>
<td>0.091</td>
<td>0.046</td>
<td>0.092</td>
</tr>
<tr>
<td>Upper limit (s)</td>
<td>208.5 ± 11.0</td>
<td>248.5 ± 23.1</td>
<td>0.043</td>
<td>0.006</td>
<td>0.044</td>
</tr>
<tr>
<td>Lower limit (s)</td>
<td>177.5 ± 12.5</td>
<td>180.5 ± 17.1</td>
<td>0.027</td>
<td>0.012</td>
<td>0.025</td>
</tr>
<tr>
<td>Unilateral (s)</td>
<td>230.5 ± 14.2</td>
<td>240.5 ± 19.3</td>
<td>0.092</td>
<td>0.046</td>
<td>0.090</td>
</tr>
<tr>
<td>Bilateral (s)</td>
<td>256.5 ± 21.3</td>
<td>268.5 ± 27.3</td>
<td>0.091</td>
<td>0.046</td>
<td>0.092</td>
</tr>
<tr>
<td>Flexed (s)</td>
<td>248.5 ± 18.8</td>
<td>258.5 ± 23.8</td>
<td>0.091</td>
<td>0.046</td>
<td>0.092</td>
</tr>
<tr>
<td>Extensive (s)</td>
<td>224.5 ± 15.6</td>
<td>234.5 ± 21.6</td>
<td>0.091</td>
<td>0.046</td>
<td>0.092</td>
</tr>
</tbody>
</table>

*STPT = spin test performance time. Exercise conditions: 120 min cycle ergometry (peak power output: 385.5 ± 51.0 W) at 75% of peak heart rate.
Dennison et al. (2012)

- The baseline SFGT time of the trained firefighters was faster than 81% of the untrained firefighters
- The EX-SFGT time of the trained firefighters was faster than 70% of untrained firefighters

Recommendations for Exercising On-Duty

- Exercise during low call volume times / end of shift
- Progression principle
  - Systematically introduce novel exercises and exercise intensity
- Include aerobic exercise
  - ↑ CRP = ↓ CVD mortality
    - Untrained: ≥ 30 min @ 64-76% HR_{max} ≥ 5 d·wk^{-1}
    - Trained: ≥ 20 min @ 60-84% HR_{max} ≥ 3 d·wk^{-1}
- Communication

Training On-Duty

What we don’t know...

Exercise Intensity  Exercise Mode
Fitness
Time
FF Physical Ability
Training Off-Duty

I can exercise hard, right?

Training Off-Duty

Advantages
- Avoid acute exercise-induced fatigue

Disadvantages
- Decreased exercise participation
  - Lack of time
  - Increased risk of chronic disease
  - Accessibility to equipment
  - Cost / no $ compensation
- Lack of supervision / guidance
- DOMS effecting subsequent work performance?

Training Off-Duty

What we don’t know...

Exercise Intensity  Exercise Mode

Fitness
Time
FF Physical Ability
Recommendations for Exercising Off-Duty

- Utilize progression principle
- Use common sense when performing novel exercises
- Training on consecutive days?
  - Training on-duty?

<table>
<thead>
<tr>
<th>Training Mode</th>
<th>Day 1</th>
<th>Day 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance / Aerobic</td>
<td>Upper body</td>
<td>Lower body</td>
</tr>
<tr>
<td>training</td>
<td>• Cardio</td>
<td>• Light cardio</td>
</tr>
<tr>
<td></td>
<td>• Whole body</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Light cardio</td>
<td></td>
</tr>
</tbody>
</table>

Post-Exercise Recovery Strategies

How can we enhance recovery?

Post-Exercise Recovery Methods

- If Exercise is important for firefighters, how can we enhance recovery?
Recovery Strategies Immediately Following Exercise to Decrease Fatigue

<table>
<thead>
<tr>
<th>Recovery Strategy</th>
<th>Effective?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutritional intake</td>
<td></td>
</tr>
<tr>
<td>Hydration</td>
<td></td>
</tr>
<tr>
<td>Cooling methods</td>
<td></td>
</tr>
<tr>
<td>Compression garments</td>
<td></td>
</tr>
<tr>
<td>Active recovery</td>
<td></td>
</tr>
<tr>
<td>Flexibility training</td>
<td></td>
</tr>
</tbody>
</table>

Nutritional Intake

- Diet: 55-70% CHO
- Pre-exercise meal: small meal, familiar foods, minimal fiber, low GI
- During exercise: 60-70 g CHO-hr⁻¹
- Post-exercise: 1.2 g CHO per kg-hr⁻¹
  - 80 kg person: 96 g-hr⁻¹ CHO

Hydration

- Minimum fluid intake recommendations
  - Men: 3.0 L·d⁻¹
  - Women: 2.2 L·d⁻¹
- Physical activity / thermo-challenging environment
  - Prior to PA: 400-600 mL
  - During PA: 200-300 mL every 10-20 min
  - Recovery: 6-8% CHO
Cooling Methods

• Hyperthermia decreases performance

Cooling Methods – Which work?

<table>
<thead>
<tr>
<th>Cooling Method</th>
<th>Decreased core temperature</th>
<th>Decreased heart rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold water immersion</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ice buckets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port-a-Cool Fan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rehab. Hood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Cooling Vest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nike Ice Vest</td>
<td></td>
<td></td>
</tr>
<tr>
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DeMartini et al. (2011)
Cooling Methods – Which work?

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<td>X</td>
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DeMartini et al. (2011)

Compression Garments

- Inconclusive
  - Some studies: Improved torque
  - Other studies: No change in subsequent power & plyometric performance
- Do not improve most types of physical performance

Active Recovery

- Does not enhance recovery
  - No improvement in performance 4 hr post-exercise
  - Does not promote glycogen resynthesis
Flexibility Training

- Generally not effective for improving performance
- Does not reduce DOMS
- Static stretching may negatively affect power performance
- Does improve ROM

Summary
Recovery Strategies Immediately Following Exercise to Decrease Fatigue

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<th>Recovery Strategy</th>
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<tr>
<td>Flexibility training</td>
<td>No</td>
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Post-Exercise Recovery Strategies to Decrease Inflammation, Soreness, or Damage

They all work, right?
Muscle Soreness

- Delayed Onset of Muscle Soreness (DOMS)
  - Manifested by high intensity, repetitive, eccentric muscle contractions, & novel exercise
  - Symptoms present 24-72 hr
  - Decreases force production
  - Strength restored within 3 days
  - More fit = faster recovery

Post-Exercise Recovery Strategies to Decrease Inflammation, Soreness, or Damage

<table>
<thead>
<tr>
<th>Recovery Strategy</th>
<th>Effective?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eccentric exercise</td>
<td></td>
</tr>
<tr>
<td>Antioxidant supplementation</td>
<td></td>
</tr>
<tr>
<td>Nitric oxide supplementation</td>
<td></td>
</tr>
<tr>
<td>Acetaminophen / NSAIDs</td>
<td></td>
</tr>
<tr>
<td>Massage</td>
<td></td>
</tr>
<tr>
<td>Stretching</td>
<td></td>
</tr>
<tr>
<td>Cooling Methods</td>
<td></td>
</tr>
</tbody>
</table>

Eccentric Exercise

- “Negatives” provide a defense mechanism
- Repeated bout effect
Antioxidant Supplementation

**↑ Blood flow**

**↓ Free radicals**

**↓ Oxidative stress**

**↓ Inflammation**

**Vt. A, C, E**

**Exercise**

- May not help younger fit firefighters
- May help older, less fit firefighters
Nitric Oxide Supplementation

- NO = increases blood flow
- May benefit sedentary, untrained populations
- Exercise provides similar vascular benefits

Acetaminophen / NSAIDs

- Most research indicates no beneficial effect of NSAIDs or analgesics on:
  - Muscle soreness
  - Muscle dysfunction
  - Muscle damage

Recovery Methods

- Stretching, massage, cryotherapy = Not effective at decreasing DOMS
  - Myofascial release may decrease soreness from scar tissue
Summary
Recovery Strategies to Decrease Inflammation, Soreness, or Muscle Damage

<table>
<thead>
<tr>
<th>Recovery Strategy</th>
<th>Effective?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eccentric exercise</td>
<td>Yes</td>
</tr>
<tr>
<td>Antioxidant supplementation</td>
<td>Conditionally</td>
</tr>
<tr>
<td>Nitric oxide supplementation</td>
<td>Inconclusive</td>
</tr>
<tr>
<td>Acetaminophen / NSAIDs</td>
<td>No</td>
</tr>
<tr>
<td>Massage</td>
<td>No</td>
</tr>
<tr>
<td>Stretching</td>
<td>No</td>
</tr>
<tr>
<td>Cooling Methods</td>
<td>No</td>
</tr>
</tbody>
</table>

Exercise Prescription for Health Benefits
How much is necessary?
Cardiac Deaths

Number of Firefighter Deaths by Career Status 1977 - 2004

Cardiovascular Disease: Factors

- Body composition
- Physical activity
- Diet
- Smothing
- Heredity
- Gender
- Stress

Risk factor | Prevalence | Threshold | Exercise Prescription
---|---|---|---
Dyslipidemia | 63% | Total-C $\geq 200$ mg/dL, LDL-C $\geq 130$ mg/dL, HDL-C < 40 mg/dL | Mode: Aerobic exercise  
Frequency: 75 d/wk  
Intensity: 40-80% HRR  
Duration: 30-60 min per session  
Resistance & flexibility training as an adjunct

Obesity | 34% | BMI $\geq 30$ kg/m², Waist circumference Men $> 102$ cm, Women $> 88$ cm | Mode: Aerobic exercise  
Frequency: 75 d/wk  
Intensity: Most/all d/wk  
Duration: 30 min

Hypertension | 23% | Blood pressure $\geq 140/90$ mmHg or Meds | Mode: Aerobic exercise  
Frequency: 75 d/wk  
Intensity: Most/all d/wk  
Duration: 30 min

Adapted from Abel & Morris (2012)
The doctor said he needed more activity. So I hide his T.V. remote three times a week.

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Prevalence</th>
<th>Threshold*</th>
<th>Exercise Prescription</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary lifestyle</td>
<td>17%</td>
<td>Perform 30 min of MOD intensity PA 3 days/week for past 3 mo</td>
<td>Mode: Aerobic exercise Frequency: 3-5 d/wk - Intensity: MOD/VIG Duration: 20-30 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Resistance training Frequency: ≥ 2 d/wk - Intensity: 8-12 RM 8-10 exercises using major muscle groups</td>
</tr>
<tr>
<td>Smoking</td>
<td>14%</td>
<td>Current smoker or quite within past 6 mo</td>
<td>NA</td>
</tr>
<tr>
<td>Pre-diabetes / Diabetes</td>
<td>3%</td>
<td>Fasting glucose ≥ 100 mg/dL</td>
<td>Mode: Aerobic exercise Frequency: 4-7 d/wk - Intensity: 50-80%HRmax Duration: 20-60 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Resistance &amp; flexibility training</td>
</tr>
</tbody>
</table>

Adapted from Abel & Morris (2012)
Considerations for Training Safely

What can we do?

Injuries in the Fire Service: Is Exercise the Achilles’ Heel

Results From 2004 to 2009, the annual injury incidence rate averaged 17.7 per 100 employees. One-third of all injuries (32.9%) resulted from physical exercise activities while patient transport, training drills and fireground operations resulted in 16.9%, 11.1% and 10.2% of injuries, respectively. For all job operations, sprains and

Considerations for Training Safely

- Departmental level
- Programmatic level
- Individual level
Departmental Level
- Promote regular participation in exercise on/off-duty
- Provide incentives
- Provide qualified supervision
- Maintain exercise equipment

Programmatic Level
- Utilize a periodized program
- Individualize program
  - Goals, training status, & previous injuries
- Use progression strategies
- Include warm-up, flexibility training, core exercises, & cool down
- Omit contraindicated exercises
- Perform regular evaluations of movement deficiencies
- Include mobility & stability exercises for knee, lower back, & shoulder

Individual Level
- Use proper exercise technique
- Orientation for new exercises
- Use spotter(s)
  - Use proper spotting technique
- Spotter(s) should communicate w/ lifter
- Use weight belts when appropriate
- Pay attention to fatigue & muscle soreness
Summary

• Train with reasonable intensities on-duty
• May be able to train harder off-duty
  — More fit = greater tolerance to fatigue
• Utilize a comprehensive periodized training program
  — Focus on weight management / cardio
  — Use effective recovery methods when possible
• Develop a positive culture for training & wellness

If you want more...

• TSAC - Special Interest Group (SIG)
• NSCA National Conference Meeting
• Online forum
• TSAC Report
### References

### Ancillary Material

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prevalence (%)</th>
<th>Thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyslipidemia</td>
<td>63</td>
<td>Total cholesterol ≥ 200 mg·dL⁻¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LDL cholesterol ≥ 130 mg·dL⁻¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HDL cholesterol &lt; 40 mg·dL⁻¹</td>
</tr>
<tr>
<td>Obesity</td>
<td>34</td>
<td>BMI ≥ 30 kg·m⁻²; Waist circumference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Men: &gt; 102 cm; Women: &gt; 88 cm</td>
</tr>
<tr>
<td>Hypertension</td>
<td>23</td>
<td>Blood pressure: ≥ 140/90 mmHg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or taking antihypertensive meds</td>
</tr>
<tr>
<td>Sedentary lifestyle</td>
<td>17</td>
<td>Perform 30 min of moderate intensity physical activity 3 d·wk⁻¹ for past 3 mo</td>
</tr>
<tr>
<td>Smoking</td>
<td>14</td>
<td>Current smoker or quit within past 6 mo</td>
</tr>
<tr>
<td>Prediabetes/Diabetes</td>
<td>3</td>
<td>Fasting glucose ≥ 100 mg·dL⁻¹</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exercise program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode: Aerobic exercise</td>
</tr>
<tr>
<td>Frequency: &gt;5 d·wk⁻¹</td>
</tr>
<tr>
<td>Intensity: 40-80% of heart rate reserve</td>
</tr>
<tr>
<td>Duration: 20-60 min per session or intermittent sessions</td>
</tr>
<tr>
<td>Resistance &amp; flexibility training as an adjunct</td>
</tr>
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<table>
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<tr>
<th>Exercise program</th>
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<tbody>
<tr>
<td>Mode: Aerobic exercise</td>
</tr>
<tr>
<td>Frequency: ≥ 5 d·wk⁻¹</td>
</tr>
<tr>
<td>Intensity: Moderate-vigorous (40-60% VO₂peak; up to 75% if low risk)</td>
</tr>
<tr>
<td>Duration: 30-60 min or 2 sessions per day of 20-30 min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exercise program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode: Primarily aerobic exercise, supplemented with resistance training</td>
</tr>
<tr>
<td>Frequency: most, preferably all days of the week</td>
</tr>
<tr>
<td>Intensity: Moderate (40-&lt;60% VO₂reserve)</td>
</tr>
<tr>
<td>Duration: ≥ 30 min of continuous or accumulated physical activity per day</td>
</tr>
</tbody>
</table>

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<tbody>
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<td>Frequency: ≥ 3-5 d·wk⁻¹</td>
</tr>
<tr>
<td>Intensity: Moderate-vigorous</td>
</tr>
<tr>
<td>Duration: ≥ 20-30 min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Mode: 8-12 repetitions to volitional fatigue</td>
</tr>
<tr>
<td>Frequency: ≥ 2 d·wk⁻¹</td>
</tr>
<tr>
<td>Intensity: 8-10 exercises using major muscle groups</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family history</th>
</tr>
</thead>
<tbody>
<tr>
<td>First degree male relative who had a cardiac event &lt; 55 yr or female relative who had a cardiac event &lt; 65 yr</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men: ≥ 45 yr; Women: ≥ 55 yr</td>
</tr>
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</table>

Non-modifiable
Research Model for Firefighters

Exercise Adherence
- Inhibitors to exercise participation

Exercise Programming
- Physical Activity
- Injuries

Dietary Intake

Firefighter Health & Performance

Smoking / Tobacco Use

Program Impact on Firefighter Health & Medical Profession

Exercise Adherence

Exercise Programming

Physical Activity

Injuries

Dietary Intake

Firefighter Health & Performance

Smoking / Tobacco Use

Figure 1: Core body temperature changes over time for volunteers. Time point 0 minutes = time before cooling began. Time point 1 minute = end of cooling phase and maximum time point for all monitoring. Significance at times 1 minute post for cold water immersion (CWI), emerging cold water immersion (ECWI), and endurance exercise (EE).

Figure 2: Heart rate changes over time for volunteers. Time point 0 minutes = time before cooling began. Time point 1 minute = end of cooling phase and maximum time point for all monitoring. Significance at times 1 minute post for cold water immersion (CWI), emerging cold water immersion (ECWI), and end resistance exercise (EE).
Training On-Duty

We don’t know...
1) What effects does exercise mode & intensity have on occupational physical ability?
2) What is the time course of recovery from various exercise modes & intensities?
3) What is the interaction of fitness level on the magnitude of fatigue & recovery rate?

Training Off-Duty

We don’t know...
1) What effect does exercise mode & intensity have on subsequent occupational physical ability?
2) What is the time course of recovery from various exercise modes & intensities?
3) What is the interaction of fitness level on the recovery rate?
Accumulation
mesocycles

Transmutation
mesocycles

Realization
mesocycles

I II III IV V

Preparation
period Competition
period

Comp.
ref.
pts Targeted
event

Issurin, 2007

Block #:

Accumulation
mesocycles

Transmission
mesocycles

Radiation
mesocycles

Competition
period

Preparation period

Targeted event

Issurin, 2007