



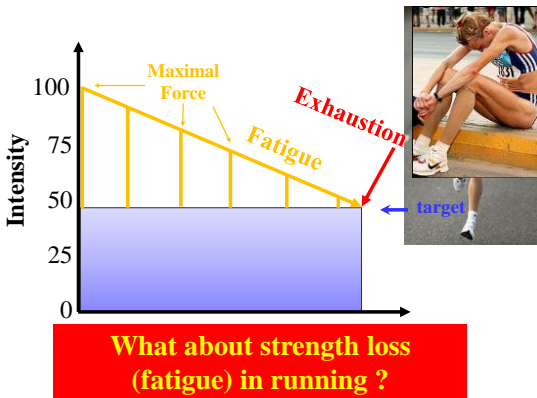
Guillaume Y Millet
Faculty of Kinesiology
Human Performance
Laboratory



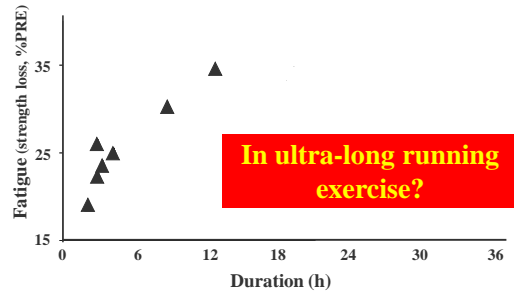
MEDICINE & SCIENCE IN
ULTRA-ENDURANCE SPORTS

Fatigue

Changes in (physical, mental) capabilities...
...leading to an increase of psychological/energy cost to perform an exercise
and/or to a decrease of maximal strength/power
(Bigland-Ritchie & Woods, 1984)...
...whether or not the task can be sustained.



Knee extensors fatigue in prolonged running



Millet and Lepers Sports Med 2004

Set of 3 experiments

1 : Lab

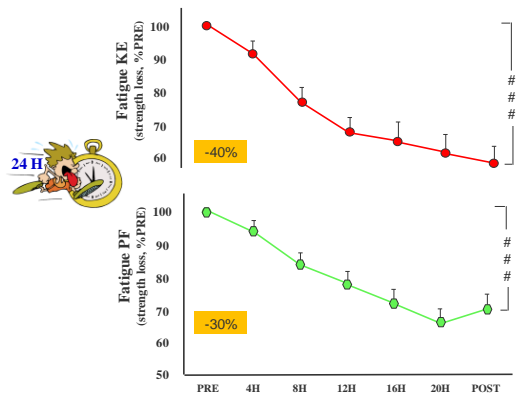
- 24 h treadmill

2007 (men)

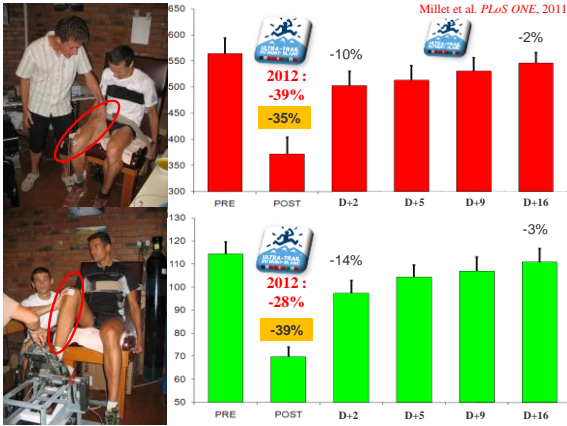
2 & 3 : Field

- race (UTMB)

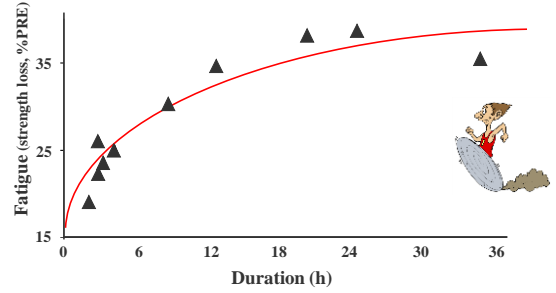
2009: 165 km / + 9000m (men)
2012: 105 km / + 5000m (men and women)



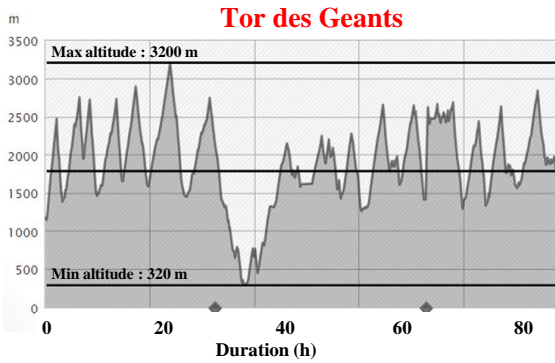
Martin et al. J Appl Physiol 2010



Knee extensors fatigue in prolonged running

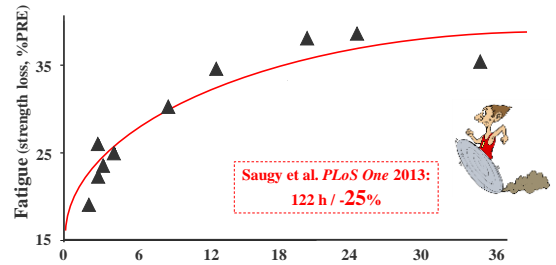


Millet Sports Med 2011



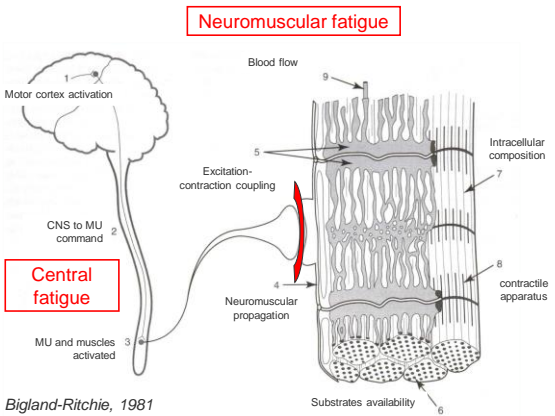
335 km / 24000 m D+

Knee extensors fatigue in prolonged running



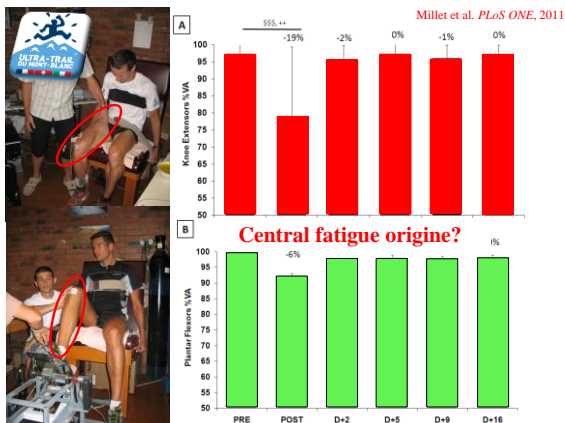
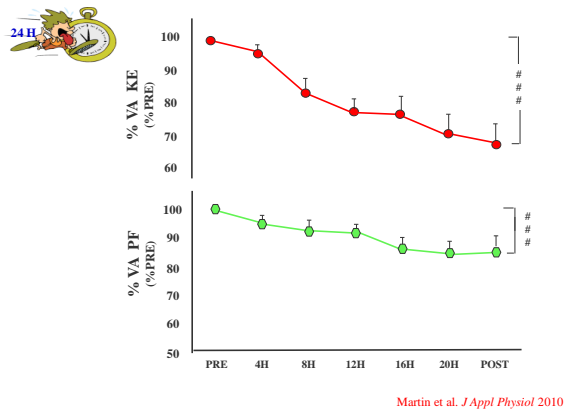
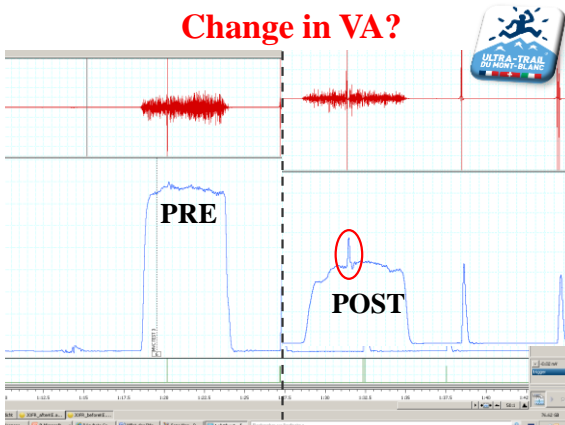
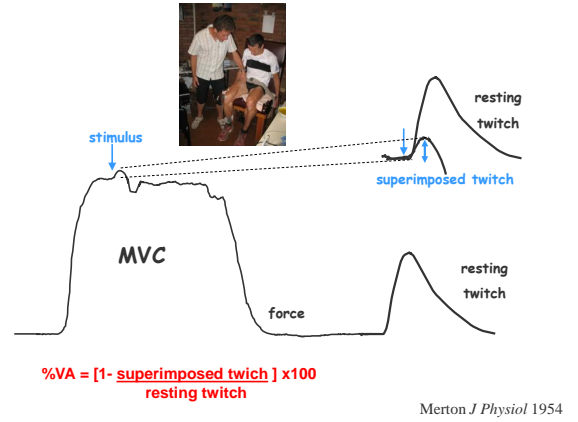
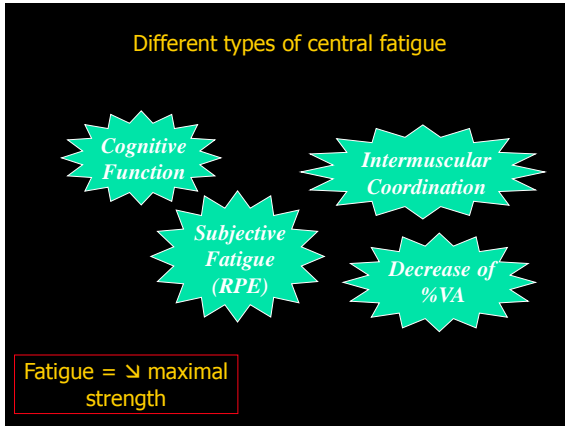
Millet Sports Med 2011

Why does maximal force decrease in ultramarathon?



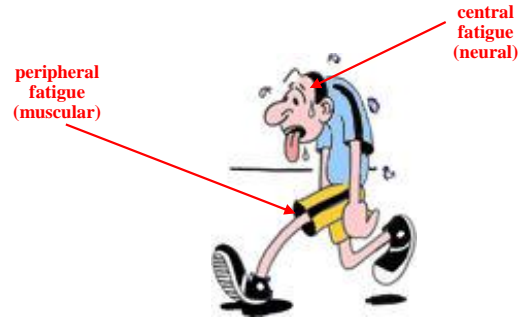
Central fatigue?



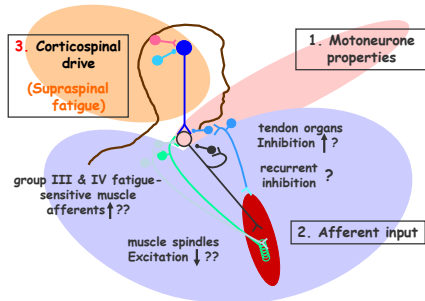


Fatigue origin?

Not as simple as that...



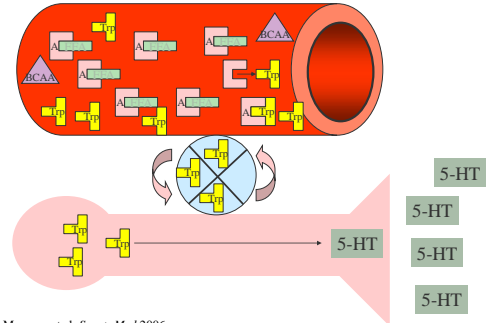
Potential sites of central fatigue



Adapted from Janet Taylor, Prince of Wales Medical Research Institute

Prolonged exercise: serotonin hypothesis

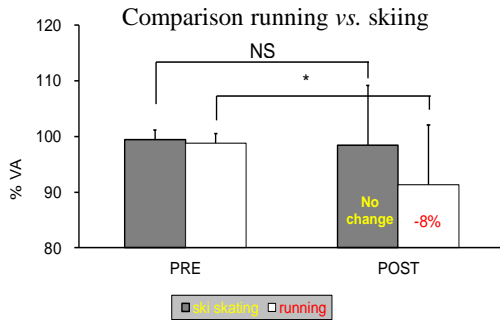
$$= \uparrow \text{Trp} / \text{BCAA}$$



For a review: Meeusen et al. *Sports Med* 2006

Comparison running vs. cycling

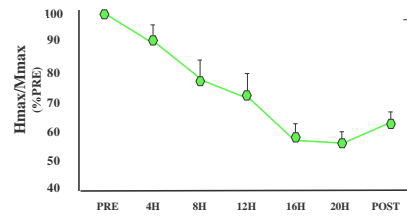
Millet et al. *Int J Sports Med* 2003; Lepers et al. *J Appl Physiol* 2002



Millet et al. *Can J Appl Physiol* 2003; Millet et al. *J Appl Physiol* 2003



Hoffmann's reflex

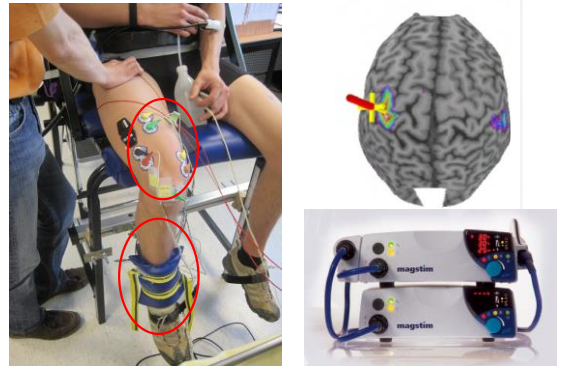


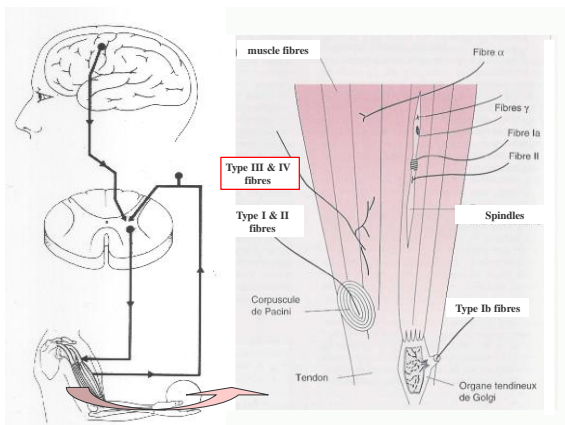
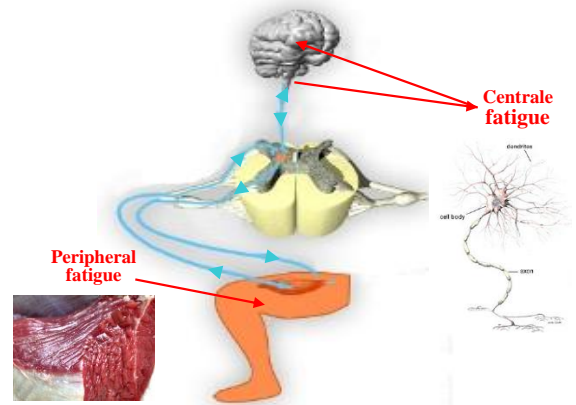
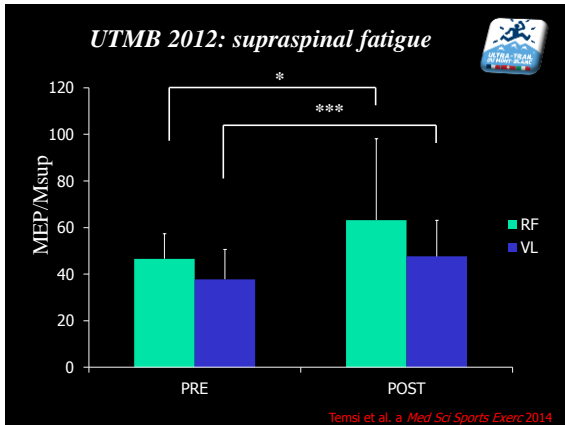
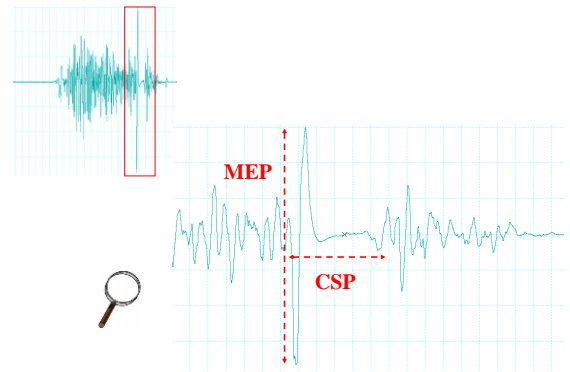
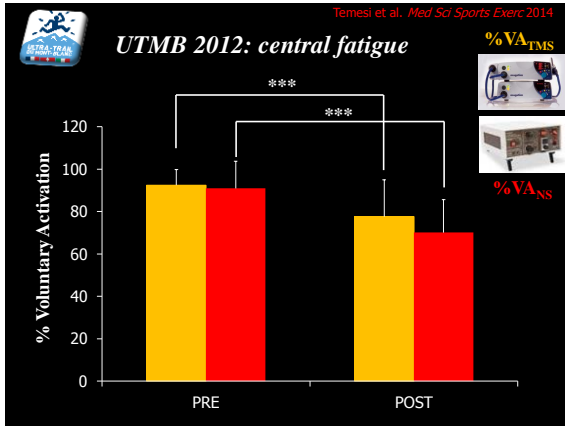
Could be Mn excitability or pre-synaptic inhibition \Rightarrow large central fatigue due to prolonged runs is **not** (totally) due to CNS biochemical changes.

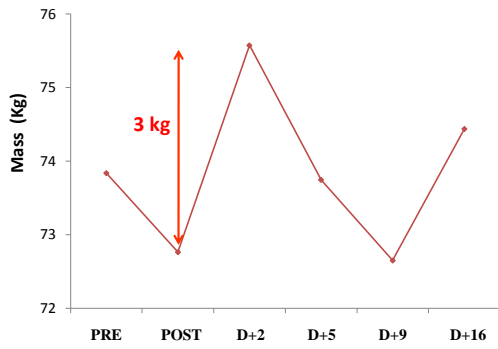
UTMB 2012: Transcranial Magnetic Stimulation



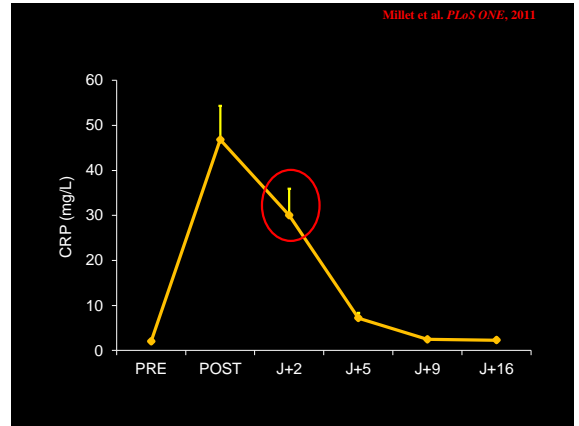
UTMB 2012: Transcranial Magnetic Stimulation



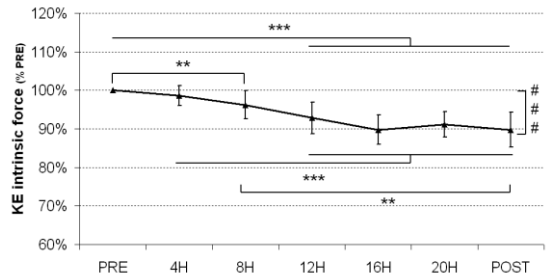
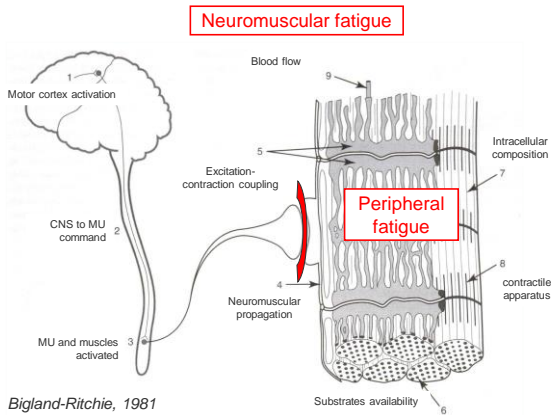




Millet et al. *PLoS ONE* 2011

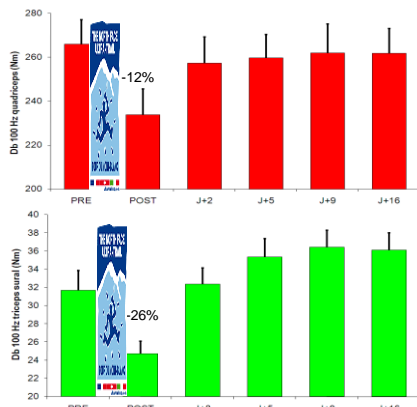


Millet et al. *PLoS ONE*, 2011

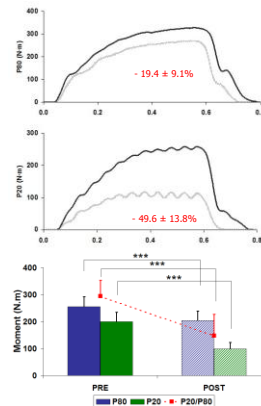


Intrinsic force: ~ -10%

Martin et al. *J Appl Physiol* 2010



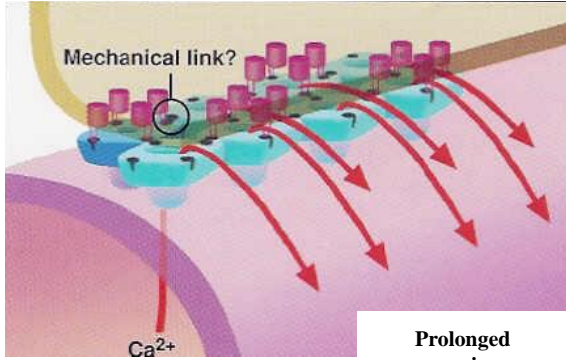
Millet et al. *PLoS ONE* 2011



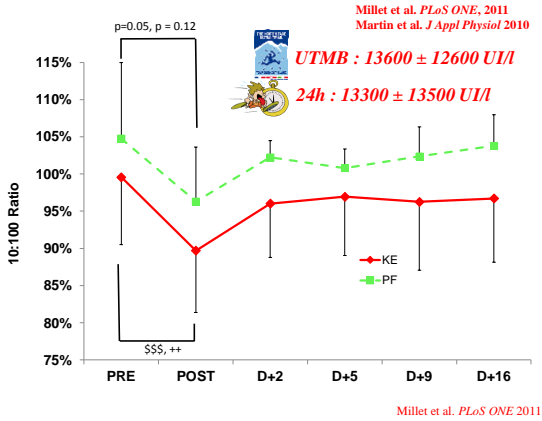
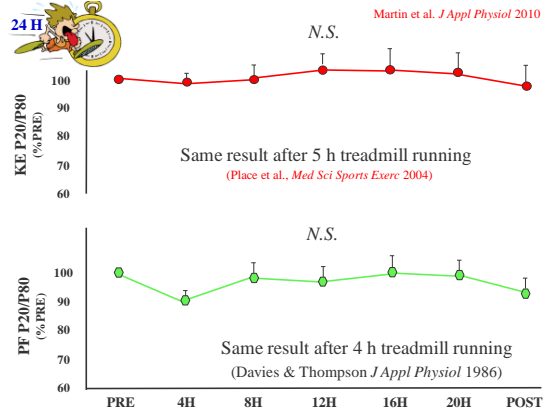
Low frequency fatigue

E-C coupling failure

Martin et al. *Med Sci Sports Exerc* 2004



E-C Failure (Ingalls et al. 1998)



Women vs men?

Temesi et al. *Med Sci Sports Exerc* in revision

