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What is Fatigue in Elite Sport:

An attempt at an explanation

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Overview

- Definition of athlete fatigue
- Genesis of fatigue
- Physiological foundations of fatigue
  - Endurance sports
  - Team (game) sports
  - Precision sports
  - Explosive / strength sports
- Preventing fatigue

Athlete ‘Fatigue’

Athlete fatigue is a **psychobiological state**

Fatigue

Fatigue is complex. It is caused by physical stress & psychological stress.

It has **central** and **peripheral** origins.

Fatigue

Fatigue:

Complex mechanism involving both **physiological** and **psychological** factors.

Impaired performance

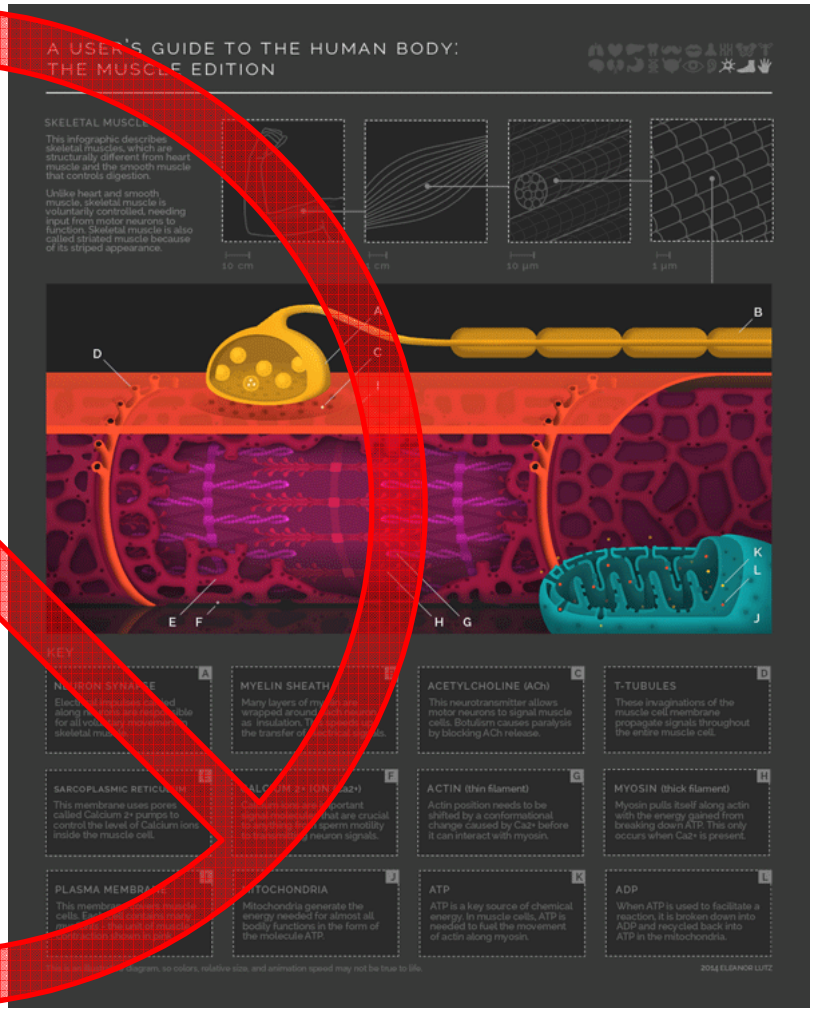
[Knicker et al., 2011]

Fatigue: Limits of Physical Performance?

What limits endurance performance?

- **Reduced ability to generate the required force.**

- **Factors that interfere with muscular contraction.**
  - **Acidosis [H^+]**
  - **Glycogen depletion**
  - **Limited blood/oxygen delivery**
  - **High core temperature**
  - **etc….**

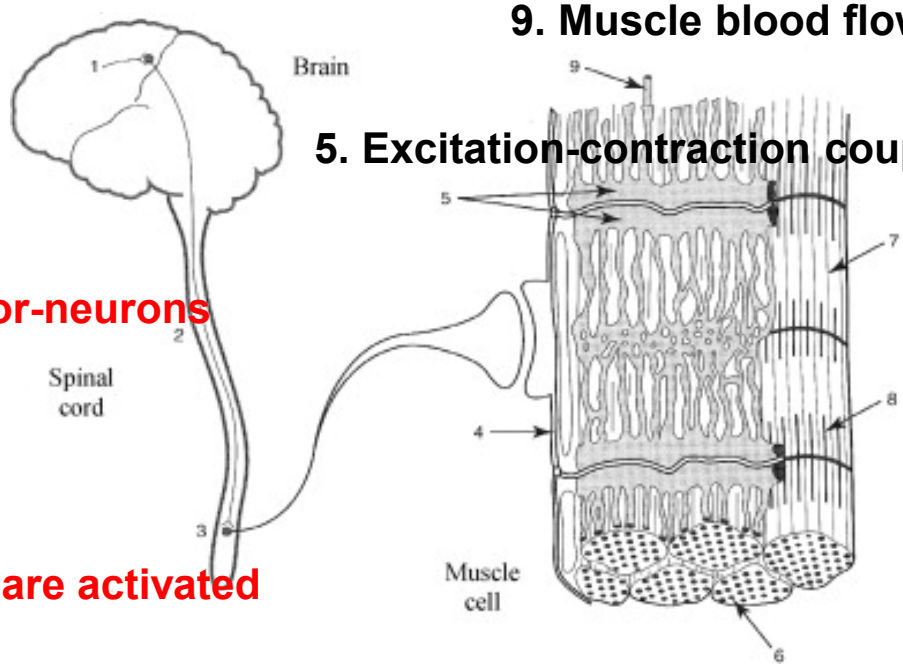


Physiological Genesis of Fatigue

Central vs. Peripheral

1. Activation of primary motor cortex

9. Muscle blood flow



5. Excitation-contraction coupling

7. Intracellular milieu

2. CNS drive to motor-neurons

8. Contractile apparatus

3. Motor units that are activated

4. Neuromuscular propagation

6. Availability of metabolic substrates

Neuromuscular ‘Fatigue’

- **Neuromuscular fatigue** can be defined as any exercise-induced decrease in a muscle's ability to develop force or power

- Muscle fatigue can be a result of vigorous exercise but abnormal fatigue may be caused by barriers to or interference with the different stages of muscle contraction.

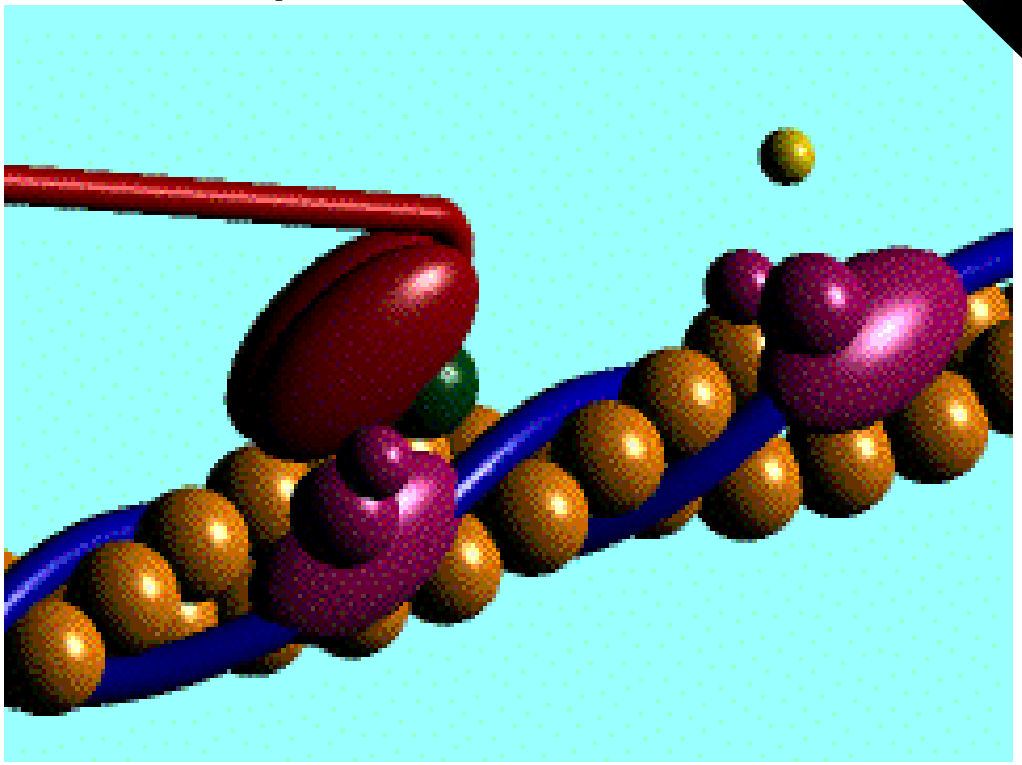
- There are two main causes:
  - the limitations of a nerve’s ability to generate a sustained signal (**neural fatigue**); and,
  - the reduced ability of the muscle fibre to contract (**metabolic fatigue**).

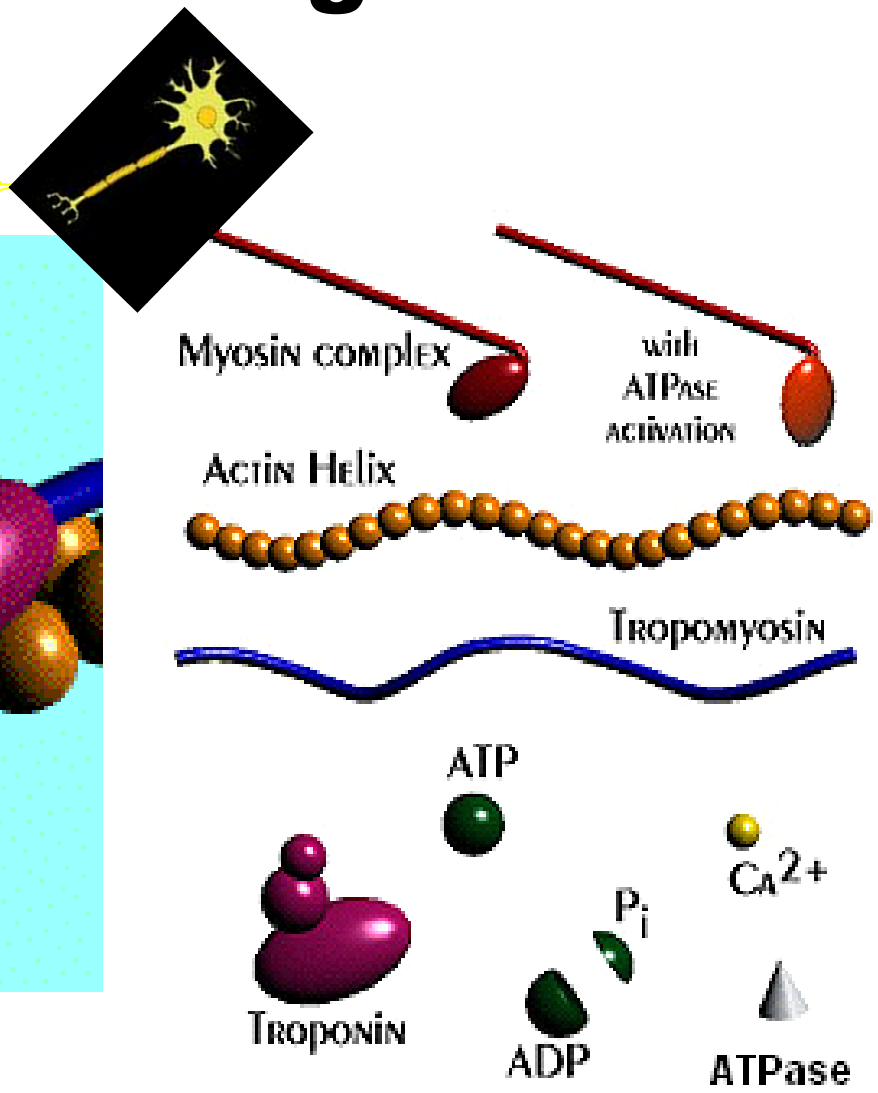
Metabolic 'Fatigue'

- **Metabolic fatigue:** the reduction in contractile force due to the direct or indirect effects of two main factors:
  - **Inadequate fuel supply** (substrates) within the muscle fibre
  - **Accumulation of metabolites** within the muscle fibre, which interfere either with the release of calcium (Ca^{++}) or with the ability of calcium to stimulate muscle contraction.

Metabolic ‘Fatigue’

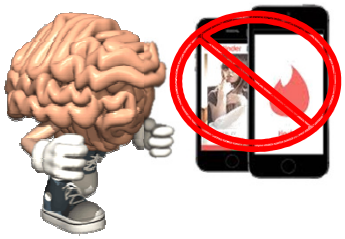
Sarcoplasmic Reticulum

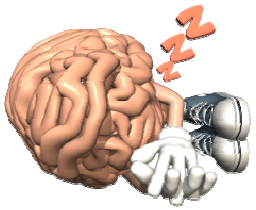




Mental ‘Fatigue’

- Fatigue induced by prolonged and demanding **cognitive activity** and other psychological stressors (high psychological load)
- Poor sleep and “jet lag” and/or ”travel fatigue” often included in this construct of mental fatigue
- Not to be confused with central fatigue, which is the exercise-induced reduction in CNS capacity to recruit muscles





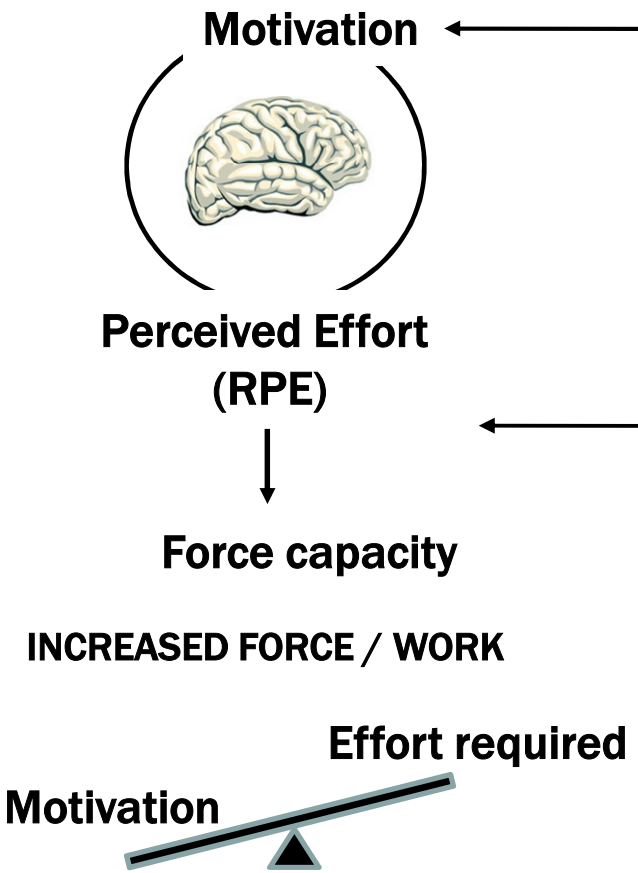
Common Sources of Fatigue in Sports




Fatigue Source	Endurance Sports	Team Sports	Explosive/Strength Sports	Precision Sports
Dehydration	✓✓	✓✓	✓	✓
Metabolic	✓✓	✓✓	✓	
Neuromuscular	✓	✓✓	✓✓	
Mental	✓	✓	✓	✓✓

Primary Contributing Factors to the Onset of Fatigue

FATIGUE: The process leading to reduced capacity to produce maximal force or do physical work.



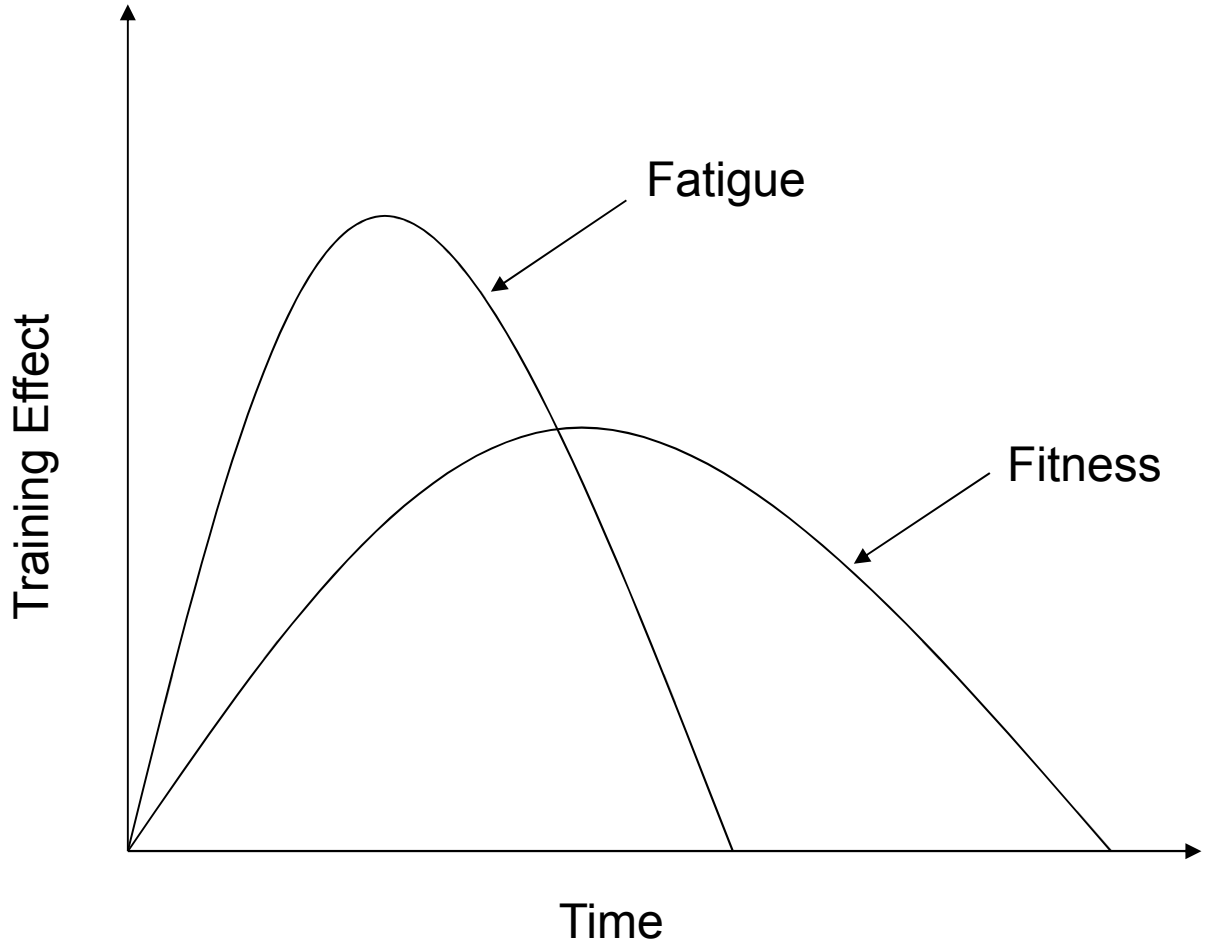
Before Exercise:

- Physiological state
- Psychological state
- Training experience
- Importance of the activity

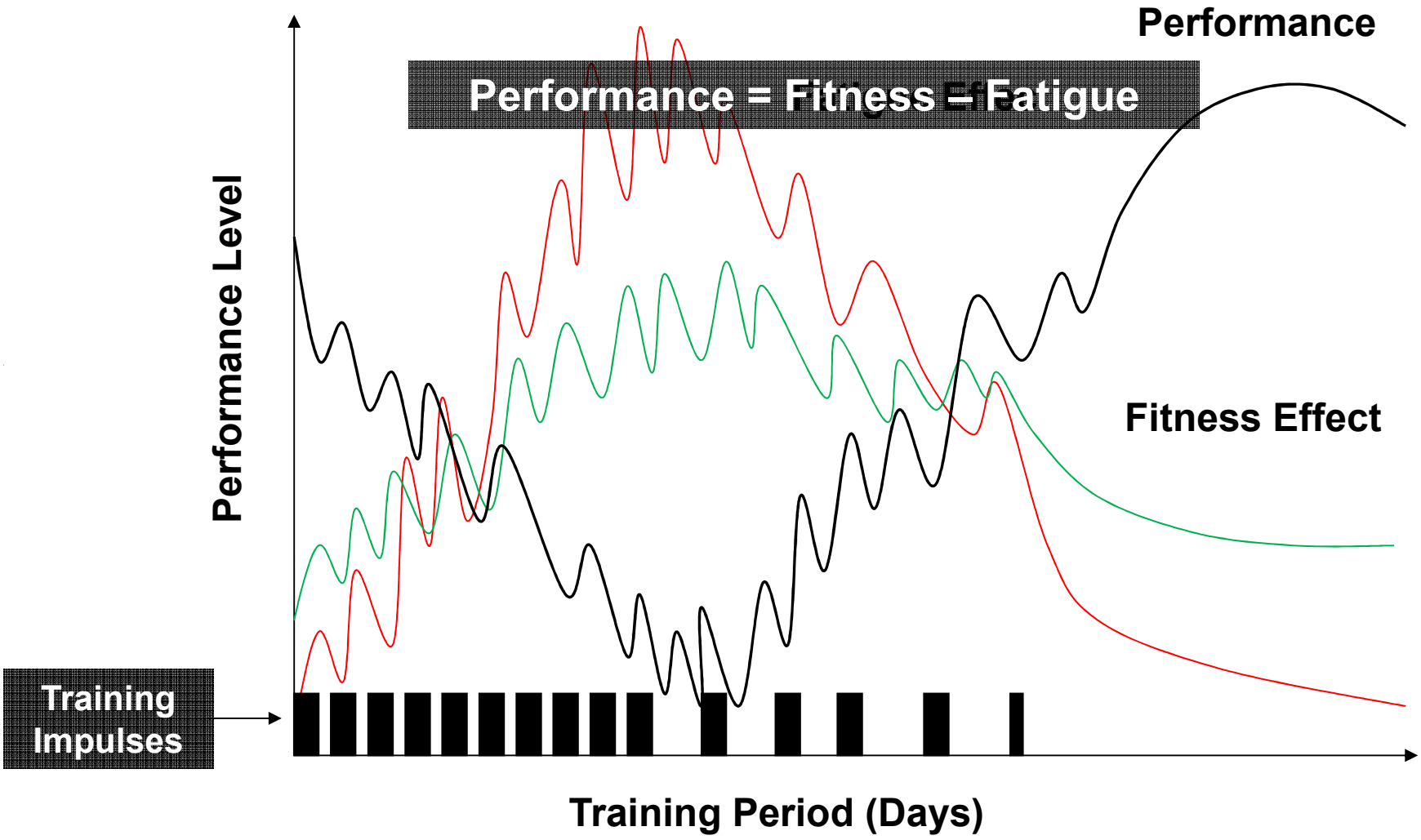
During Exercise:

- Fuel availability
- Rate of heat accumulation
- Hydration status
- .....

Fatigue: The Training Response

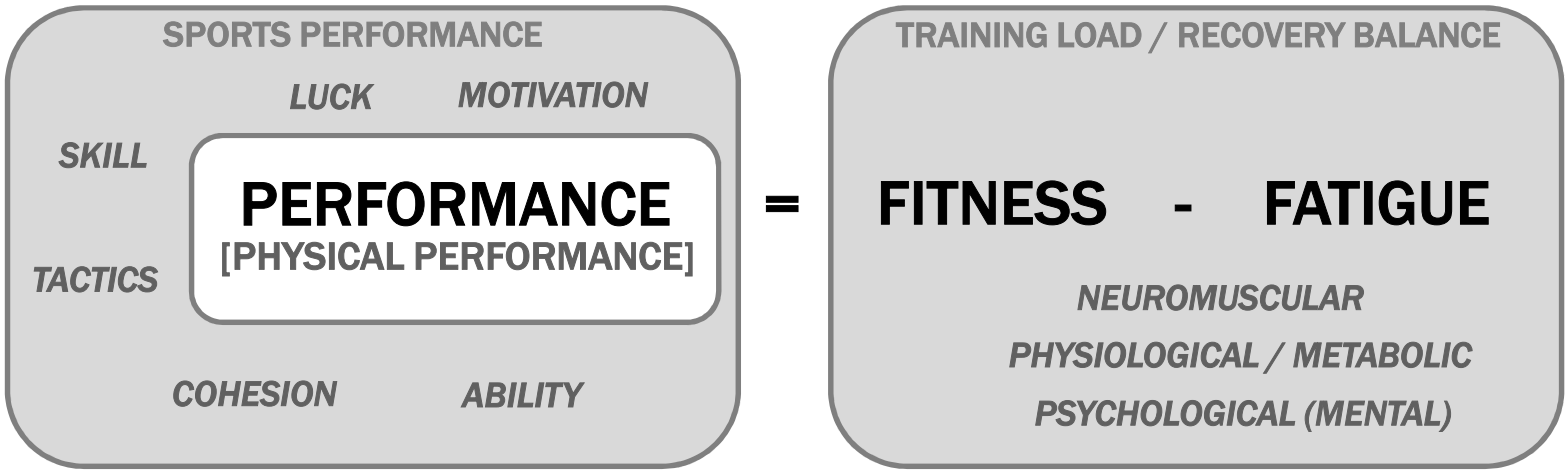


Modelling Training Responses

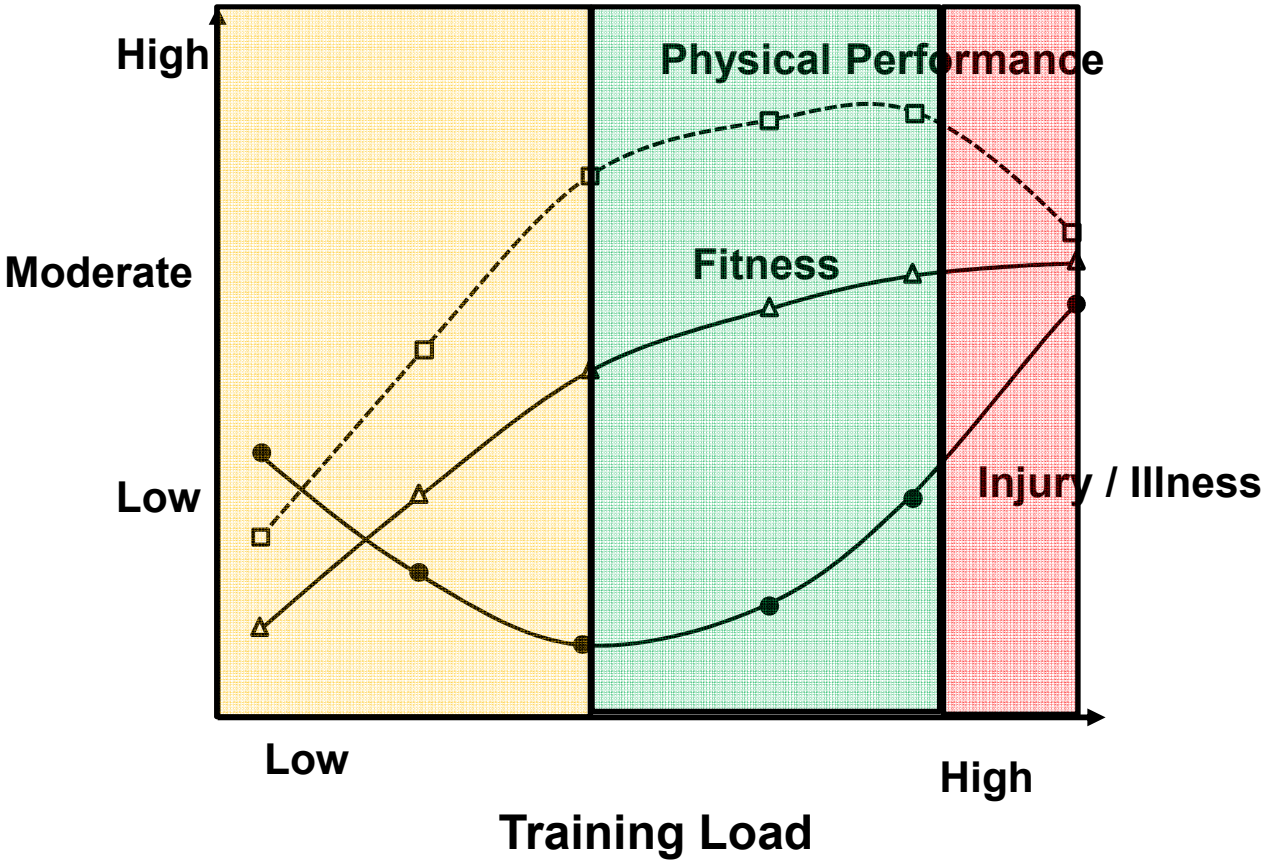


[Banister et al., 1975, Busso et al., 2003]

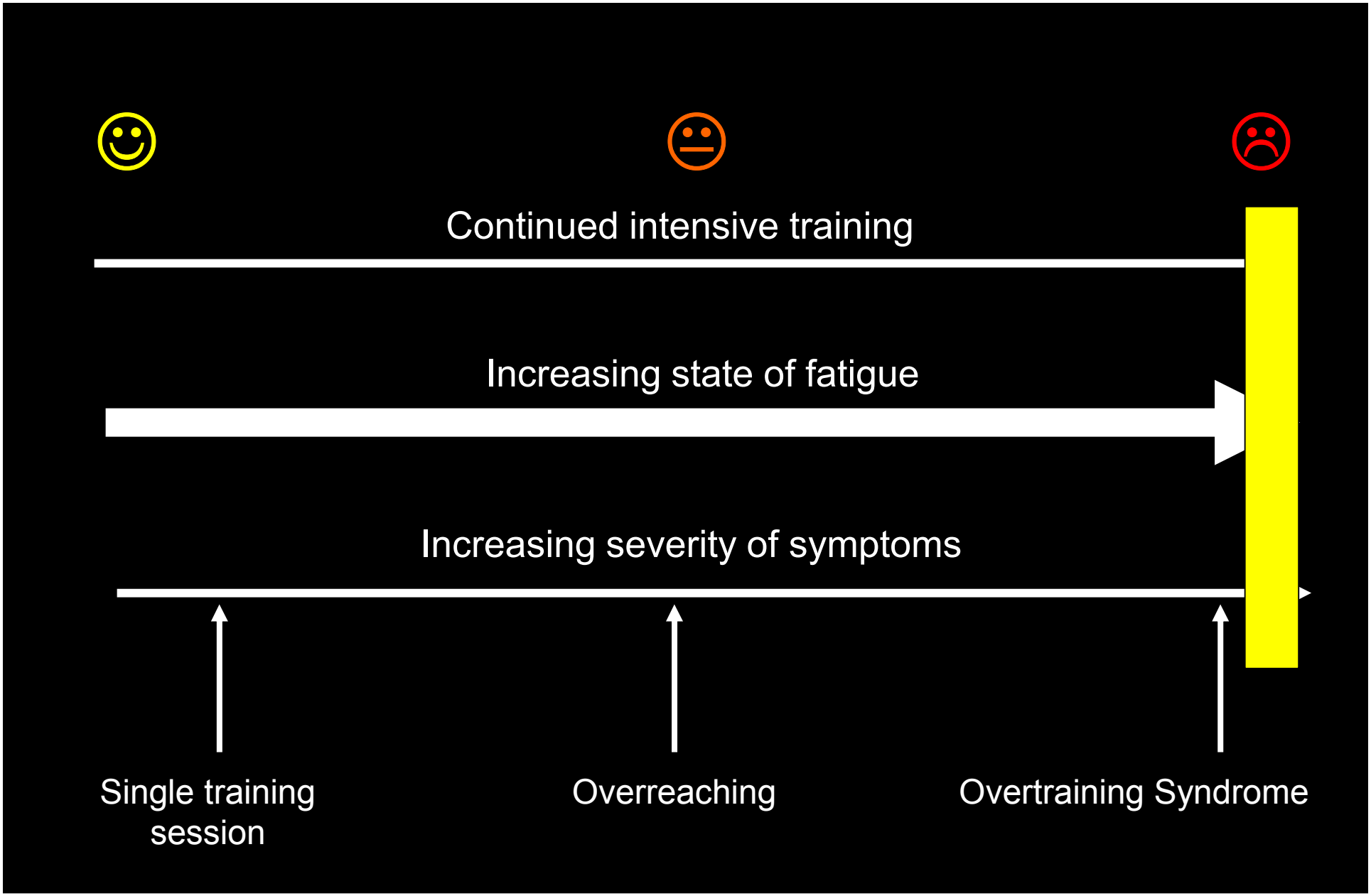
Factors Affecting Performance in Sports



The Influence of Training Load



Continuum of Training Fatigue



THE DIFFERENT STAGES OF FATIGUE

Overreaching

FUNCTIONAL

- An accumulation of training and non-training stress resulting in a ***short-term decrement*** in performance cap… ogical and psy… rtraining in which restoration of performance capacity may take from ***several days to several weeks***.

NON-FUNCTIONAL

(Meeusen et al., 2011 MSSE)

Overtraining

- An accumulation of training and non-training stress resulting in a ***long-term decrement*** in performance capacity with or without related physiological and psychological signs and symptoms of overtraining in which restoration of performance capacity may take from ***several weeks, months or years***.

(Meeusen et al., 2011 MSSE)

The only reliable criteria for diagnosing overtraining is decreased performance

The Prevalence of Overtraining (*verb*)

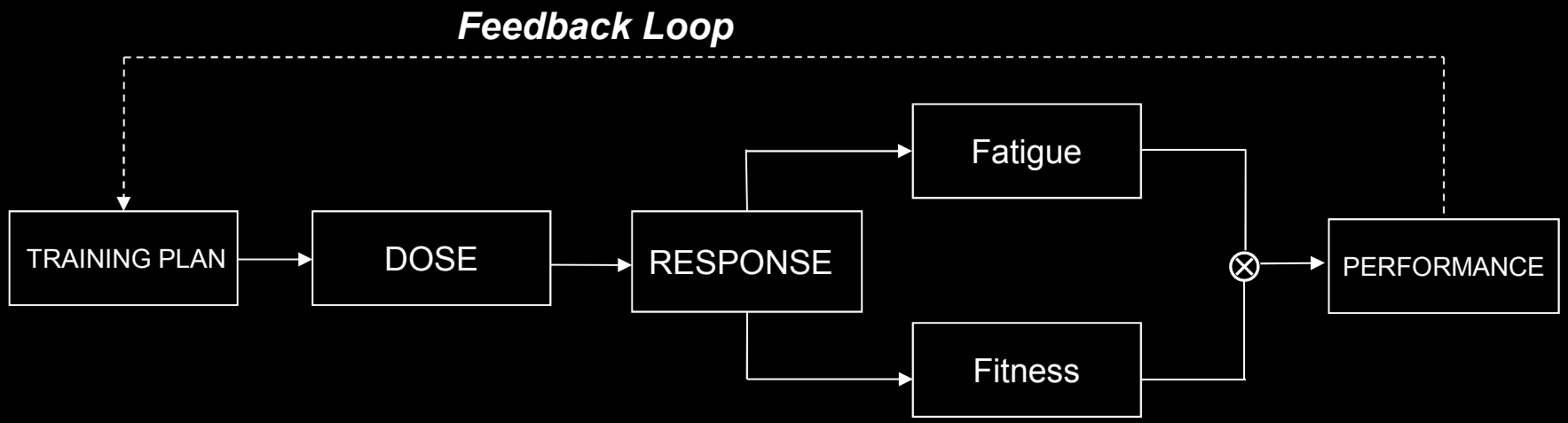
- ~10-21% of acyclic sports (Raglin & Wilson, 2000)
- ~37% of young national level Swedish athletes (Kentta et al., 2001)
- 70% of endurance athletes during career (Morgan et al., 1987)
- 30-50% national level soccer players (Lehmann et al., 1992)
- 1/3 of Professional football team during a season (Naessens et al., 2000)
- Reports of 34-91% chance of reoccurrence in college swimmers (Raglin, 1993)

Foundations of Overtraining

- Numerous causes of training maladaptation:
  - Central and/or Peripheral Fatigue
  - Neuroendocrine dysfunction
  - Autonomic imbalance
  - Catabolic / Anabolic Imbalance
  - Carbohydrate Deficit
  - Immune suppression
  - ….

Typical symptoms of overreaching in endurance trained athletes

Model for Monitoring Training



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Monitoring Tools

Monitoring Tools:

- Heart Rate
  - Resting
  - ↑/↓Response to standardised workload (Fatigue context)
  - ↓ HR_{max}
  - ↓ $HR_{recovery}$
  - ↓ Heart rate variability (HRV)
- Monitor perception of fatigue/wellness
  - POMS, DALDA, Wellbeing
- Blood analytes are too expensive, variable and invasive to measure for most athletes
- Control the process of training to avoid maladaptive training

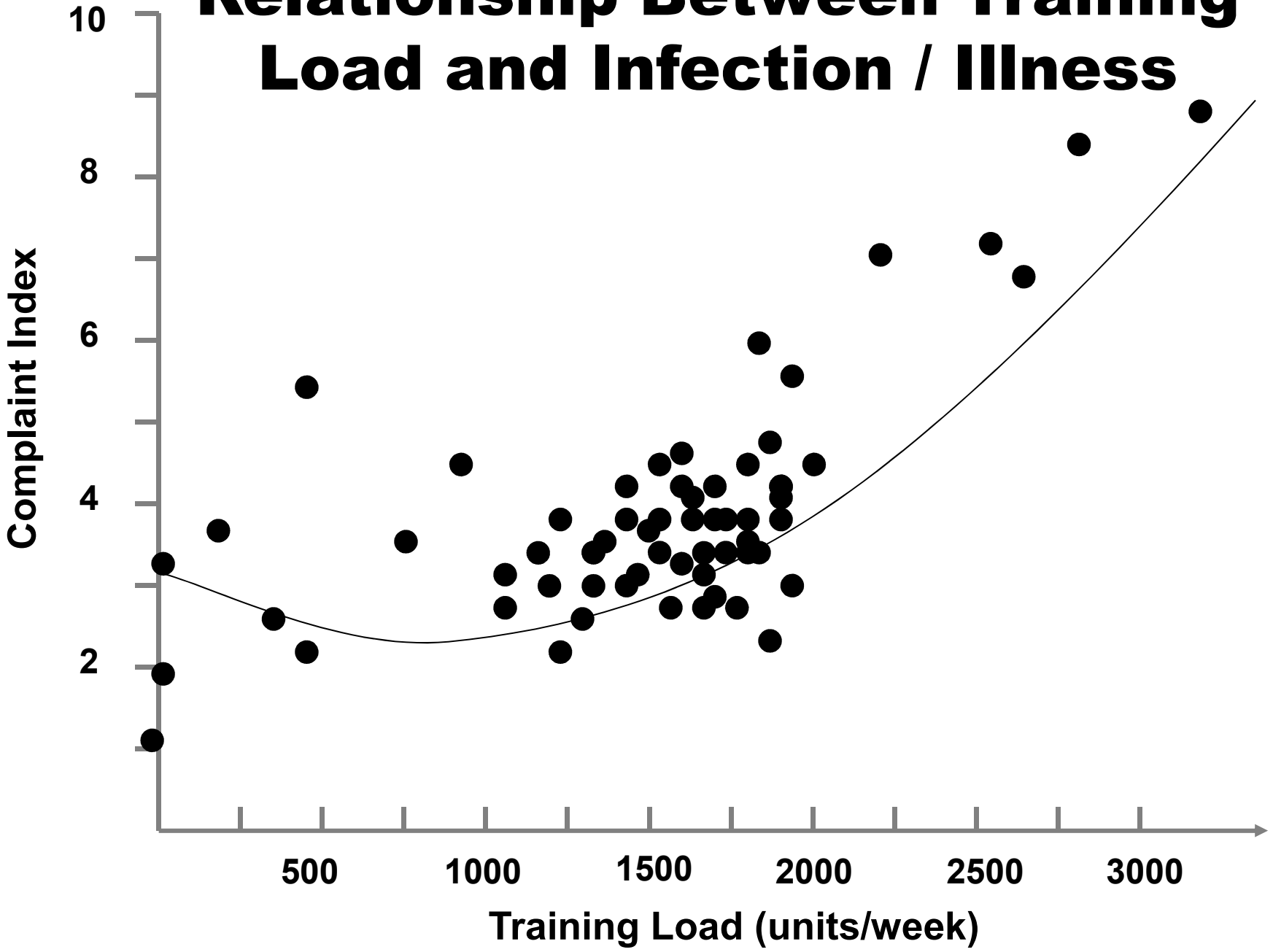
Muscle Damage Response

- Elevation in muscle proteins
  - LDH, CK, myoglobin, myosin heavy chain fragments
- Muscle damage activates immune system
- WBC increase to repair damaged fibres
- Stress hormone cortisol can suppress [WBC]
- This may prevent damage to muscles by the immune system
- However, may also increase risk of infection

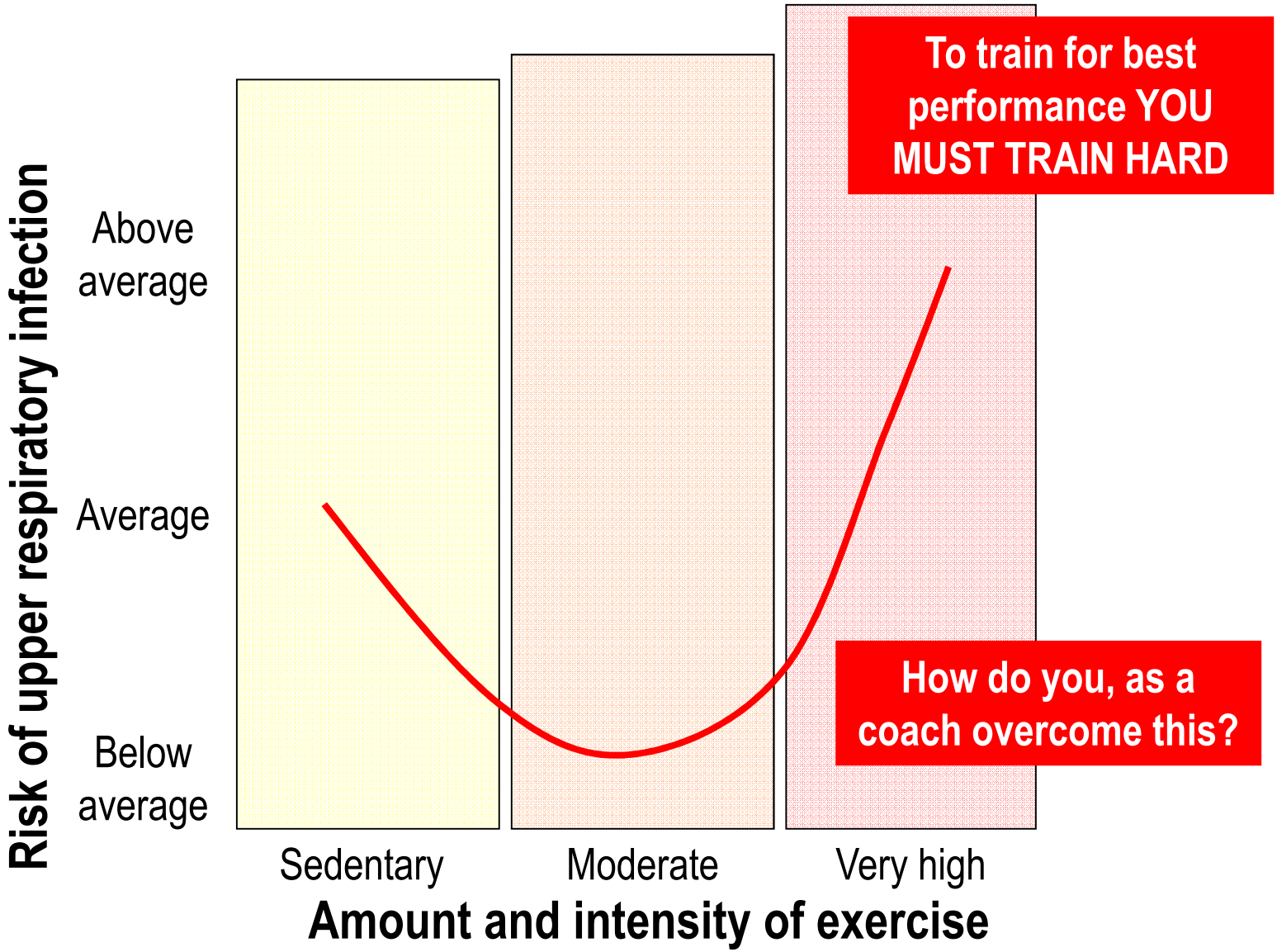
Muscle Damage-Illness Response

- Muscle damage decreases [muscle carbohydrate]
- Decreased glucose uptake into exercising muscle from the blood
- Increase in stiffness & soreness (*decreased performance*)
- Continual low [muscle glycogen] combined with heavy training and poor diet will lead to ↓ [plasma glutamine]
- Decreased immunity
- Increased risk of illness

Relationship Between Training Load and Infection / Illness



Training Volume & Risk Of Infection



Treatment of Overtraining

- Prevention the key: plan and control the training dose
- Periodisation [gradual, variety, sensible, plan!]
- Match diets to loads
- Plan and periodise recovery activities
- Athletes need to ‘listen to their bodies’
- Avoid rapid, increasing in training volume and intensity

Summary

- Fatigue is complex: it is a psychobiological phenomena
- Its development depends on the athletes, the environment and training.
- Fatigue is necessary for performance adaptation
- Understand signs and symptoms of acute and chronic fatigue
- Recognise the cause of fatigue for various sports

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Thank you

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