Overtraining and Chronic Fatigue
Mark Lavallee, MD, CSCS, FACSM
Director, York Hospital Sports Medicine Fellowship, York PA
Ass’t Clinical Professor, Penn State Univ. College of Medicine, Hershey, PA
Team Physician, Gettysburg College, Gettysburg, PA
Disclosures/ Conflicts of Interests

• I have no conflicts of interest in regards of this topic.

• I have no financial relationships to divulge that would impact the bias nature of this lecture.

• I give credit to my colleague, Tom Howard, MD who allowed me to BLATANTLY steal some of his slides to make this presentation.
Objectives

- Review the terminology of overtraining.
- Review the epidemiology and etiology of overtraining syndrome.
- Describe the clinical presentation, diagnosis, management and prevention of this disorder including chronic fatigue.
Terminology

- Training
- Adaptation
- Recovery
- Periodization
- Overreaching
  - FOR
  - NFOR
- Overtraining Syndrome
- Under-recovery
- Training Fatigue
Training

Progressive overload to displace homeostasis and create stimulus for adaptation

Improved performance

CJ Cumming’s World record 182 kg C&J at 69kg body weight at 16y.o. in Oct 2016 in Penang, Malaysia
Adaptation

Physiologic response to stress (training load) to better respond to similar stress in the future.
RECOVERY from Exercise

• Recovery is initiated by a disturbance in homeostasis; unclear when complete.
• The necessary process that links training and adaptation.
• Individual capacities/thresholds:
  • Psychologic
  • Physiologic
  • Social
RECOVERY

• Nutrition and hydration
• Rest and sleep
• Relaxation and emotional support
• Stretching and active rest

Inadequate Recovery = Fatigue
Influences on the Athlete

- Coach
- Team
- SPORT

- HOME
  - Parent/spouse
  - Sibling/child

- WORK/SCHOOL
- Teacher/Boss
- Peer
PHYSIOLOGIC Fatigue

• Insufficient Sleep
• Nutritional
• Jet Lag
• Pregnancy
• Training induced
  • Excessive competition
  • Overreaching
PATHOLOGIC Fatigue

• Medical
  • Infectious, Neoplastic, Hematologic, Endocrine, Toxic, Iatrogenic, Psychiatric
• Chronic Fatigue Syndrome
• Overtraining Syndrome
Periodization

- Planned sequencing of training loads and recovery periods within a training program.

- Series:
  - Microcycles (1 week)
  - Mesocycles (4-12 weeks),
  - Macrocycles (1 year)
  and
  - Phases designed to emphasize unique aspects of training and adaptation.

- Final phase of a macrocycle is the transition phase which allows for restoration.
Performance Capacity =

Intrinsic Capacity + Accumulated Fitness - Accumulated Fatigue

"What you can do, naturally" + "Effect of your Training" - "Things that tear you down"
Functional Overreaching (FOR)

- Acute phase during which training load (intensity or volume) is significantly increased
  - (i.e. Think for increasing mileage before a marathon)
- Short-term deterioration in performance
- Physiological Fatigue
- Usually lasts 2 weeks
Non-Functional Overreaching (NFOR)

- Short term decrements in performance
- Same as FOR
- Recovery a bit longer
  - Vague? 2-4 or 6 wks
Overtraining

• Maladaptive response to training from an extended period of overload
• Usually > 4 weeks
• “Staleness” with failure to improve performance
• Overuse injuries, mood disturbance, blood chemistry changes, immune dysfunction*

*CD4 counts dropped in medical students before finals.
Overtraining Model

Performance

Overreaching

Supercompensation

Overtrained

Time
Overtraining Progression

- Overreaching
- Decreased Performance
- Failure to Regenerate
- Panic Training
- Overtraining Syndrome
Epidemiology of Overtraining Syndrome
“Overtraining or staleness is the bug-a-boo of every experienced trainer...it is a condition often difficult to detect and still more difficult to describe... consider nutrition, training load, competition stress, and a psychologic predisposition...go slow and maintain balance between sleep, work, and recreation”

Some medical aspects of the training of college athletes
Parmenter, *Boston Medical and Surgical Journal* 1923
Research Findings

• No diagnostic criteria
• Inconsistent data
  • small numbers studied
  • difficult to establish controls and lab models
  • most studies too short
• Confounding influences
  • illness, injury, menstruation, different training methods for different sports

CAUTION
Avoid Overtraining
Overtraining Epidemiology

• Incidence
  • **7-20% elite** athletes at any one time
  • 2/3rds of elite runners over the course of a career

• Common “At Risk” Sports
  • Endurance events
  • Swimming, running, cycling
  • Power lifting, basketball
Overtraining Susceptibility

• Highly motivated, goal-oriented individuals
  • POMS (Profile of Mood States) testing demonstrates that athletes tend to be somewhat focused, conventional and conservative
• Exercise regimens designed by the athlete
• Psychologic predisposition?
Risks of Overtraining Syndrome

- Prolonged poor performance
- Injury
- Illness
- Premature retirement
Etiology of Overtraining Syndrome
FIVE Current Hypotheses

• BCAA Hypothesis
• Autonomic Imbalance Hypothesis
• Glycogen Depletion Hypothesis
• Glutamine Deficiency Hypothesis
• Cytokine Hypothesis
I. BCAA Hypothesis

“Branched Chain Amino Acid Dysbalance Theory”
1) Severe sustained exercise leads to glycogen depletion
2) then, BCAA consumed as fuel
3) thus, Increased brain levels of tryptophan with an increased synthesis of serotonin
4) Resulting in FATIGUE
II. Autonomic Imbalance Hypothesis

• Parasympathetic OTS is dominant form, with decreased intrinsic sympathetic activation.
• Prolonged strenuous exercise leads to an increased concentration of free circulating catecholamines, Cortisol, T3, and ?
• Sustained levels lead to a down regulation of adrenoreceptors.
II. Autonomic Imbalance Hypothesis

- **Peripheral:**
  - This negative feedback results in a lower sympathetic resting tone

- **Central:**
  - Increased brain tryptophan also decreases sympathetic tone
III. Glycogen Depletion Hypothesis

- Inadequate energy intake resulting in:
  - decreased exercise induced rise in pituitary hormones, cortisol, & insulin
  - decreased resting testosterone
  - decreased protein and glycogen synthesis
- Decreased RQ (increased reliance on FFA)
- Poor subsequent response to training
- “Fatigue”
IV. Glutamine Hypothesis

• Chronic exercise with inadequate recovery creates a glutamine deficient state
• This sets up immunologic “open windows” for infection that further stress the system
IV. Glutamine

- Most abundant AA in muscle and plasma
- Synthesized in muscle, lungs, liver, brain and fat tissues
- Maintains acid-base balance during acidosis
  - Glutamine = Glutamate + NH$_3$
- Nitrogen precursor for synthesis of nucleotides for cell replication
- Fuel for intestinal mucosal and immune system cells
  - (Lymphocytes, Macrophages, NK Cells)
IV. Glutamine with Exercise

• Linear relationship with plasma glutamine and exercise intensity
• Considerable time may be required between training sessions to allow complete recovery of plasma glutamine
• 50% reduction of resting levels in athletes after 10-day overload period
IV. Confounding factors to Interpretation of Glutamine Levels

- Diurnal cycles
  - Max 10% over 24hrs
- Dietary
  - Increase Glutamine up to 29% after meals esp if HIGH PROTIEN
- Infection
  - Increased with viral or others
V. Cytokine Hypothesis

Adaptive Microtrauma

Local Chronic Inflammation

Systemic Immune/Inflammatory Response

Local Acute Inflammation
V. Stress Cytokines

- From circulating monocytes
- IL-6, TNF-α
- Induce fever, stimulate ACTH, stimulate release of acute phase proteins
- Activate sympathetic nervous system and H-P-A axis and inhibition of H-P-G axis
- Behavioral changes
  - Lethargy, anorexia, somnolence

26 French soldiers
3 weeks of intense combat training

Increased IL-6

Decreased secretory IgA, DHEA, Prolactin, testosterone

### V. Cytokine Theory

Cytokines and growth factors during and after wrestling season in adolescent boys

- During season: inc IL-1ra, IL-6, IGFBP-1&2, and BHBP with rebound post season; insignificant change in TNF-α and IL-1β

- Anabolic rebound post-season

---

- MSSE, Vol 36(5):794-800, 2004

**Systemic inflammatory mediators contribute to widespread effects in work-related musculoskeletal disorders**

- Repetitive, forceful hand-intensive occupational tasks

- Induction of a chronic inflammatory conditions from persistent injury stimulus with elevated IL-1& CTGF


- An exercise of physical activity in healthy older men

- Inc IL-10 and dec IL-6 with balanced exercise program

- MSSE 36(6):960-4, 2004

---

Smith, MSSE 32(2): 317-331, 2000
Clinical Presentation of Overtraining Syndrome
Case Report

• 16 y/o runner
• Running 60+ miles per week
  • 6 days/week
• Working 2.5 hrs/day & going to school
• Family very goal-oriented; father is a General in Army
• He is applying to a service academy
• c/o decreased performance, fatigue, increased URI frequency
Complaints

• Sport-Specific Performance
  • inability to meet prior performance standards
  • prolonged recovery time
• Physiologic
  • weight loss
  • increased resting heart rate
  • injuries
• Subjective
  • sleep disorder
  • emotional instability
  • apathy
Categories of Overtraining

- Sympathetic
- Parasympathetic
Sympathetic Overtraining

• ? *Early Overtraining?*  “Classic Form”
  • Increased resting HR & BP
  • Loss of Sleep
  • Decreased appetite
  • Loss of body mass
  • Irritability
  • Poor performance and fatigue
  • Stress response
Parasympathetic Overtraining

- Late Overtraining? "Modern Form"
- Impaired performance & easily fatigued
- Low resting HR & BP
- Long periods of sleep/ depression
- Normal appetite and constant weight
- Decreased libido, amenorrhea, loss of competitive desire
- Anorexia Nervosa-like
Diagnosis of Overtraining Syndrome
Diagnostic Criteria

• No specific diagnostic criteria or useful lab parameters for overtraining syndrome.

• Diagnosis of exclusion
“The overtraining syndrome refers to a symptom complex characterized by non-adaptation to training, decreased physical performance and chronic fatigue following high-volume and/or high-intensity training and inadequate recovery.”

Randy Eichner 1995
Differential Diagnosis

• Systemic Illness
  • Mono, CMV, Hepatitis, Cancer, Post-viral, Fibromyalgia, Chronic Fatigue Syndrome, Collagen vascular disorder

• Metabolic Problem
  • anemia, hypothyroid, hypoglycemia, glycogen storage disease

• Substance abuse

• Primary psychiatric process
  • Depression
Chronic Fatigue Syndrome

• In a patient with severe fatigue that persists or relapses for 6 months, with 4 symptom criteria:
  • **Severe**: fatigue of new or definite onset, not alleviated by rest, resulting in a substantial reduction in occupational, educational, or personal activities.
  • **Symptom Criteria**:  
    • impaired memory or concentration  
    • Multi-joint pain  
    • sore throat  
    • new headaches  
    • tender cervical or axillary nodes  
    • unrefreshing sleep  
    • muscle pain  
    • postexertional malaise
Medical Evaluation

• History and Physical
• Training program
• Goals of program
  • Fitness, to race, to lose weight
• Diet & medications/supplements
• Nutrition
• Illnesses
• Review of Systems
  • weight loss, fever, sweats, rash, myalgia, arthralgia, STD’s

• Lab Evaluation
  • CBC, ESR
  • Chemistry Profile
  • Monospot
  • Thyroid Function
  • Urine Analysis
  • Ferritin
  • bHCG
  • Other labs as directed
Additional Studies/Consultation

- Drug screen
  - Illicit, ETOH, Performance enhancing
- MMPI (MM Personality Inventory)
- POMS (Profile of Mood States)
- Nutrition Consultation
- Exercise Physiologist
- Sports Psychologist
First Visit

• History
• Physical Examination
• Dietary evaluation
• Training Diary review
• Lab: CBC, ESR, TSH, Ferritin CMP, UA, b-HCG for females
• Consider Monospot, Hep Panel, drug screen, CXR, BAL, Lyme titer
• Rx: Decrease intensity X 2-3 weeks
Follow up Visit

Not improved
- Pathologic fatigue
- *Overtrained*
- Further w/u as indicated
- TSH, POMS, CXR,
- Nutrition consultation
- Rx: Rest/relative rest for another 3-6 weeks

Improved
- Physiologic fatigue
- *Overreached*
- Modify Schedule
- Periodization
Case Report - 16 y.o. runner

- CBC, chemistries, TFT’s, Ferritin all WNL
- Repeat throat culture, CXR WNL
Management of Overtraining Syndrome
Treatment

• **Rest** (relative)
  - from training and other situations
  - initially **one to two weeks**

• Short-term/limited goals
• Communication training
• Social Support
• Survey for confounding factors
  - depression/drugs/diet/disease...
BCAA Supplements

- ↑ NH3, but ↓ free Tryp:BCAA ratio
- ↓ POMS scores
- Improved energy and decreased fatigue
- Supplementation limited by GI side effects
- ? Performance improvement
Glutamine Supplementation

• Enteral or parenteral supplementation to speed recovery
• No demonstrated immune modulation with glutamine supplementation in healthy athletes
Case Report- 16 y.o. runner

• No response to a Z-pack
• Three week period of rest with sports psychology and nutrition consults. Declined family counseling.
• Readjusted school, work, sleep habits.
• Reintroduced running at 2 miles/day.
• Successfully completed SATs.
• Rejoined Indoor track team; qualified for States in 1000 and 3000m.
Prevention of Overtraining Syndrome
Prevention

• Nutrition
• Life-style factors
• Flexible programs
• Control stress and recovery within training cycles
  • Periodization
• Monitoring
Detect poor recovery (overreaching) before the development of overtraining syndrome.
Poor Markers

- Body mass
- CBC
- Serum ferritin
- CK
- Hormones
Indicators of Insufficient Recovery

• Increased resting HR
• Mood evaluation (POMS)
• Decreased Free Testosterone/Cortisol Ratio
  • Anabolic/Catabolic balance
  • > 30% decrease from baseline
• Serum glutamine (serial)
  • Glutamine:Glutamate ratio < 3.58
• Decrease HRV (heart rate variability)
Heart Rate Monitoring

• Most coaches and athletes use increase in rest HR of 10% as significant.

• “Reversal of Runner’s Bradycardia with Training Overstress”

• Runners who developed a reversed bradycardia (RB) of greater than 10% with a training stress, demonstrated a significant decrement in performance compared to runners who did not develop a RB.

Psychologic Tools

- Profile of Mood States (POMS)
  - More of a research tool
  - 65 questions assessing mood state
  - 5-negative and 1-positive
  - Tension-Anxiety, Anger-Hostility, Fatigue-Inertia, Depression-Dejection, Confusion-Bewilderment, Vigor-Activity
  - Total mood disturbance score (TMD)

- Studies have demonstrated a direct relationship between psychometric and physiologic assessments.
  - The effects of a four-day march on the gonadotropins and mood states of army officers
  - No significant change in gonadotropins (LH, FSH) or mood states (POMS-TMD ∼130) but indicate that psychological and physiological measurements could be used to monitor predisposed conditions.

  Mil Med 169;491-5, 2004
RESTQ-Sport

- Questionnaire
- 25-75 Questions
- 7 general life stress
- Recovery scales

Figure 1: Player A’s Rest-Q scores at both ends of the season
Psychologic Tools

Total Quality Recovery

- **TQR action**
  - Nutrition and Hydration: 10 pts
  - Sleep and rest: 4 pts
  - Relaxation and emotional spt: 3 pts
  - Stretching and Active rest: 3 pts

- **TQR perceived**
  - Reverse Borg scale for recovery
  - Intensity balanced with degree of recovery
<table>
<thead>
<tr>
<th>Relative Perceived Exertion (RPE)</th>
<th>Total Quality Recovery (TQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7 Very, very light</td>
<td>7 Very, very poor recovery</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>9 Very light</td>
<td>9 Very poor recovery</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>11 Fairly light</td>
<td>11 Poor recovery</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>13 Somewhat hard</td>
<td>13 Reasonable recovery</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>15 Hard</td>
<td>15 Good recovery</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>17 Very hard</td>
<td>17 Very good recovery</td>
</tr>
<tr>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>19 Very, very hard</td>
<td>19 Very, very good recovery</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>
Recommended Monitoring

- Day-to-day
  - Diary, sleep patterns
  - HR rest
- TQR
- Microcycle
  - time trials
Overtraining in the Future

• Further identification of parameters of overtraining
• Development of reliable lab models
  • identification of markers and patterns of response to specific loads
• Use of Immune Modulators and/or supplements
THANK YOU!!