Detection and Prevention of Overtraining in Athletes

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Overtraining lecture summary

- Definition of overtraining
- Symptoms & causes of overtraining
- Diagnosis of overtraining
- Evaluation of markers
- Prevention of overtraining
Overtraining – ECSS-ACSM Consensus

Prevention, diagnosis and treatment of the Overtraining Syndrome (2012)
Joint consensus statement of the European College of Sport Science (ECSS) and the American College of Sports Medicine (ACSM)

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What is overtraining syndrome?

- Burnout
- Overwork
- Staleness
- Chronic fatigue
- Unexplained under-performance
Definition of overtraining

**Overtraining**: An accumulation of training-related stress resulting in **persisting** decrement in performance capacity lasting **weeks or months**

**Overreaching**: An accumulation of training-related stress resulting in **temporary** decrement in performance capacity lasting **less than 2 weeks**
Relationship between Training Load and Performance

Peaking after taper

Undertraining

Overreaching

Overtraining Syndrome

Performance (% Personal Best)

Training Load
Overtrained or fatigued?

Possible causes of under-performance:

- Acute fatigue after exercise
- Glycogen depletion (24-48 hrs to recover)
- Delayed onset muscle soreness (2-3 days)
- Illness (e.g. viral infection)
- Allergy
- Anaemia
- Vitamin D deficiency?
Unexplained Under-performance Syndrome (UPS):
A persistent unexplained performance deficit (recognised and agreed by coach and athlete) despite two weeks of relative rest

Symptoms of Overtraining

ALWAYS:
Fatigue and unexpected sense of effort during training and under-performance in competition

ALSO:
- History of heavy training and competition
- Frequent minor infections
- Heavy/stiff/sore muscles
- Mood disturbance: irritability, depression
- Disturbed sleep
- Loss of energy/drive/appetite
No.1 marker of overtraining in male athletes

Loss of sexual appetite

Sorry love, I’m too tired
Major signs of overtraining

- Fatigue
- Infections
- Under-performance
- Depression
Diagnosis of overtraining

Previous high training load; underperformance → OTS?
Key symptoms present despite adequate recovery time?
Persistent fatigue/underperformance lasting > 4 weeks

Rule out diseases that could explain underperformance
Viral (EBV, Hepatitis, HIV); Bacterial (Borreliosis, Streptococcal);
Allergic/Inflammatory; Other (Diabetes, Hyperthyroidism, Anaemia)

Performance changes defined
Max Performance (e.g. TTE, TT, Isokinetic power) reduced >10%
Reduced sport-specific performance. Altered hormonal responses

Possible provoking conditions checked
Recent illness, psycho-social factors, nutritional disorders,
extreme environments, increased training load

→ OTS is likely
Causes of overtraining

- Excessive number of competitive events
- Limited recovery time
- Training too hard for too long
- Inadequate diet/negative energy balance
- Competing/training with injuries/infections
- Psychological stress

Maladaptation to excessive stress – probably in response to a combination of stressors
Training and hormones

- Acute bouts of exercise and stress elevate stress hormone secretion
- Excessive training (stress) may lead to a hormonal imbalance:
  - Reduced adrenal hormone responses to exercise and tissue insensitivity to catecholamines
  - Disturbance of pituitary hormone secretion
  - Causing “parasympathetic” type of overtraining syndrome
Increased training

- Training
  - Chronically elevated catecholamines
    - Downregulation of β-adrenoreceptors
      - HRmax
      - [Lactate]
      - [Glucose]
      - [FFA]
Hypothalamic dysfunction?  

Barron et al Endocrinol Metab 60: 803-806, 1985

Hypoglycaemia induced by insulin injection (n=4 OTS vs n=5 control athletes)

Stress → Hypothalamus → Anterior pituitary gland → Adrenal glands

Prolactin → GH → ACTH → Cortisol

OTS
Conclusions

- Overtraining may result in lower submaximal and maximal lactate concentrations during exercise.

- This may be due to decreased intrinsic activity of the sympathetic nervous system rather than muscle glycogen depletion.

- Overtraining is associated with reduced pituitary hormone and cortisol responses to stress.

- Other hormonal and neurotransmitter changes may be responsible for some of the symptoms of UPS.
According to the cytokine hypothesis of overtraining (OT), high volume/intensity training, with insufficient rest, will produce tissue trauma stimulating monocytes to produce large quantities of proinflammatory cytokines including IL-6 and TNF-α (L Smith, 2000, *Med Sci Sports Exerc* 32: 317-331). These then induce mood and behavior changes (e.g. fatigue, depression) and immune function changes.

However, no change in resting plasma concentration of IL-6 or TNF was detected after 2 weeks of overtraining in cyclists (Gleeson *et al.* 2001, *Med Sci Sports Exerc* 33(5): Suppl. ISEI, 44)
N=8 elite male rowers monitored during training (24 h/week) for 8 weeks prior to the 2007 Rowing World Championships. Self-report measures of overtraining and plasma cytokines (IL-1β, IL-6, IL-8, IL-10, IL-12p70 and TNF-α) were assessed every 2 weeks.

Levels of plasma pro-inflammatory cytokines IL-1β and TNF-α were significantly associated (p<0.05) with measures of depressed mood, sleep disturbances, and stress. Similarly, IL-6 was significantly associated (p≤0.01) with depressed mood, sleep disturbances, and fatigue.
## Practical tools to monitor training adaptation

<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
<th>Evidence/Limitations</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diaries, questionnaires, sleep and resting HR</strong>&lt;br&gt;Diaries, POMS, DALDA, TDS, TQR and RESTQ-Sport. Sleep and HR&lt;sub&gt;rest&lt;/sub&gt;.&lt;br&gt;Psychomotor speed tests</td>
<td>Self-report questionnaires for monitoring mood, exertion, life demands and recovery. Simple monitors (e.g. Actigraph) can assess sleep. Sleeping HR elevated in overreaching</td>
<td>Limited on predicting progression to OTS. Issues with compliance. Unclear whether the quantity and quality of sleep identifies progression into OTS.</td>
<td>●●●○○</td>
</tr>
<tr>
<td><strong>Training load</strong>&lt;br&gt;Distance, time, speed, power etc. HR zones, TRIMP, session RPE.</td>
<td>Some simple, yet descriptive, tools now easily monitored with GPS/power meters etc. HR, TRIMP and session RPE provide more specific information about training stress.</td>
<td>Training load assessment can be subjective (e.g. session RPE). Nevertheless, session RPE may be useful when HR monitors are unavailable. TRIMP provides information beyond HR alone but has limited utility for exercise above the anaerobic threshold.</td>
<td>●●●○○</td>
</tr>
<tr>
<td><strong>Exercise and performance testing</strong>&lt;br&gt;Sub-maximal and maximal exercise testing.</td>
<td>Assess HR, blood lactate and neuroendocrine responses (e.g. blood ACTH, cortisol) to exercise test.</td>
<td>Maximal HR and blood lactate are reduced in OTS. Blunting of cortisol response to exercise. Utility of lactate and neuroendocrine responses to exercise to track progression into (and recovery from) OTS is mixed.</td>
<td>●●○○○</td>
</tr>
<tr>
<td>Exercise performance tests.</td>
<td>Exercise performance tests are essential to diagnose OTS.</td>
<td>Useful to identify recovery from intensified training. Less useful to confirm recovery from OTS as fitness will likely decrease during OTS. Exercise performance tests should be sport specific.</td>
<td>●●●●○</td>
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HR during sleep

Jeukendrup et al IJSM 13: 534-541, 1992
Decreased blood lactate response to incremental exercise

Jeukendrup et al IJSM 13: 534-541, 1992
## Biochemical and haematological tools to monitor training adaptation

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<th>Evidence/Limitations</th>
<th>Rating</th>
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</thead>
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<tr>
<td><strong>Biochemical</strong></td>
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<tr>
<td>Free testosterone: cortisol ratio</td>
<td>Indicator of anabolic/catabolic balance. Can be assessed in both blood and saliva.</td>
<td>May indicate response to training but cannot identify OTS. A low free T:C ratio (&lt;30%) indicates over-reaching. Unclear how these changes relate to performance. Costly and time consuming.</td>
<td>●●○○○</td>
</tr>
<tr>
<td>Plasma glutamine</td>
<td>Non-essential amino acid. Important fuel for immune cells. Ratio to glutamate may indicate training stress.</td>
<td>Plasma glutamine decreases in response to intensified training, over-reaching and OTS. Ratio to glutamate has been shown to indicate training intolerance. Requires blood sample. Costly and time consuming.</td>
<td>●●●○○</td>
</tr>
<tr>
<td>Blood CK and CRP</td>
<td>Indicators of muscle damage and inflammation.</td>
<td>Not suitable to indicate training adaptation, over-reaching or OTS. Some utility to exclude other explanations for underperformance. Requires blood sample. Costly and time consuming.</td>
<td>●○○○○</td>
</tr>
<tr>
<td>Serum iron, ferritin and transferrin</td>
<td>Indicators of inflammation and chronic recovery. Iron deficiency can lead to anaemia.</td>
<td>May be reduced in chronically exercising individuals, particularly during high intensity training. Decrease may negatively affect performance. Requires blood sample. Costly and time consuming.</td>
<td>●●○○○</td>
</tr>
<tr>
<td><strong>Haematological</strong></td>
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<tr>
<td>Red blood cell count, haemoglobin and haematocrit. Differential white blood cell count</td>
<td>Standard clinical laboratory tests.</td>
<td>Normal clinical ranges established. Cannot detect over-reaching or OTS. Useful for determining overall health status. Can be performed on finger prick rather than venous blood sample.</td>
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Exercise test to diagnose OTS


Can exercise-induced hormonal responses be used to diagnose OTS vs overreaching (OR)?

Two bout maximal incremental exercise test in n=5 OTS vs n=5 OR athletes

Hypothalamus

Anterior pituitary gland

Prolactin

ACTH

Much lower prolactin and ACTH release in OTS following the second exercise bout. Blood lactate also lower in OTS

Two graded exercise tests to exhaustion (~20-25 min) performed 4 h apart. Overshoot of ACTH and PRL responses to bout #2 in NFO but blunting in OTS.

**OTS = Overtraining Syndrome; NFO = nonfunctional overreaching**
DETECTION OF OVER-REACHING: Salivary cortisol and testosterone responses to a two-bout exercise protocol are blunted after 11 days of intensified training (John Hough PhD thesis 2012)

Bout 1: 30 min intermittent \(55\% W_{\text{max}}\)[1min]/\(80\% W_{\text{max}}\)[4min]
Bout 2: \(70\% W_{\text{max}}\) for 30 min or to fatigue (if sooner)
Treatment of overtraining

- Fatigue
- Infections
- Depression

- Rest
- Medication

Under-performance

Counselling; Anti-depressants
Minimise the stress hormone response to exercise

- Maintain energy balance
- Eat a high carbohydrate diet
- Avoid Dehydration
- Consume carbohydrate and fluid during and after exercise
- Supplement diet with antioxidants
- Allow adequate recovery between training sessions
Overtraining Study +/- CHO supplements

<table>
<thead>
<tr>
<th>NORMAL</th>
<th>INTENSIFIED</th>
<th>RECOVERY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue ride</td>
<td>VO₂ max + training</td>
<td>VO₂ max</td>
</tr>
<tr>
<td>Day</td>
<td></td>
<td>Day</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>9</td>
</tr>
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<td></td>
<td></td>
<td>Day</td>
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<tr>
<td></td>
<td></td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23</td>
</tr>
</tbody>
</table>

Day 1 to Day 8: 5 training days
Day 8 to Day 9: 13 light training days

Pre-exercise
- High CHO: 6.4% (32g) 500ml
- Low CHO: 2% (10g) 500ml

During-exercise
- High CHO: 6.4% (32g) 500ml / hr
- Low CHO: 2% (10g) 500ml / hr

Post-exercise
- High CHO: 20% (200g) 1000ml
- Low CHO: 2% (20g) 1000ml

CHO: Carbohydrate

**Intensified Recovery**

CHO supplements:
- Pre-exercise: 6.4% (32g) 500ml
- During-exercise: 6.4% (32g) 500ml / hr
- Post-exercise: 20% (200g) 1000ml

**Normal Recovery**

CHO supplements:
- Pre-exercise: 2% (10g) 500ml
- During-exercise: 2% (10g) 500ml / hr
- Post-exercise: 2% (20g) 1000ml
Volume and intensity of training performed during normal training, intensified training and recovery periods

<table>
<thead>
<tr>
<th>Time</th>
<th>Normal week</th>
<th>Intense week</th>
<th>Recovery week 1</th>
<th>Recovery week 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>04:00</td>
<td></td>
<td>04:00</td>
<td>04:00</td>
<td>04:00</td>
</tr>
<tr>
<td>08:00</td>
<td>&gt;90% HRmax</td>
<td>&gt;90% HRmax</td>
<td>83 - 90% HRmax</td>
<td>83 - 90% HRmax</td>
</tr>
<tr>
<td>12:00</td>
<td>&gt;90% HRmax</td>
<td>&gt;90% HRmax</td>
<td>70 - 83% HRmax</td>
<td>70 - 83% HRmax</td>
</tr>
<tr>
<td>16:00</td>
<td>&gt;90% HRmax</td>
<td>&gt;90% HRmax</td>
<td>60-70% HRmax</td>
<td>60-70% HRmax</td>
</tr>
</tbody>
</table>

Exercise test to exhaustion at 74% VO₂max
Total energy intake during a period of normal training and during periods of intensified training with supplementary high or low CHO drinks.

- **Normal Training**
  - Energy Intake: 119 kJ/kg BM$^{-1}$
  - CHO Drinks: 23
  - Protein: 42
  - Fat: 43
  - Dietary CHO: 119

- **High CHO Training**
  - Energy Intake: 200 kJ/kg BM$^{-1}$
  - CHO Drinks: 73
  - Protein: 22
  - Fat: 43
  - Dietary CHO: 86

- **Low CHO Training**
  - Energy Intake: 200 kJ/kg BM$^{-1}$
  - CHO Drinks: 14
  - Protein: 24
  - Fat: 44
  - Dietary CHO: 95
Percentage changes from baseline for exercise time to fatigue during low and high CHO trials

-35 -25 -15 -5 5 15
% change

Normal Intense Recovery

High CHO
Low CHO

P<0.05
Alterations in mood state during low and high CHO trials

P<0.05
Plasma cortisol response to exercise during Normal Training (NT) and Intensified Training (IT)

Plasma Cortisol (nmol.l$^{-1}$)

Rest 60 Post 1h Post
Time (min)

Plasma cortisol response to exercise during Normal Training (NT) and Intensified Training (IT)

* P<0.05 vs NT

NT
IT Hi-CHO
IT Lo-CHO
Higher dietary carbohydrate content during intensified running training results in better maintenance of performance and mood state. *J Appl Physiol* 96(4): 1331-1340

Isoenergetic diets
5.4 g CHO/kg (41%) vs 8.5 g CHO/kg (65%)
Minimise the stress hormone response to exercise

- Maintain energy balance
- Eat a high carbohydrate diet
- Avoid Dehydration
- Consume carbohydrate and fluid during and after exercise
- Supplement diet with antioxidants
- Allow adequate recovery between training sessions
Increased stress hormone response to a repeated bout of endurance exercise (65 min cycling at 75%VO₂max)

Cortisol (nmol/L)

Adrenaline (nmol/L)

Longer recovery time decreases the stress hormone response to a repeated bout of endurance exercise (65 min cycling at 75%VO$_2$max).

### Monitoring overtraining DALDA

*a = worse than normal, b = normal, c = better than normal*

#### Part A

1. a  b  c  Diet
2. a  b  c  Home-life
3. a  b  c  School/College/Work
4. a  b  c  Friends
5. a  b  c  Sport training
6. a  b  c  Climate
7. a  b  c  Sleep
8. a  b  c  Recreation
9. a  b  c  Health

Total “a” response: _______
Total “b” response: _______
Total “c” response: _______

**Record these values and the day’s date on the data log part A**

DALDA = Daily Analyses of Life Demands in Athletes

*From Rushall, 1990*
1. a b c Muscle pains 14. a b c Enough sleep
2. a b c Techniques 15. a b c Between sessions recovery
3. a b c Tiredness 16. a b c General weakness
4. a b c Need for a rest 17. a b c Interest
5. a b c Supplementary work 18. a b c Arguments
6. a b c Boredom 19. a b c Skin rashes
7. a b c Recovery time 20. a b c Congestion
8. a b c Irritability 21. a b c Training effort
9. a b c Weight 22. a b c Temper
10. a b c Throat 23. a b c Swellings
11. a b c Internal 24. a b c Likability
12. a b c Unexplained aches 25. a b c Running nose
13. a b c Technique strength

a = worse than normal
b = normal
c = better than normal

Sum of “a” scores for DALDA Part B
Monitoring overtraining using DALDA

"a" score >5 for >4 consecutive days
Monitoring overtraining in runners

PJ Robson, PhD thesis, University of Birmingham, 1999

- "a" score
- Additional interval training
- Normal training
- Mean values for 8 runners
Essentials to avoid overtraining

- Control rate of progression of training
- Reduce risks of infection
- Avoid monotonous training
- Maintain good nutrition
- Ensure adequacy of carbohydrate and energy intake during intensified training periods
- Monitor the training load and the athlete

Thank you for listening!