

Neuromuscular fatigue and performance in ultra-trail running

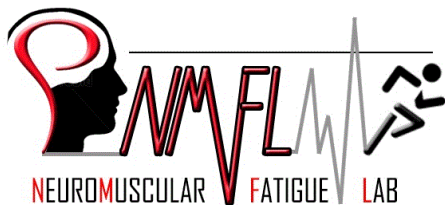
6th

International Congress

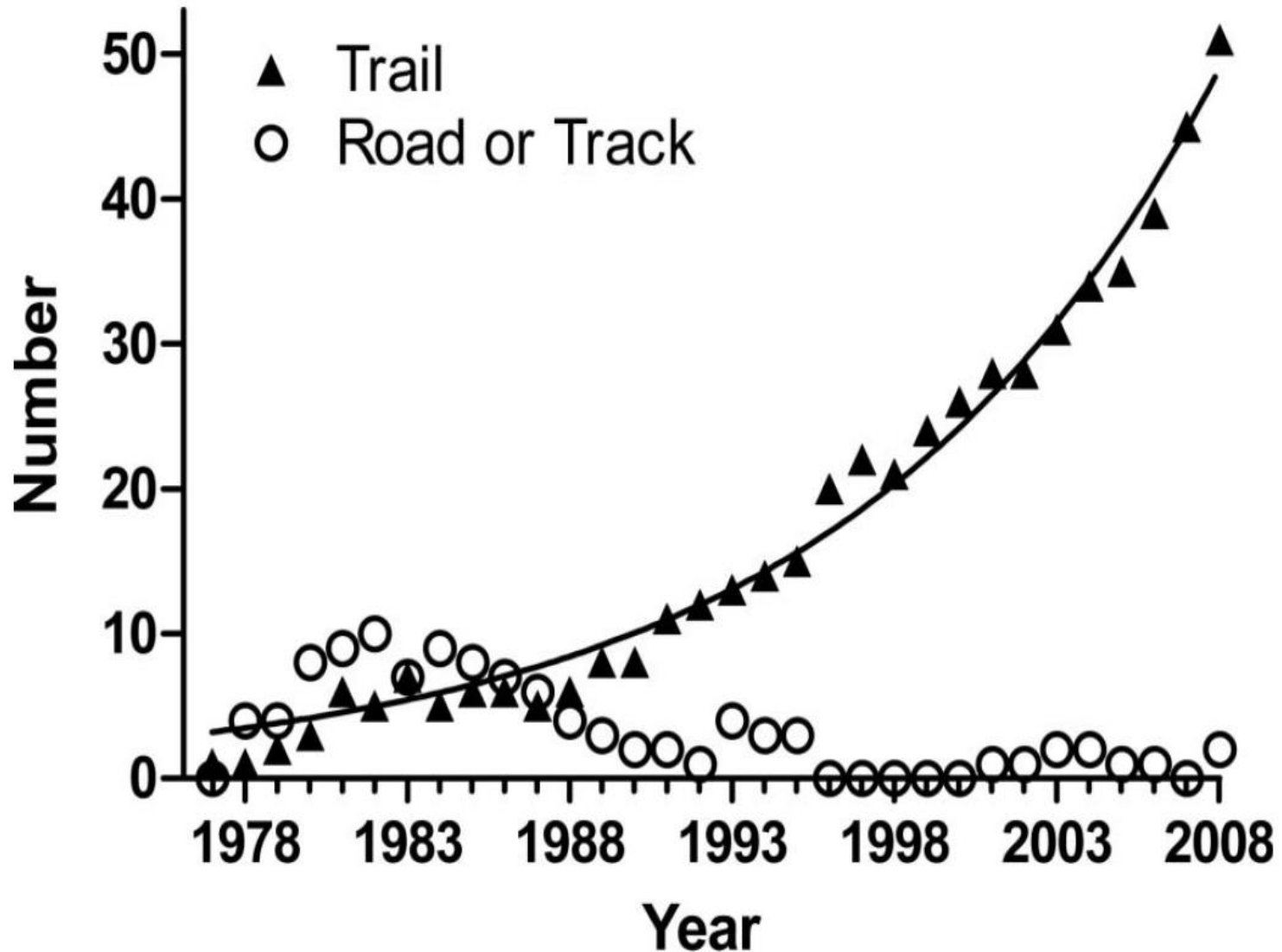
**Mountain,
Sport & Health**

updating study and research
from laboratory to field

Guillaume Millet



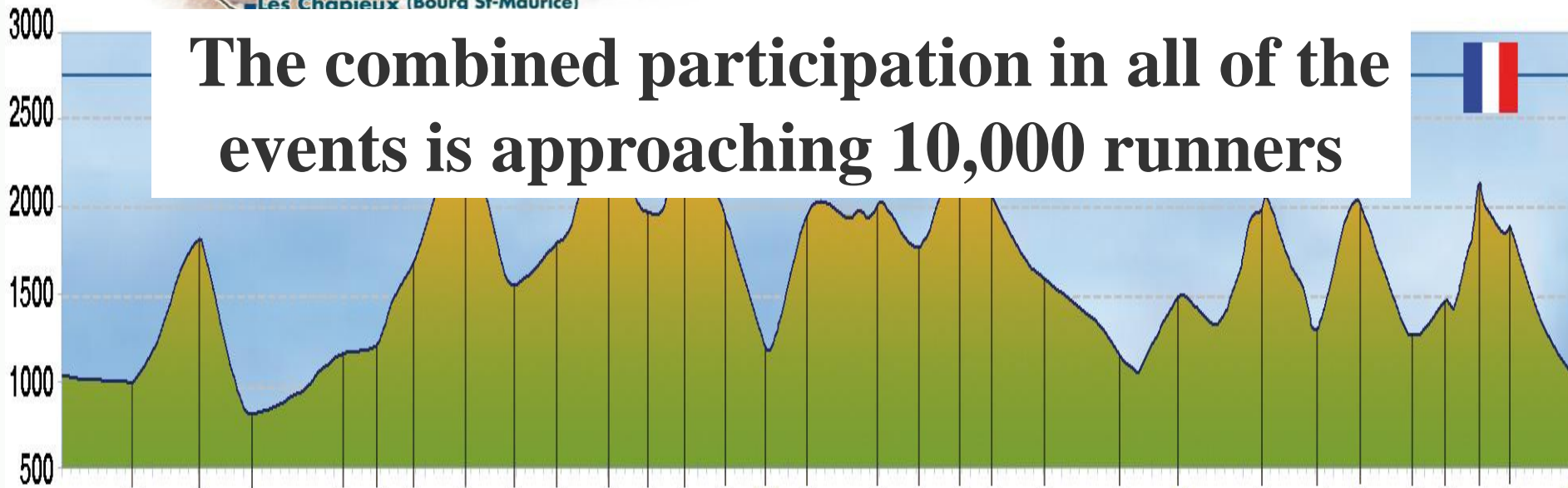
Same tendency in Europe



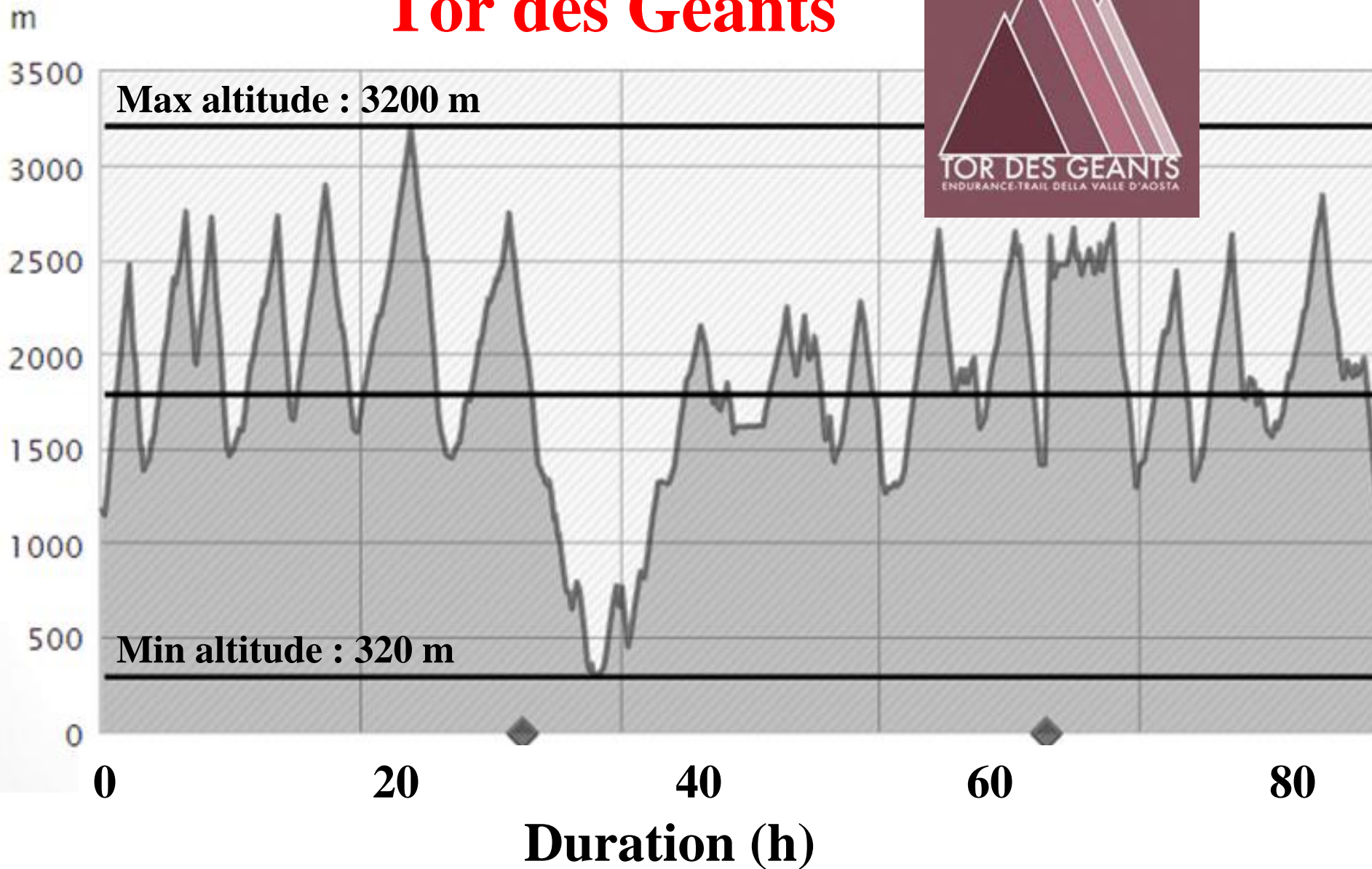


166 km / D+: 9500m

The combined participation in all of the events is approaching 10,000 runners

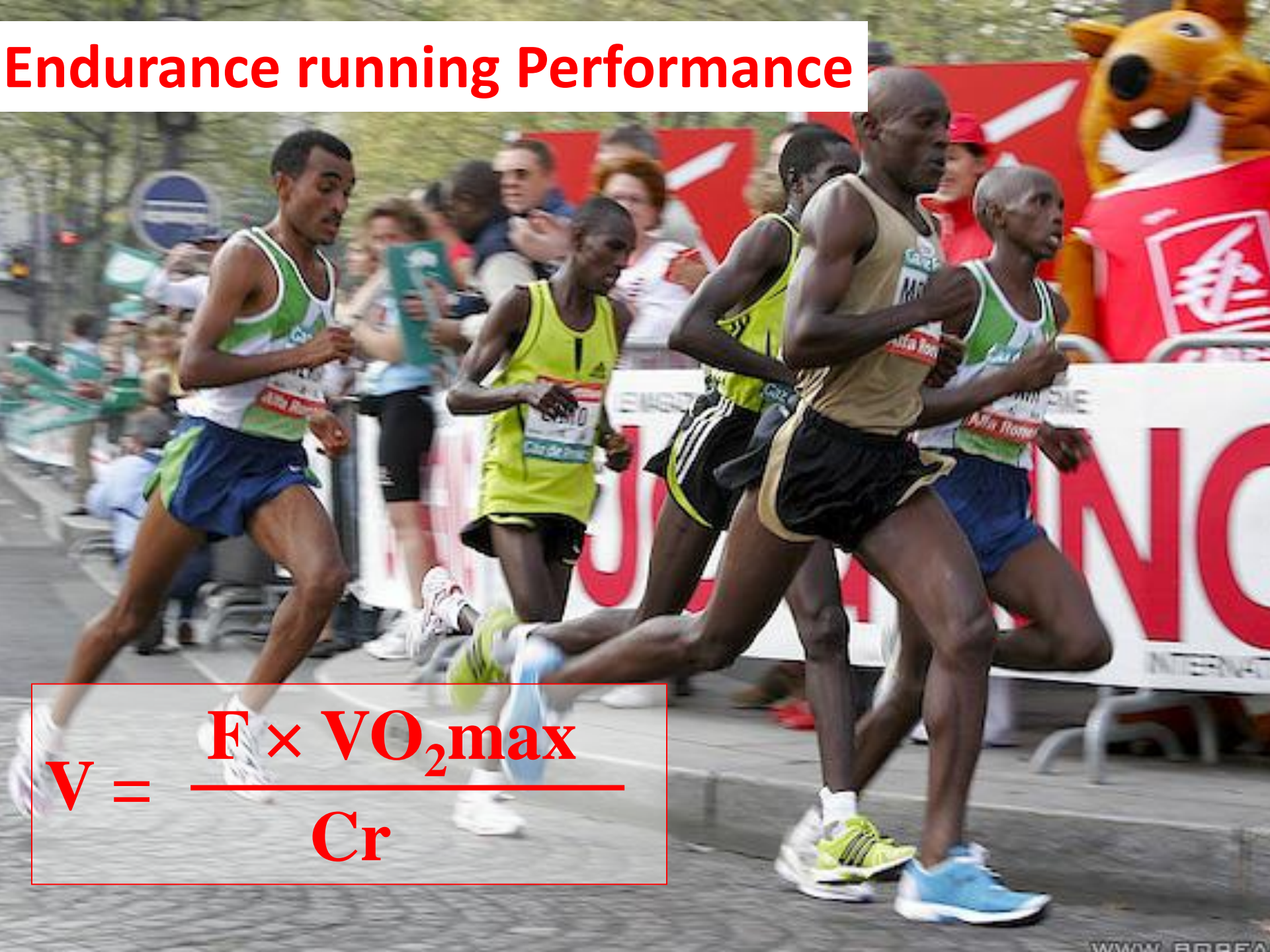


Tor des Geants

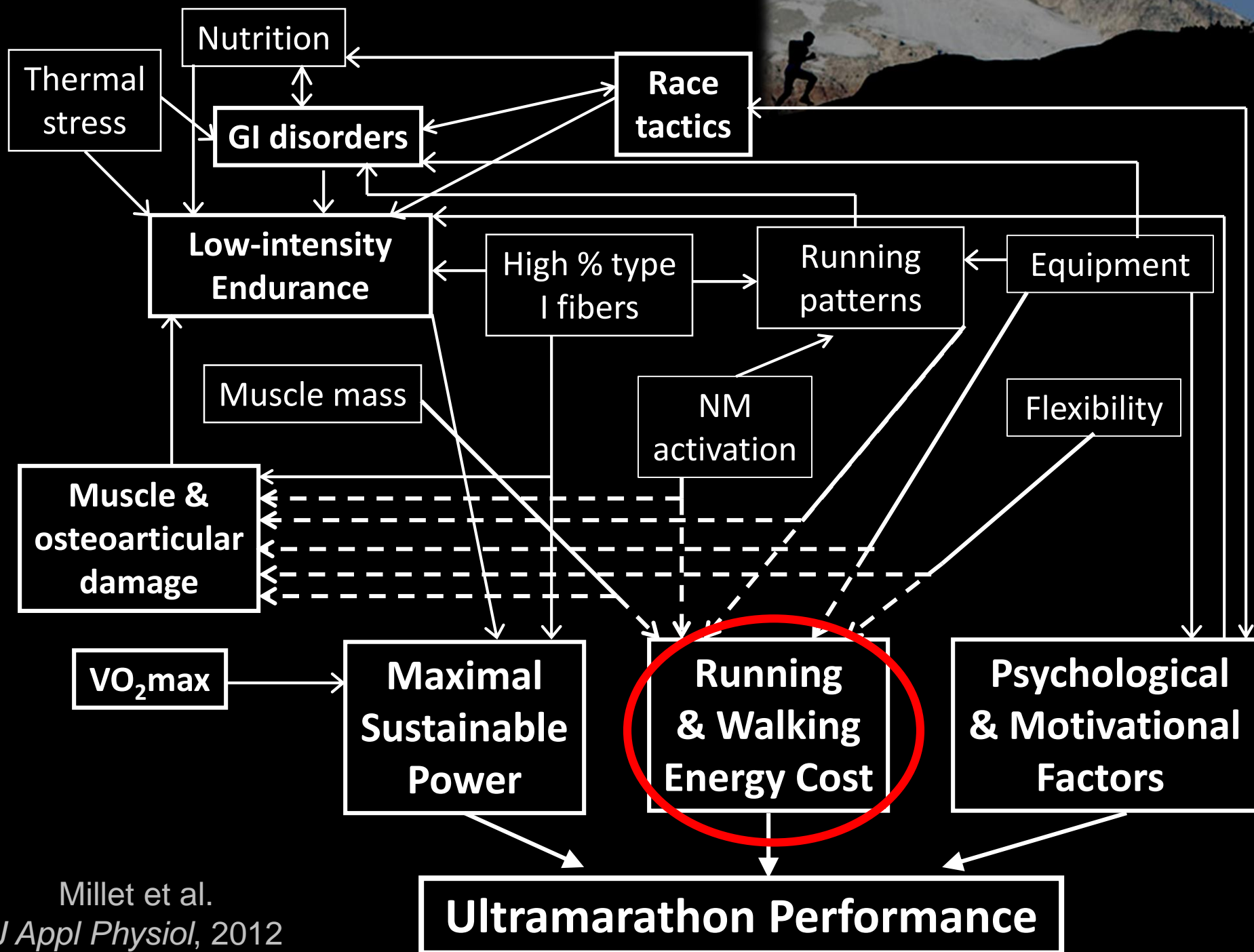


335 km / 24000 m D+

Endurance running Performance



$$V = \frac{F \times VO_2\text{max}}{Cr}$$



≤ marathon

Ultra-marathon

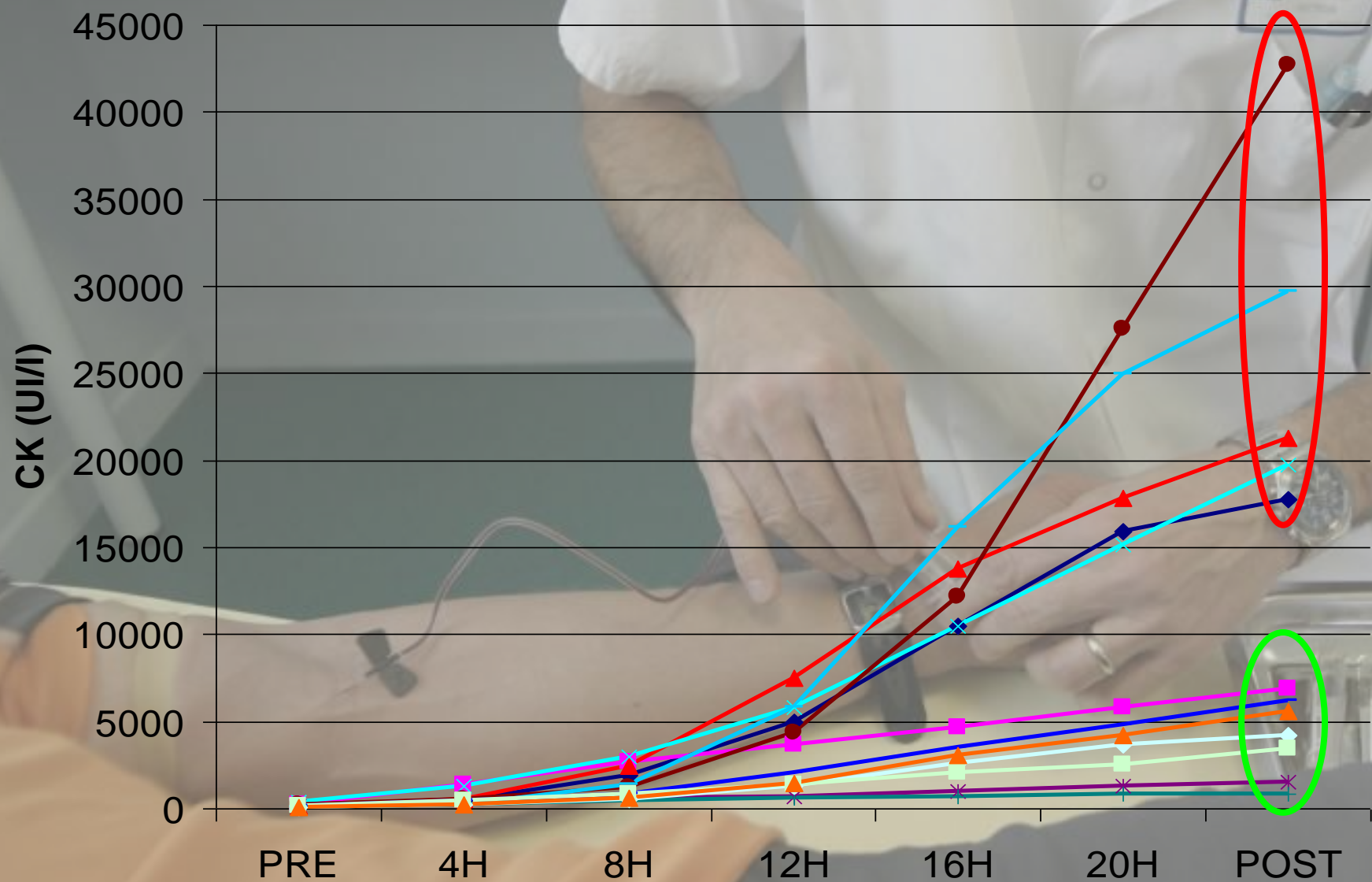
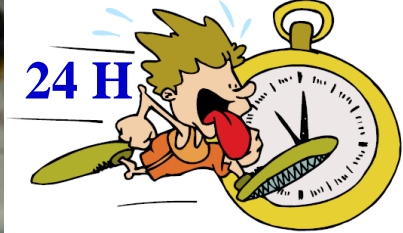
Endurance

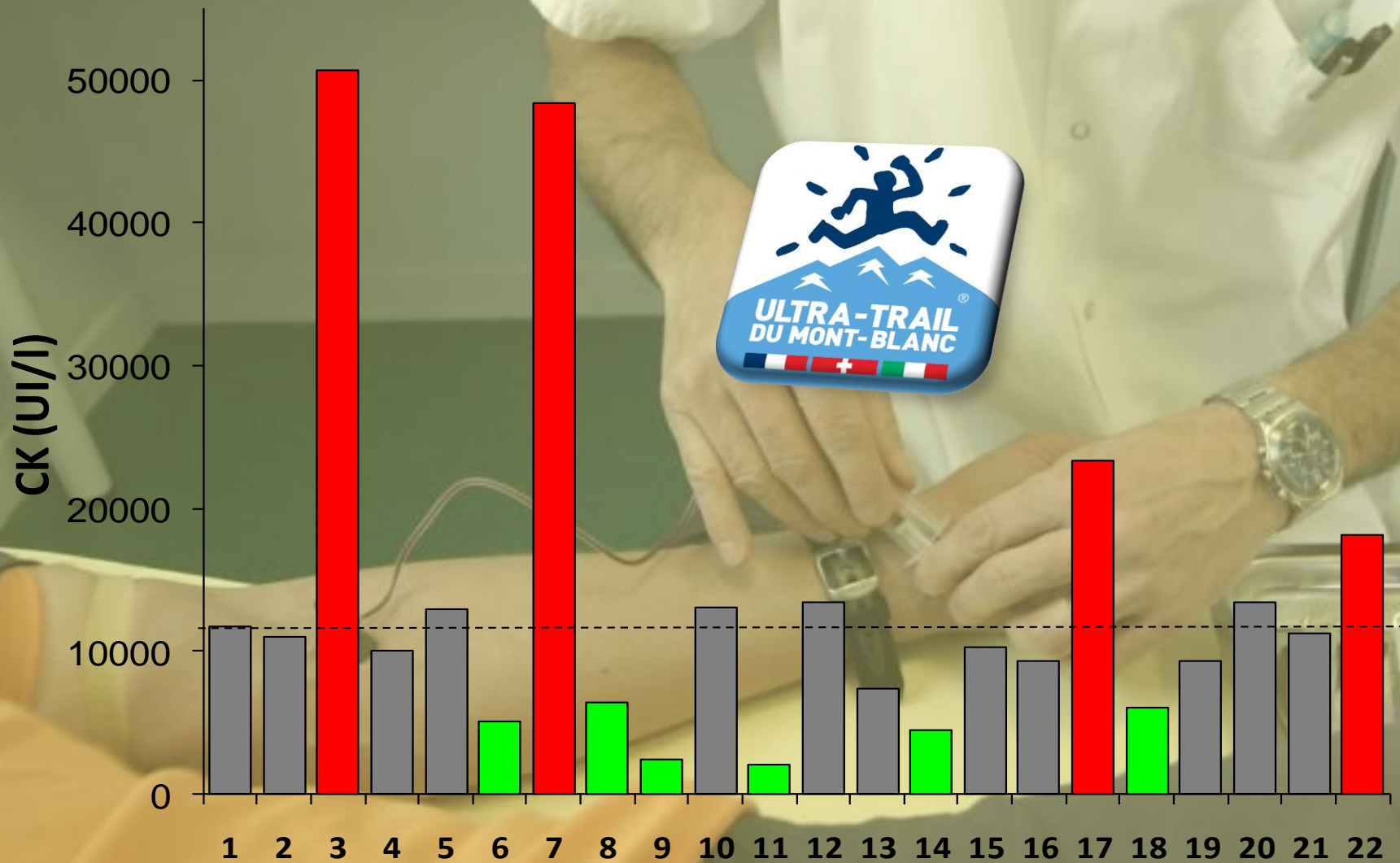
High intensity

- Glycogen stores
- Anaerobic Threshold

Low intensity

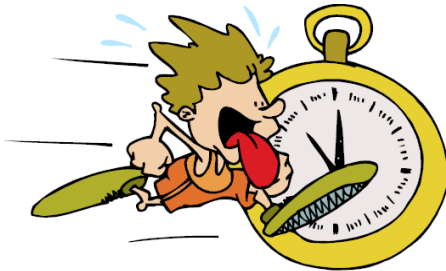
- Ability to eat without nausea or GI symptoms
- Resistance to muscle & joint damage.







UTMB : 13,600 \pm 12,600 UI/l



24h : 13,300 \pm 13,500 UI/l

≤ marathon

Ultra-marathon

Endurance

High intensity

Low intensity

- Glycogen stores
- Anaerobic Threshold

- Ability to eat without nausea or GI symptoms

- Resistance to muscle & joint damage.

Energy

Economy

Leg tissue

Energy \longleftrightarrow **Economy** \longleftrightarrow **Leg tissue**

Pref. stride frequency \longleftrightarrow **Higher stride frequency**

Fore/mid foot strike \longleftrightarrow **Rearfoot strike**

Minimalist shoes \longleftrightarrow **Protective shoes**

Without pole \longleftrightarrow **With poles**

Less flexible \longleftrightarrow **More flexible**

Low muscle mass \longleftrightarrow **Higher muscle mass**



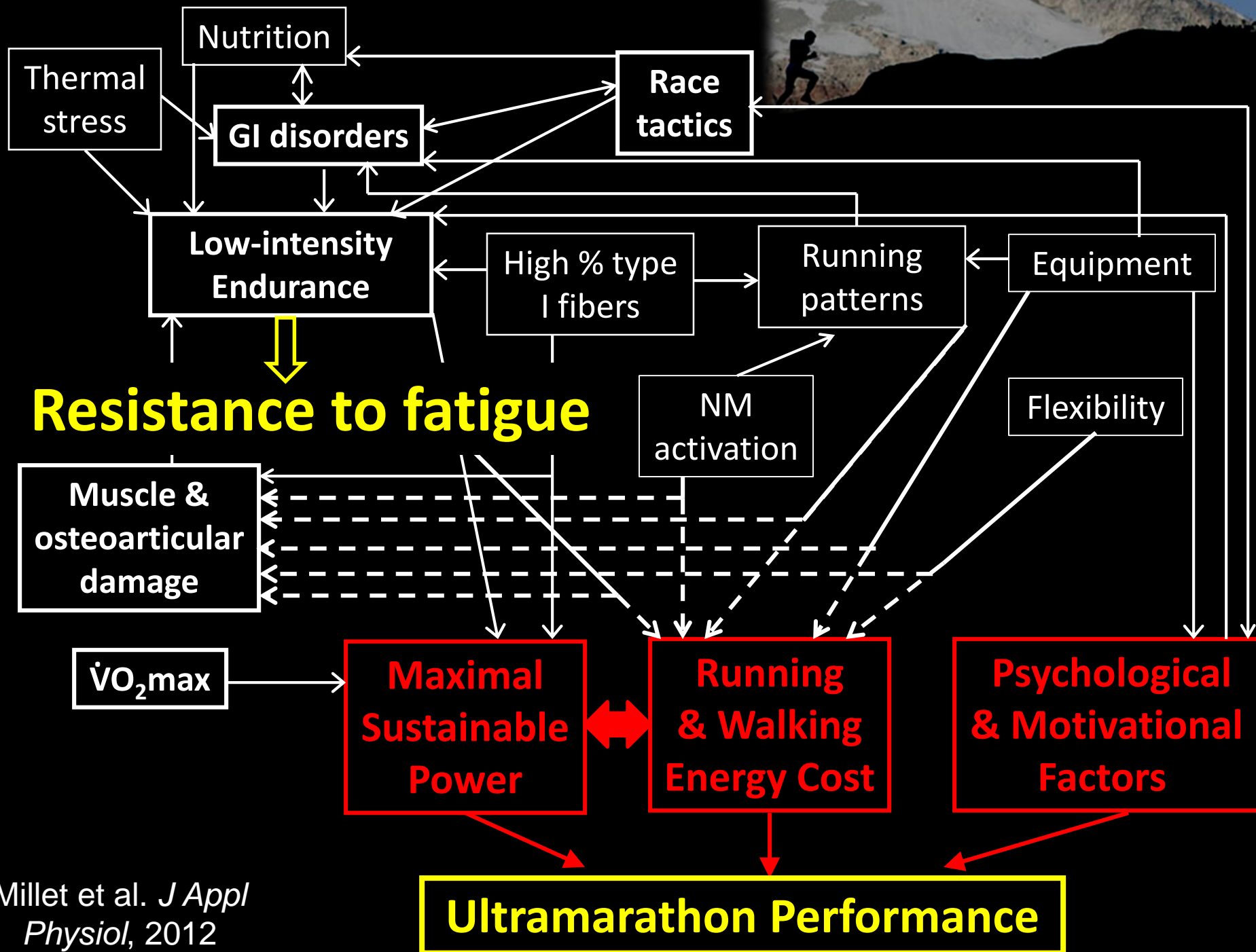
VIEWPOINT |

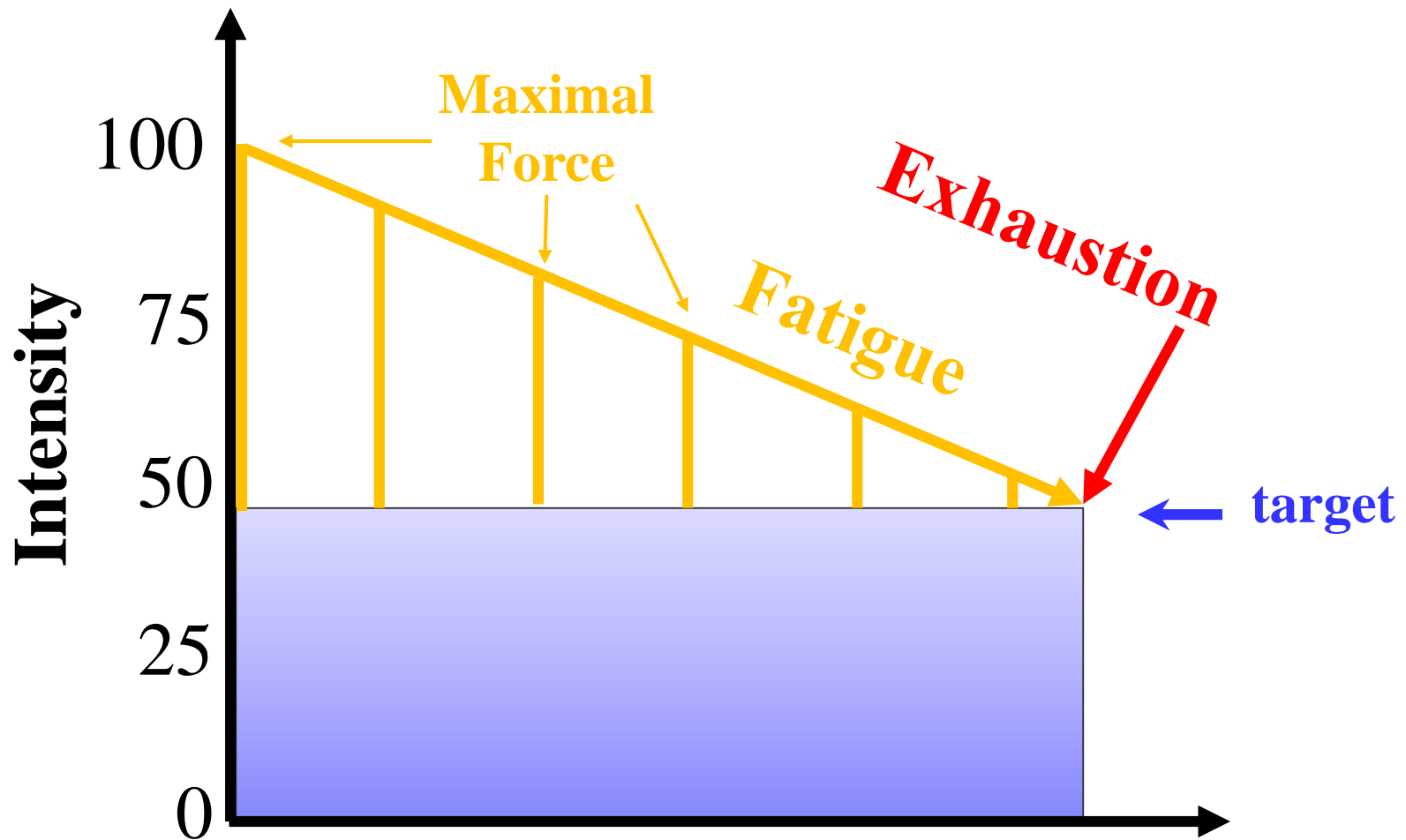
Sacrificing economy to improve running performance—a reality in the ultramarathon?

G. Y. Millet,¹ M. D. Hoffman,² and J. B. Morin¹

¹*Université de Lyon, Saint-Etienne, France; and* ²*Department of Veterans Affairs, Northern California Health Care System and University of California Davis Medical Center, Sacramento, California*

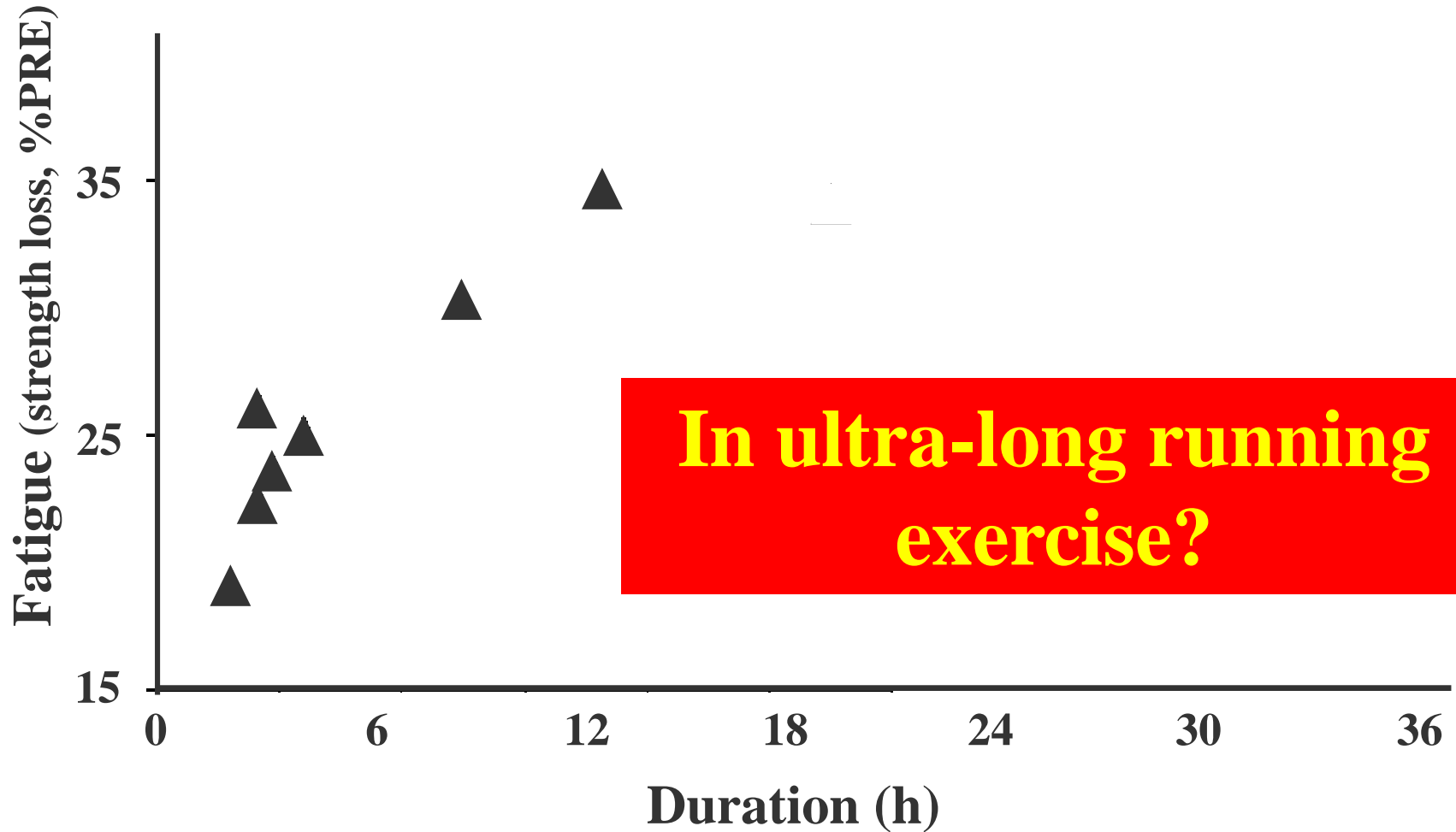
Submitted 4 January 2012; accepted in final form 2 April 2012

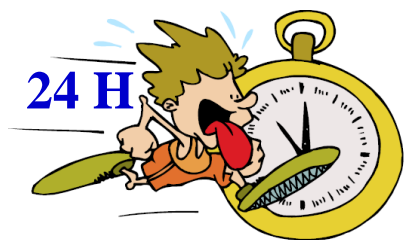




**What about strength loss
(fatigue) in running ?**

Knee extensors fatigue in prolonged running





Fatigue KE
(strength loss, %PRE)

100
90
80
70
60

-40%

#

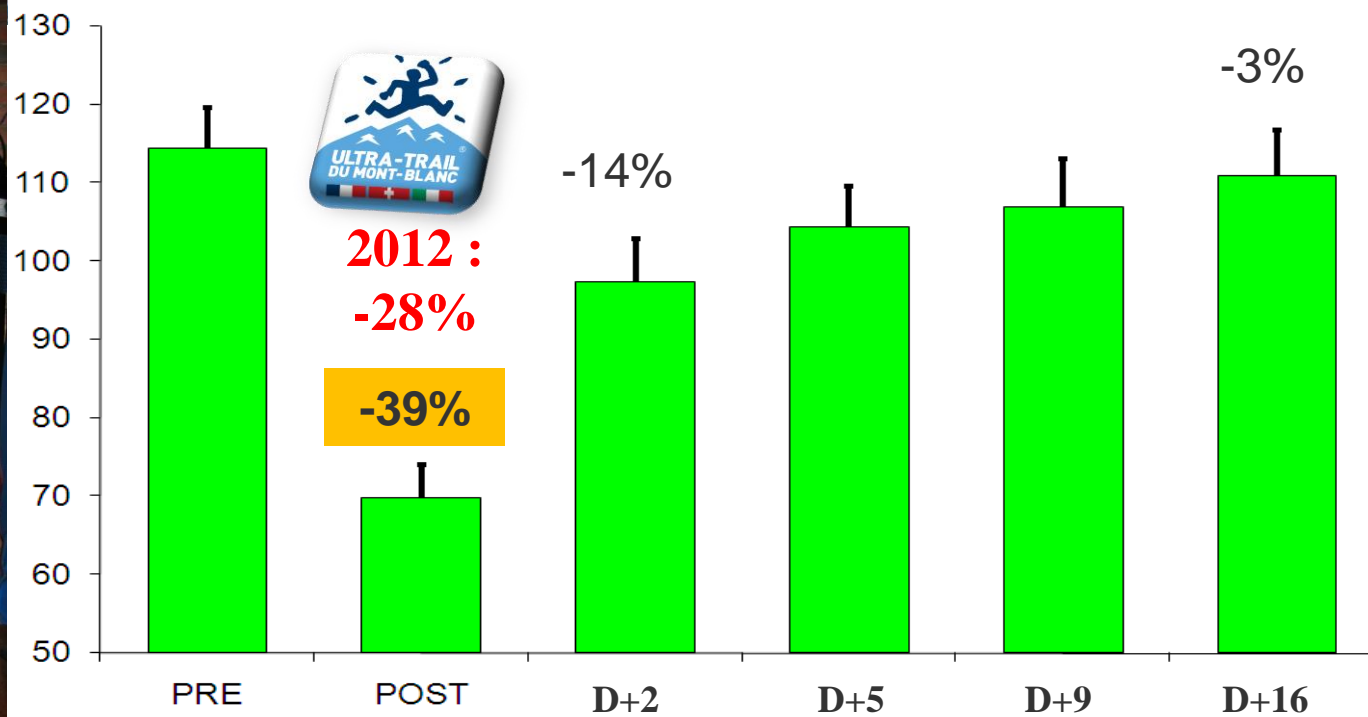
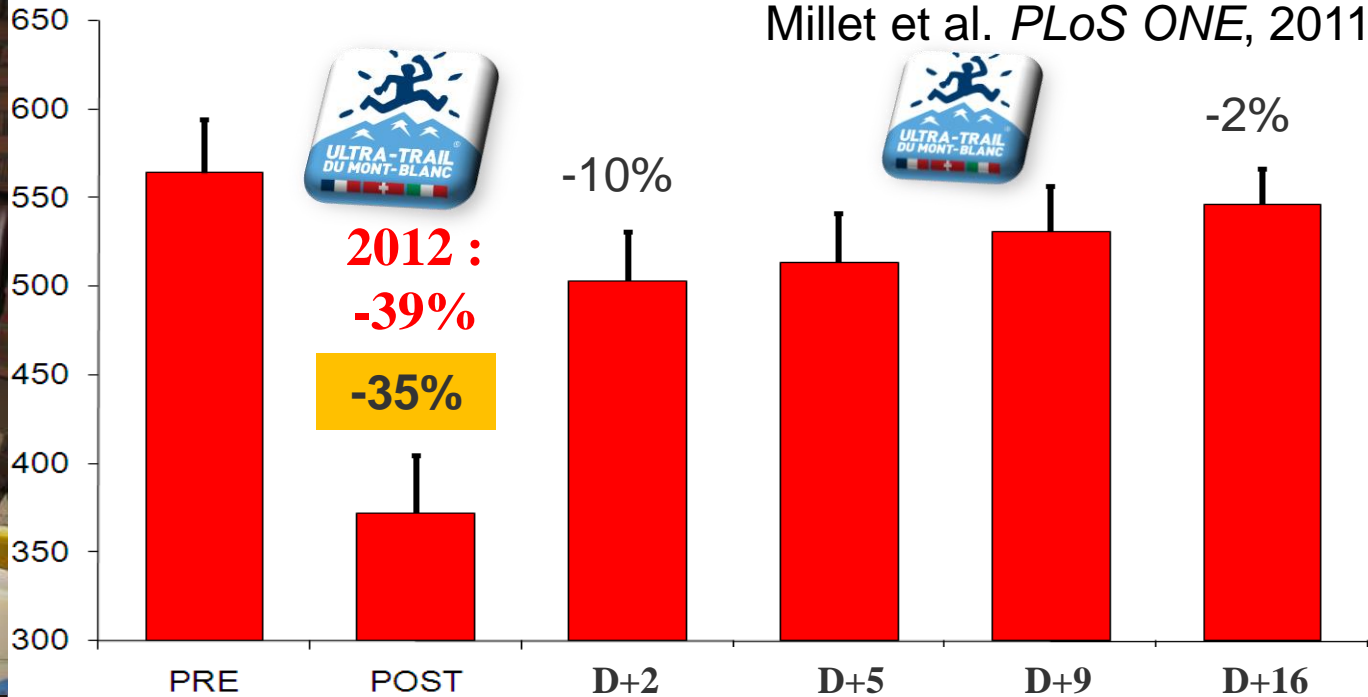
Fatigue PF
(strength loss, %PRE)

100
90
80
70
60
50

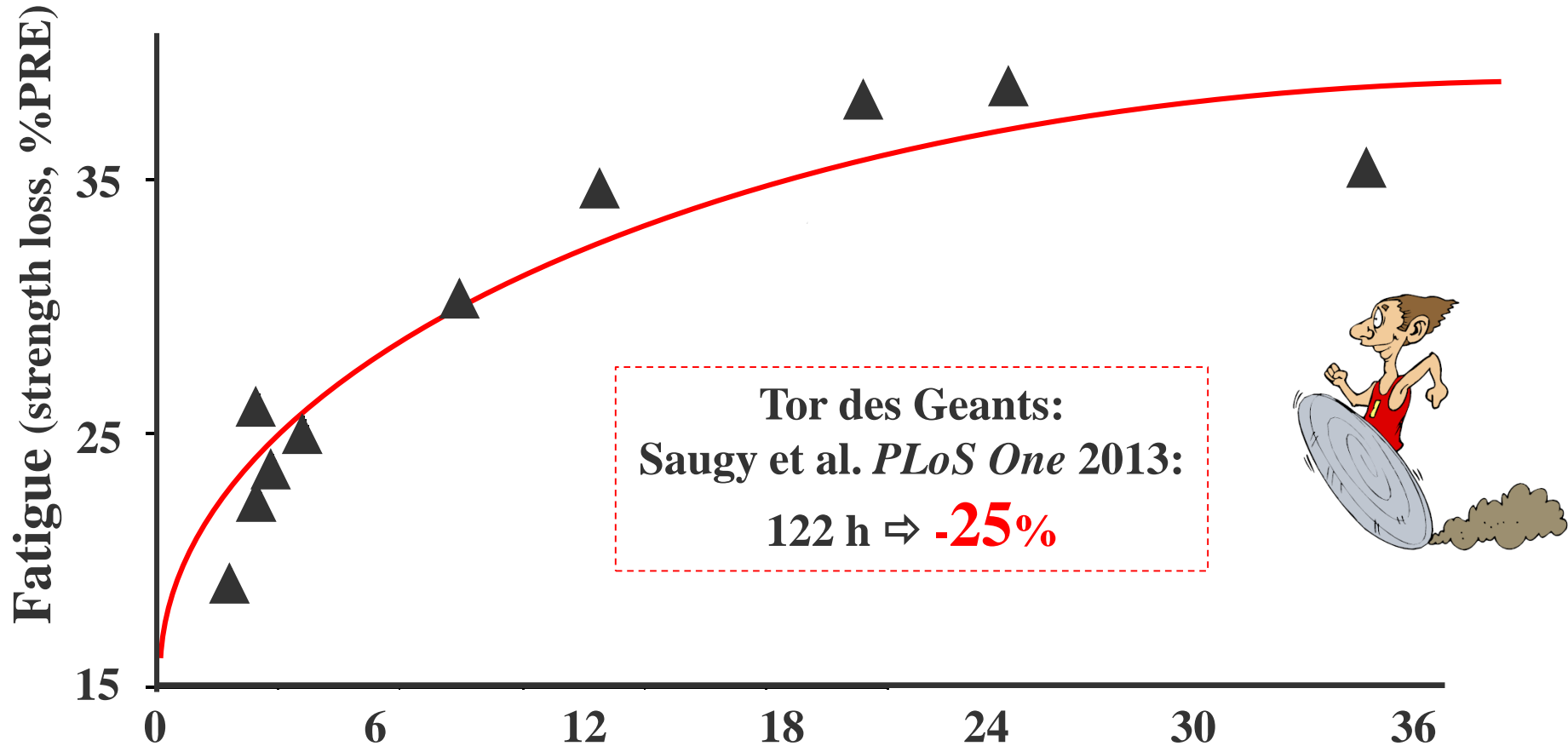
-30%

#

PRE 4H 8H 12H 16H 20H POST

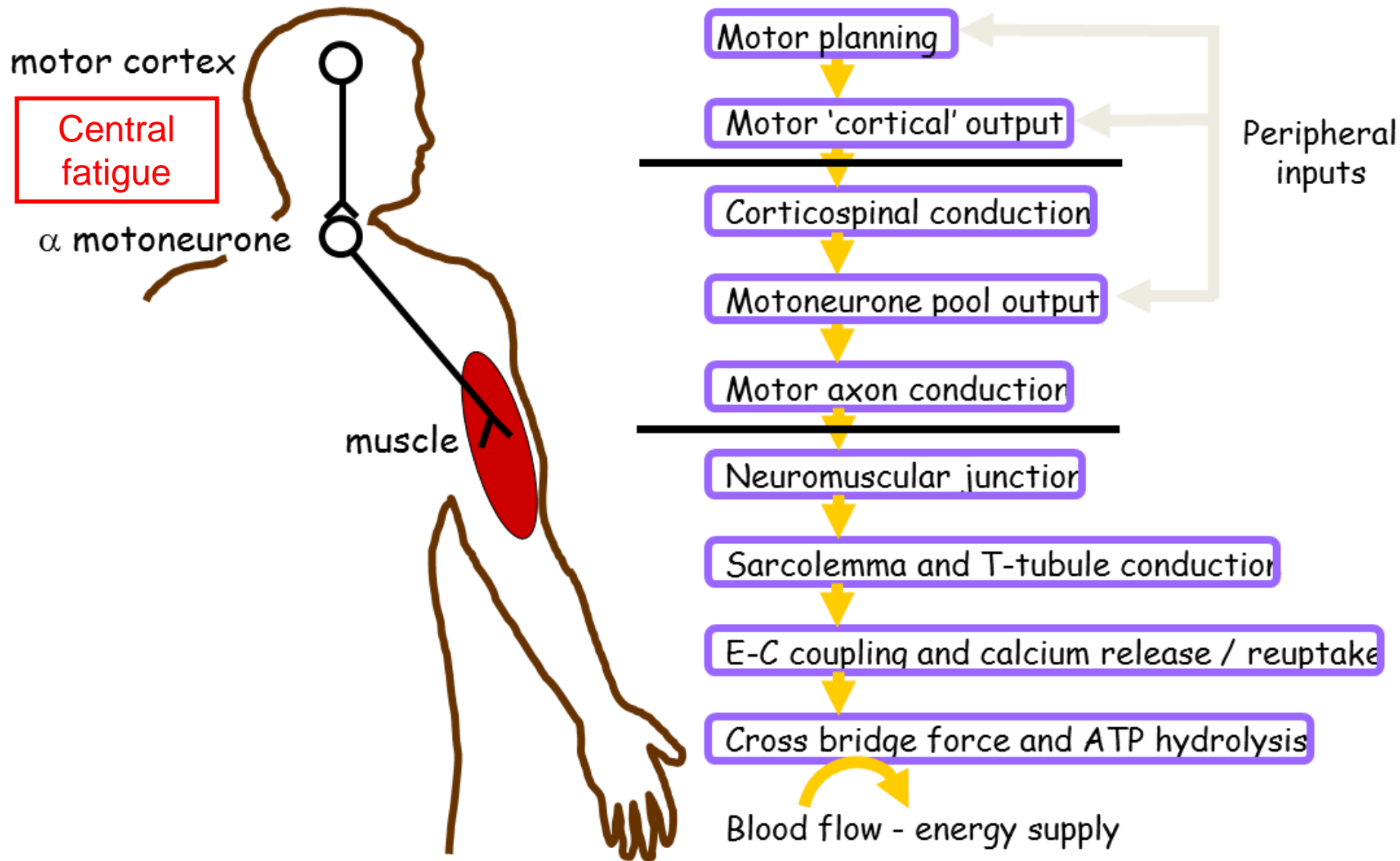


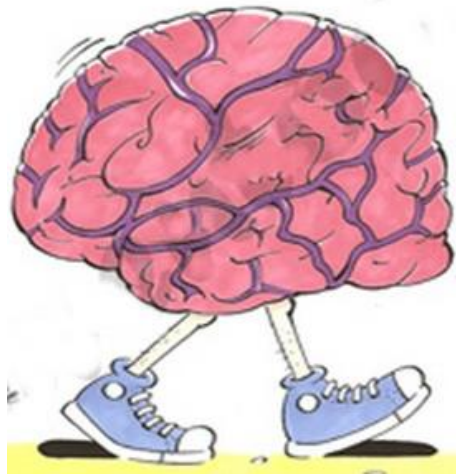
Knee extensors fatigue in prolonged running



Why does maximal force decrease in ultramarathon?

Potential reasons for NM fatigue





stimulus



superimposed twitch



resting
twitch

MVC

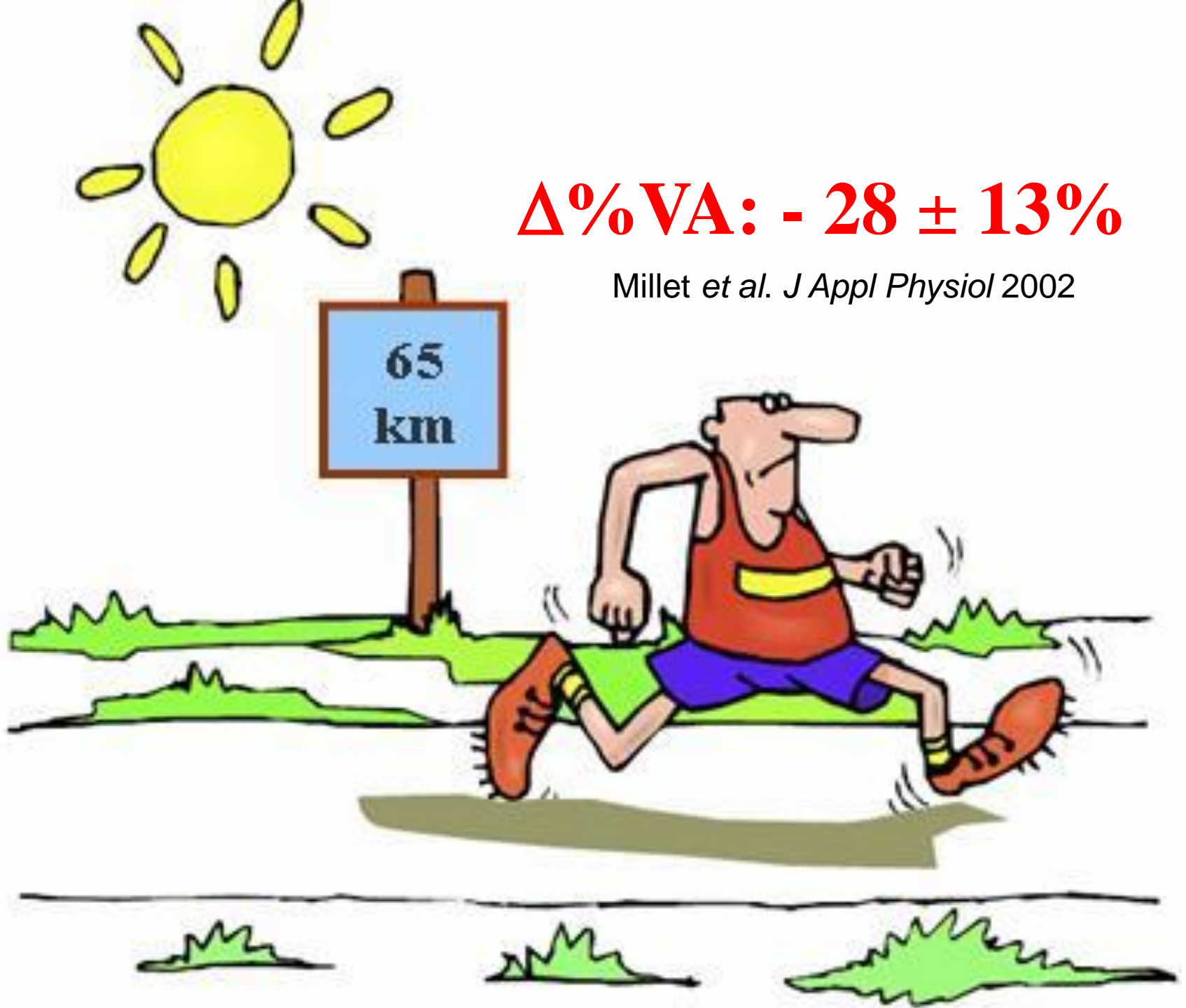
force

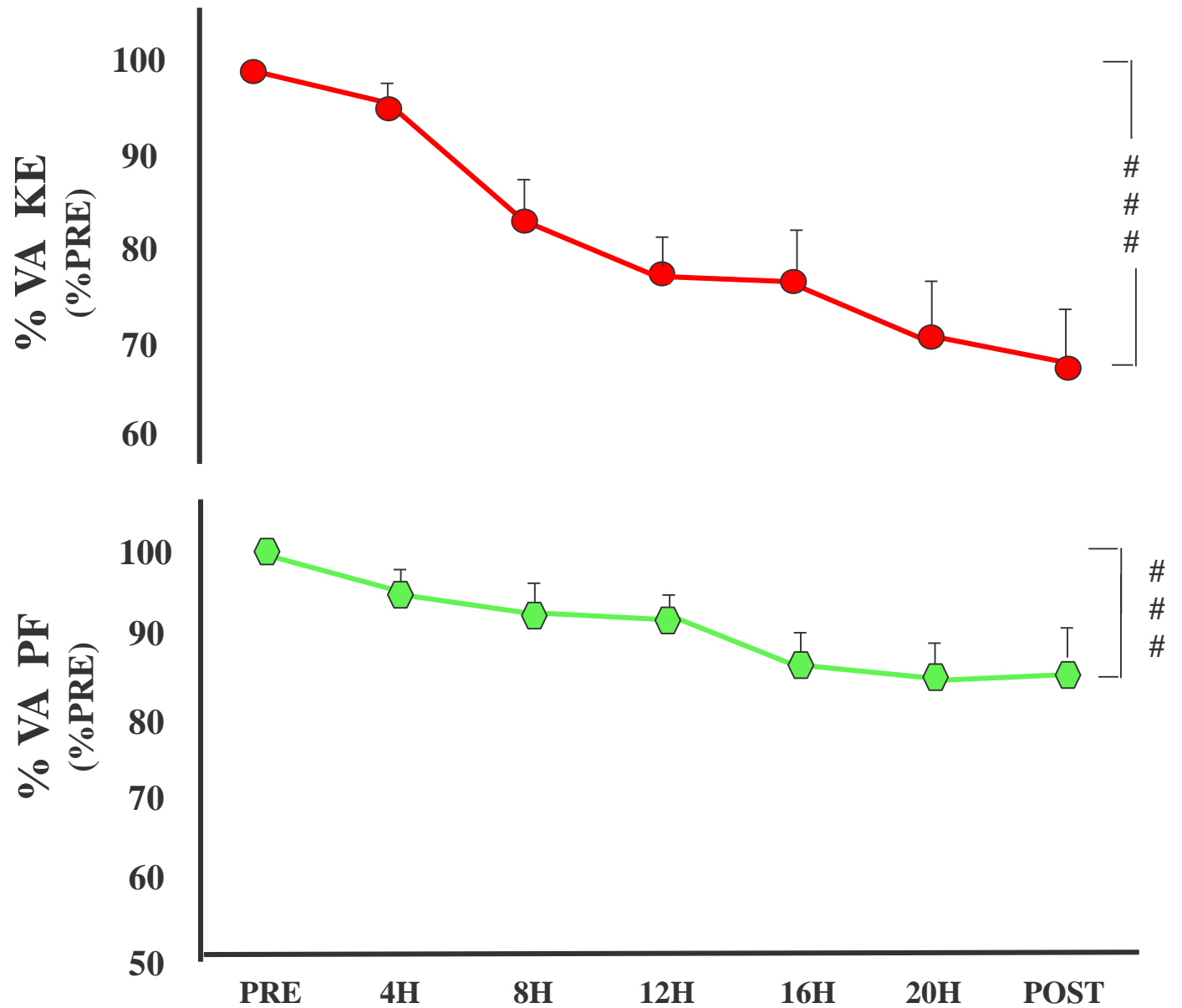
resting
twitch

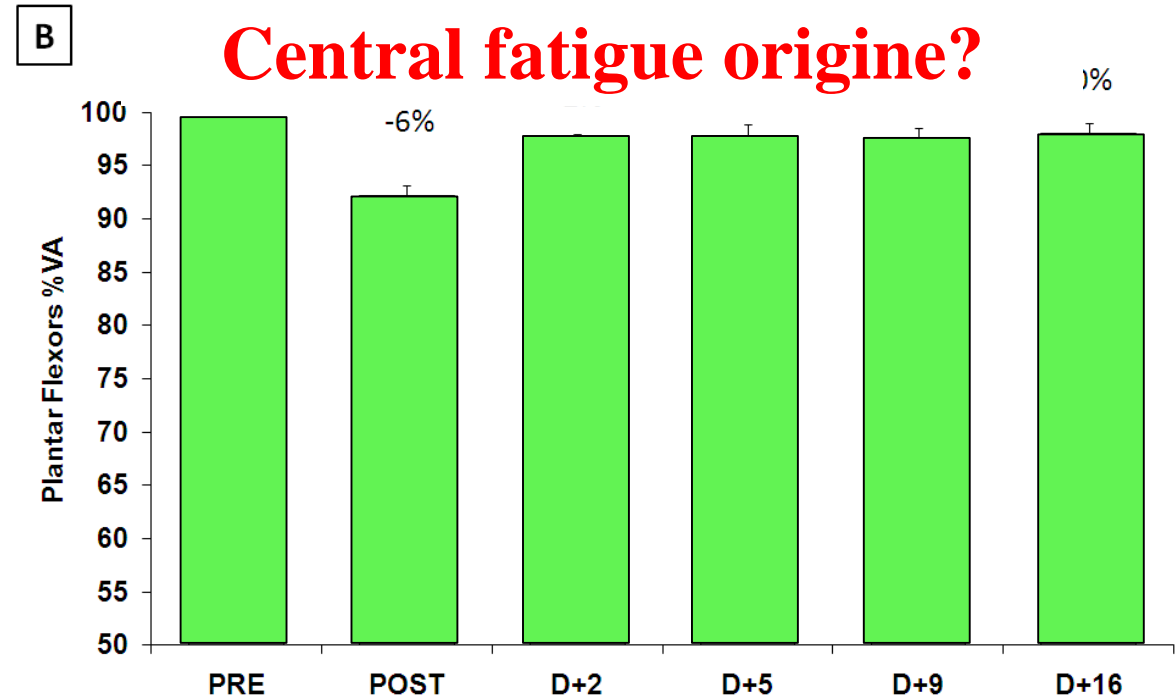
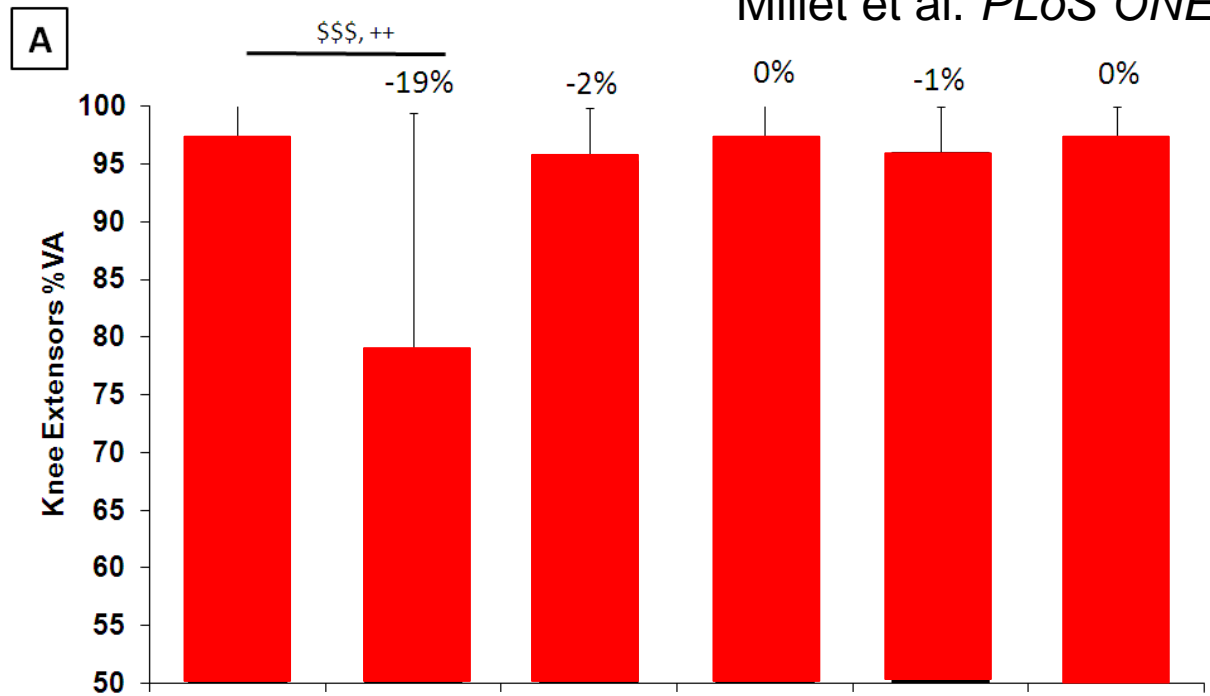
$$\%VA = \left[1 - \frac{\text{superimposed twitch}}{\text{resting twitch}} \right] \times 100$$

$\Delta\%VA: -28 \pm 13\%$

Millet et al. *J Appl Physiol* 2002







Fatigue origin?

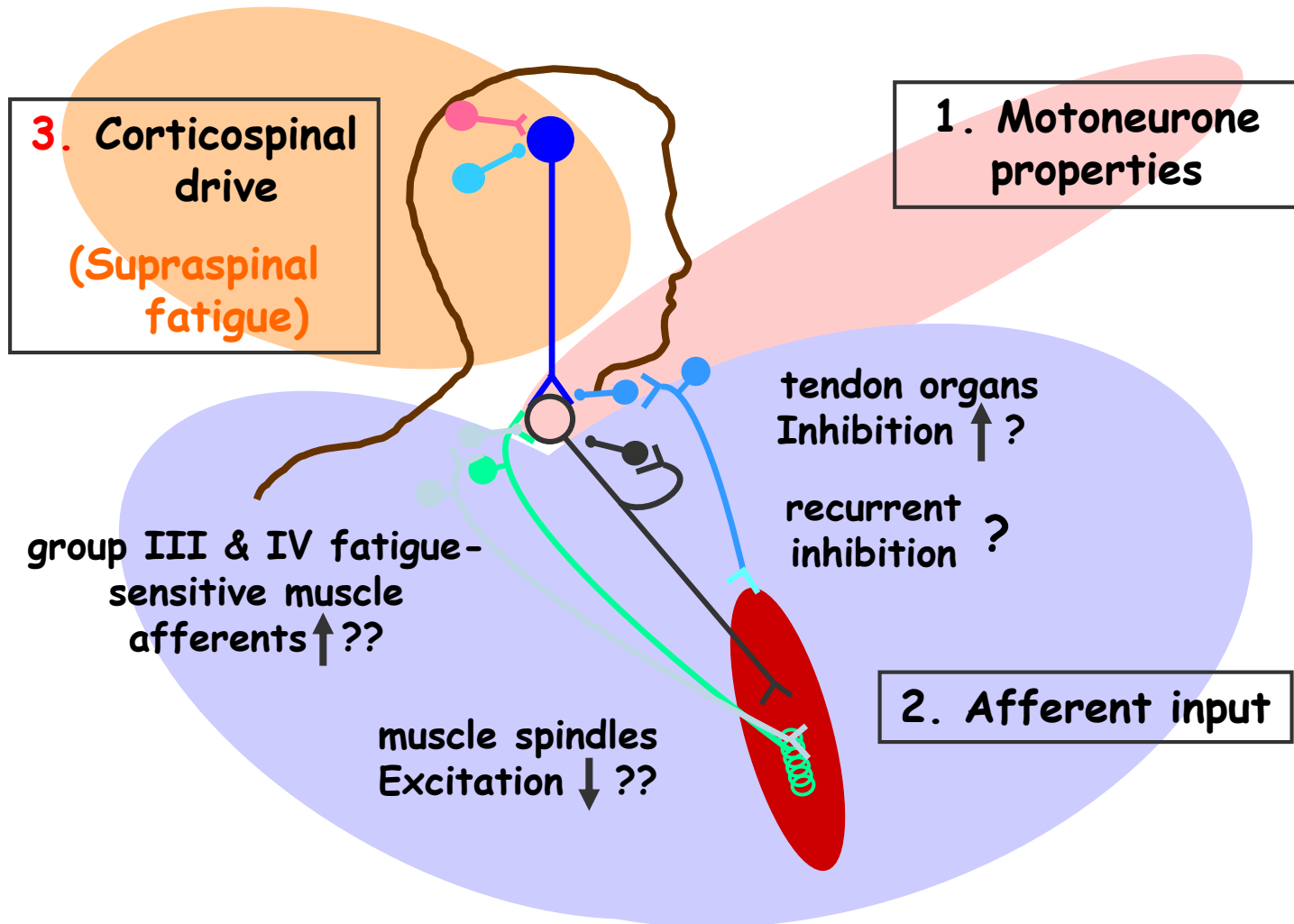
Not as simple as that...

peripheral
fatigue
(muscular)

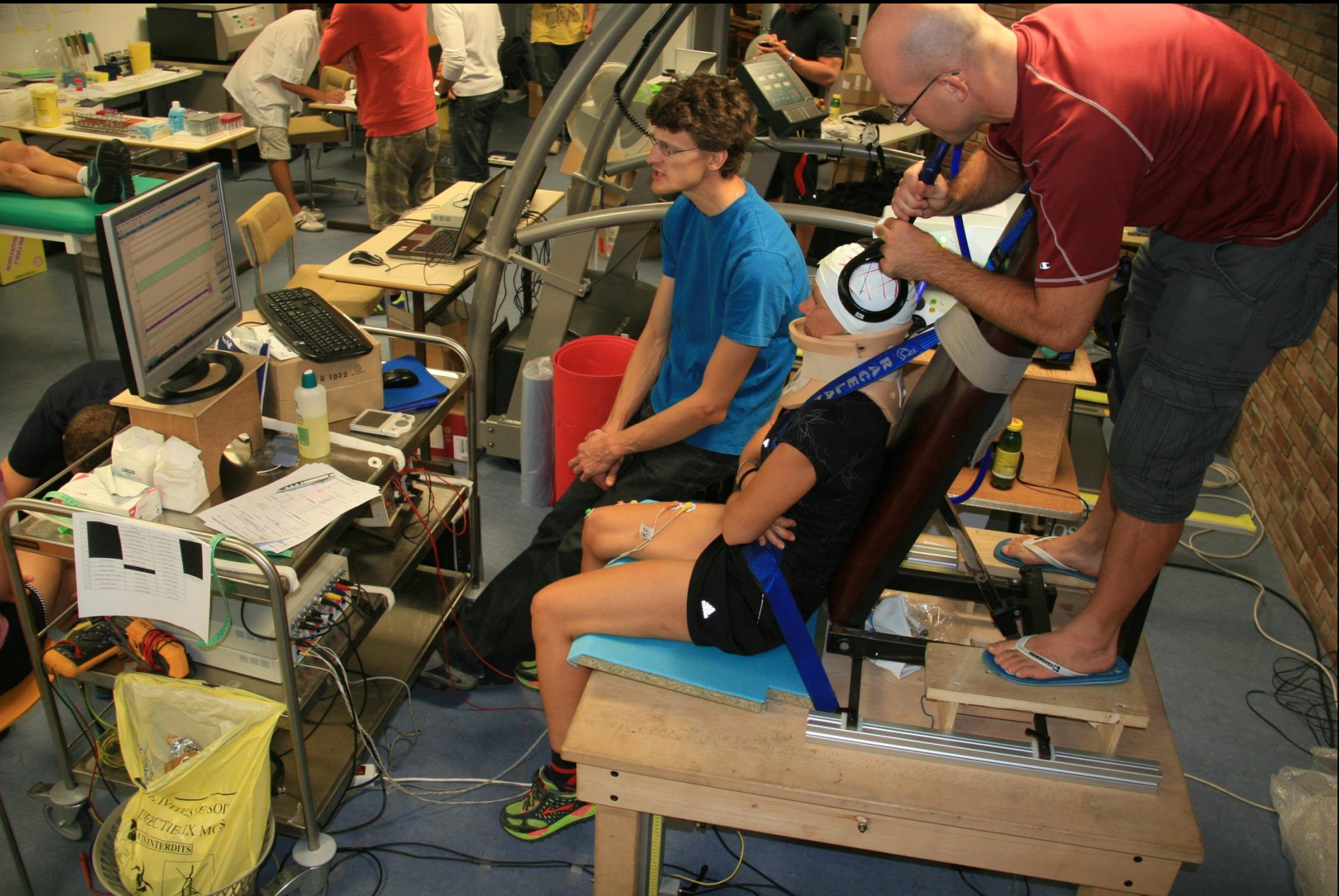
central
fatigue
(neural)



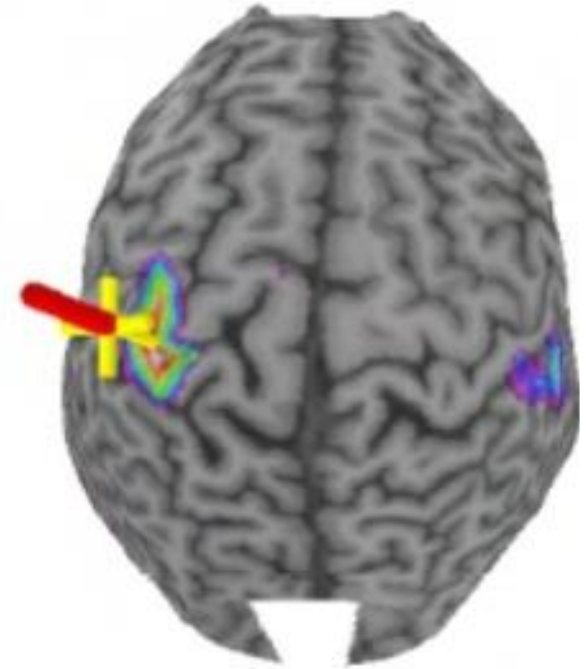
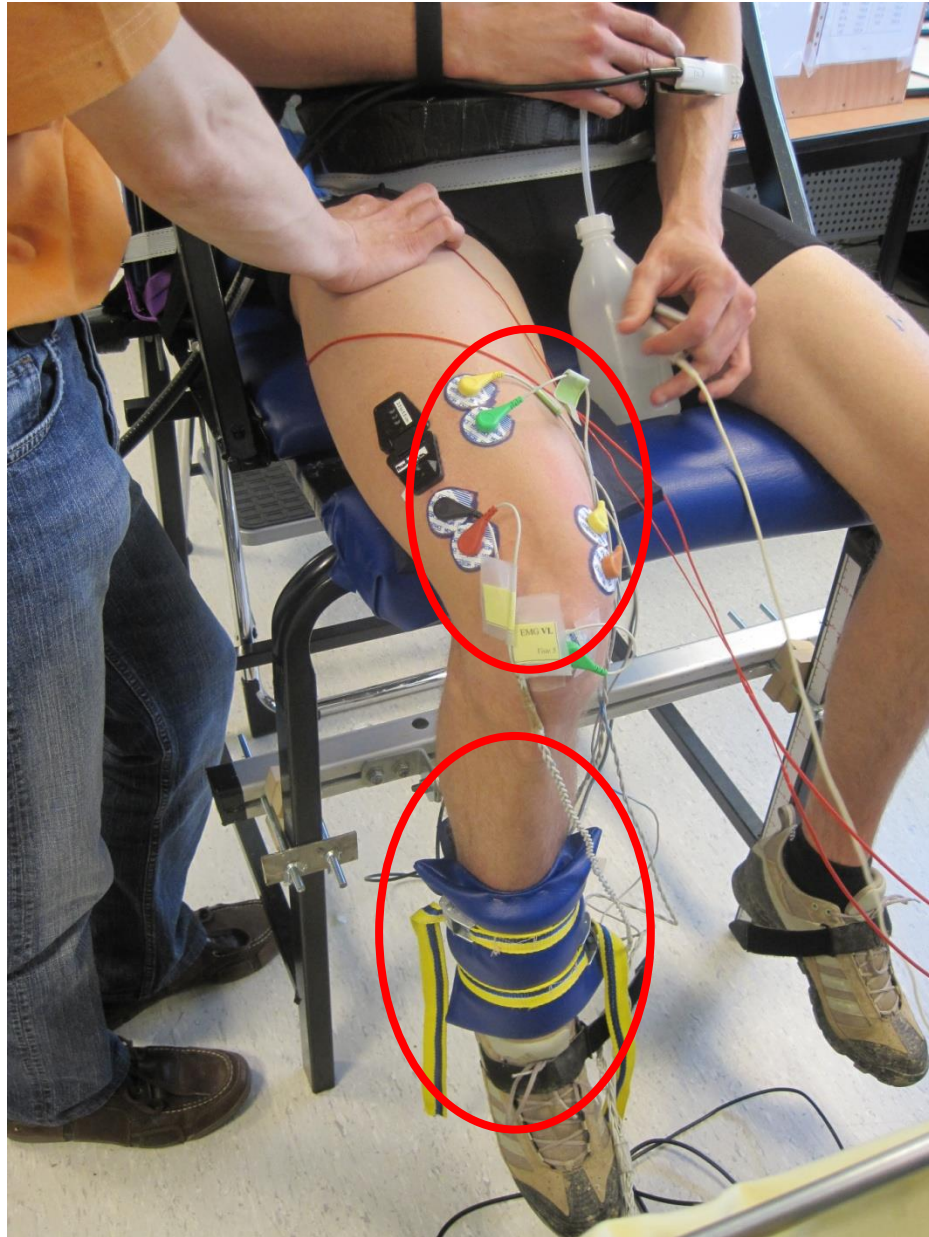
Potential sites of central fatigue



UTMB 2012: Transcranial Magnetic Stimulation



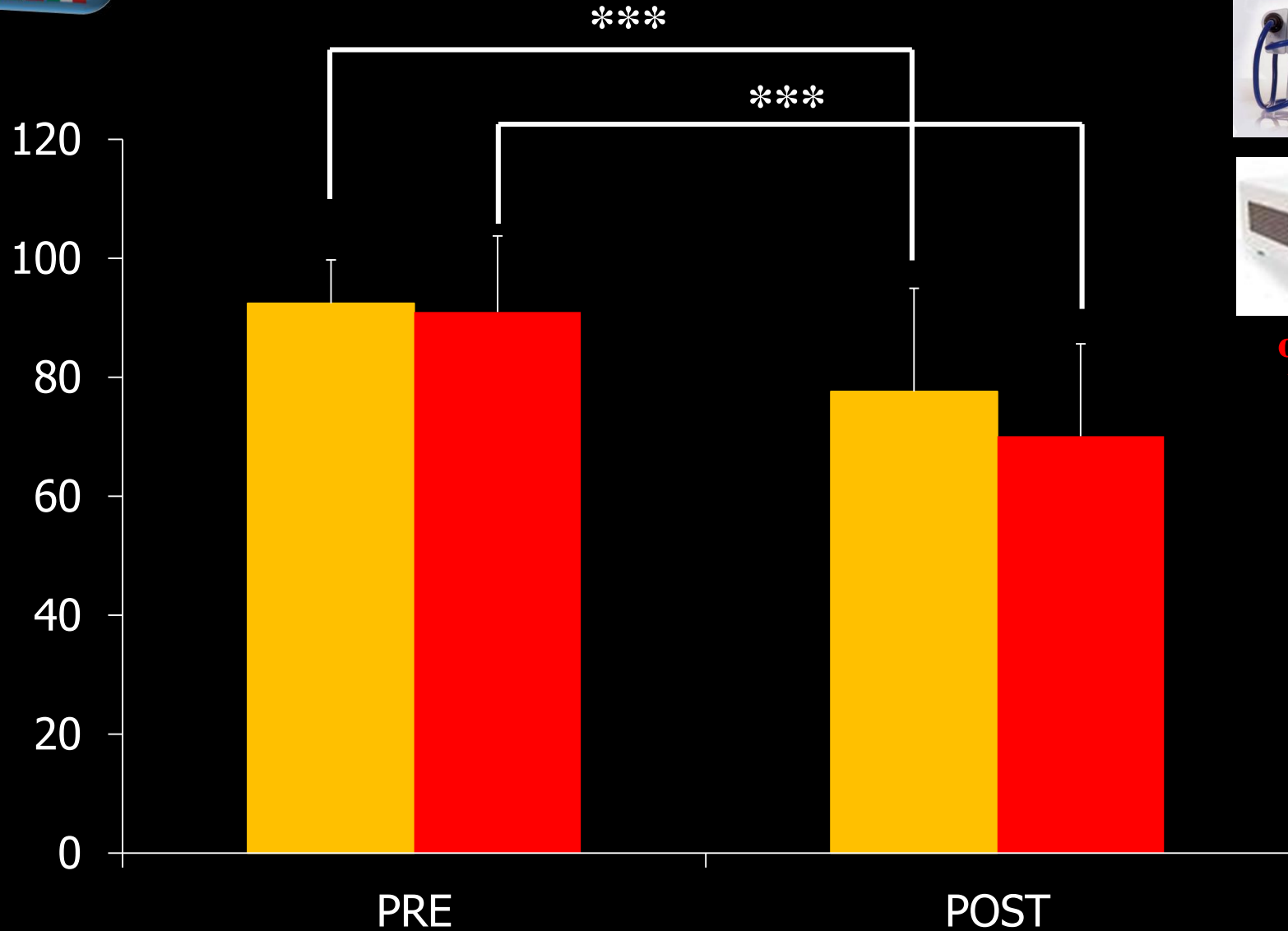
*UTMB 2012: Transcranial **M**agnetic **S**timulation*





UTMB 2012: central fatigue

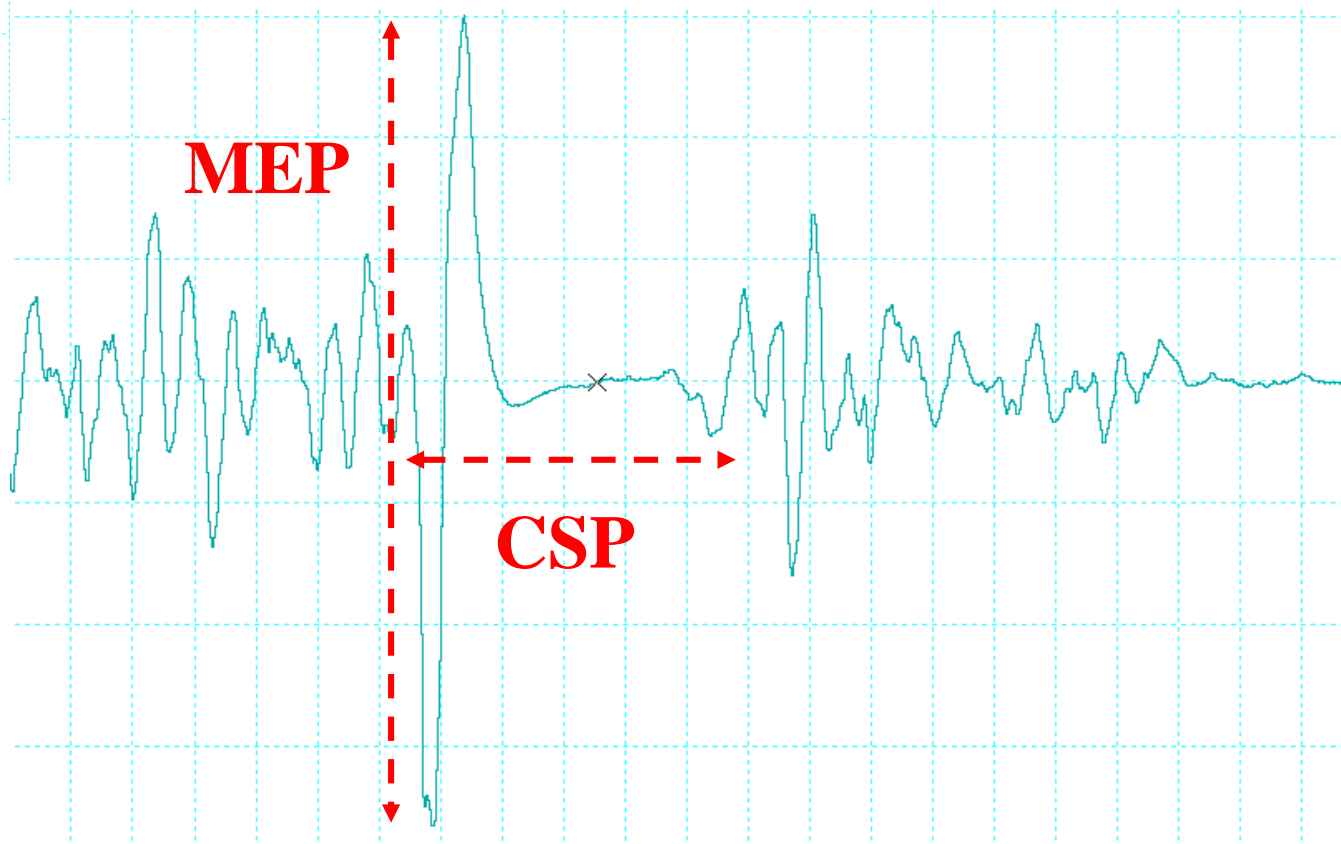
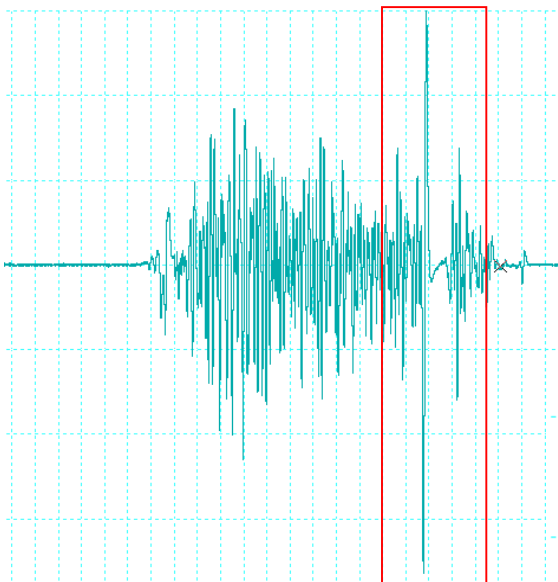
% Voluntary Activation



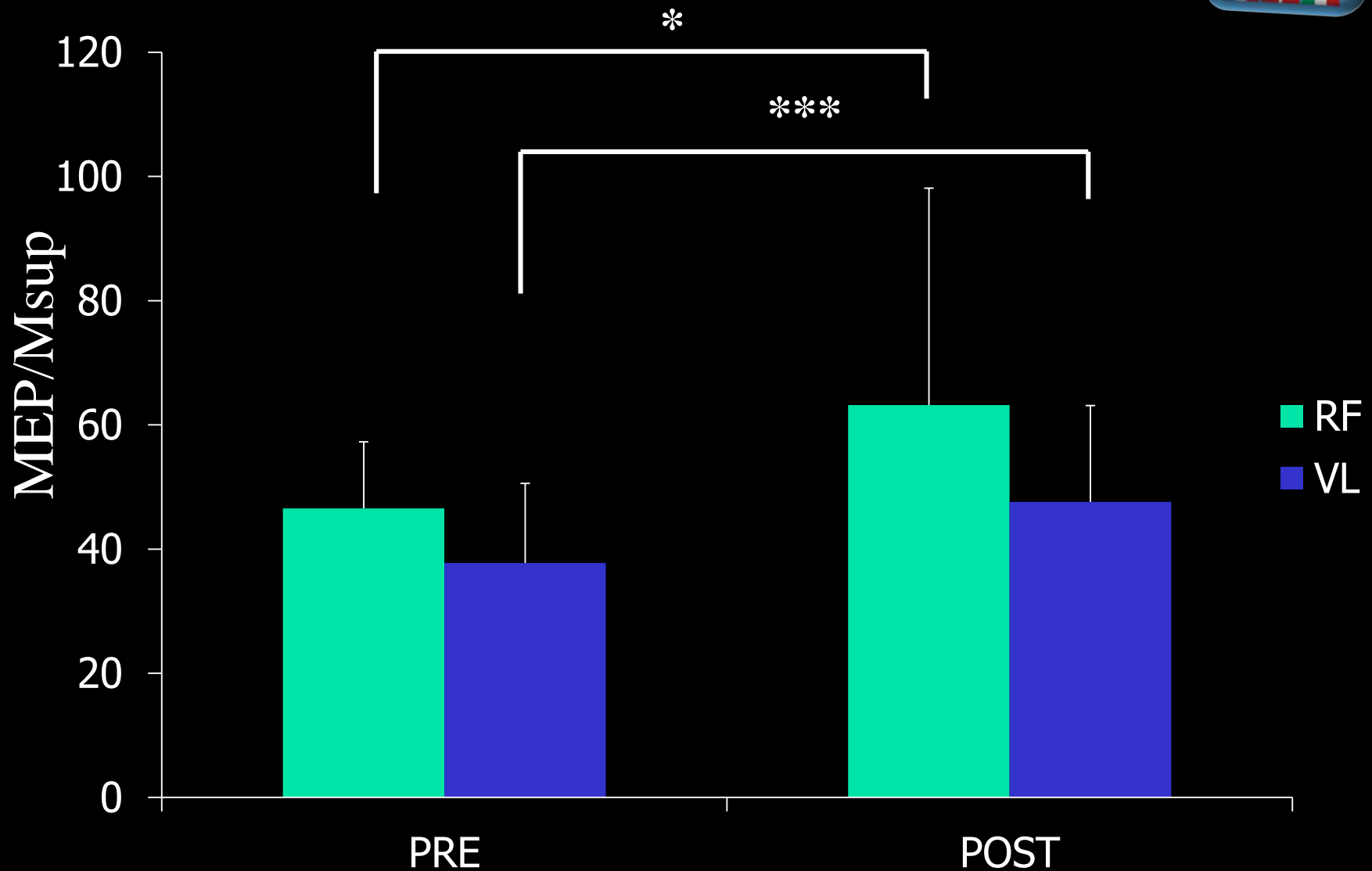
%VA_{TMS}

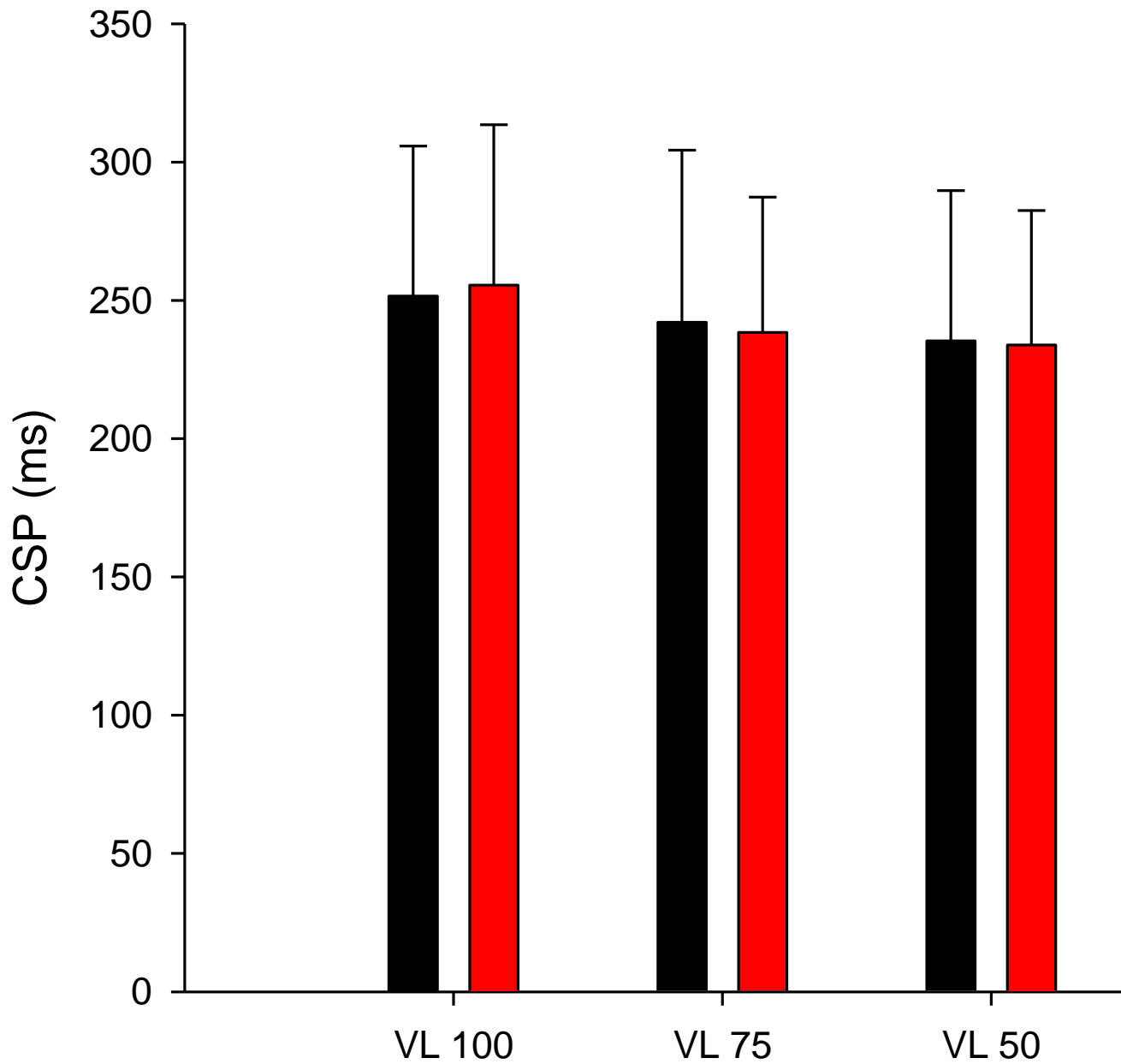


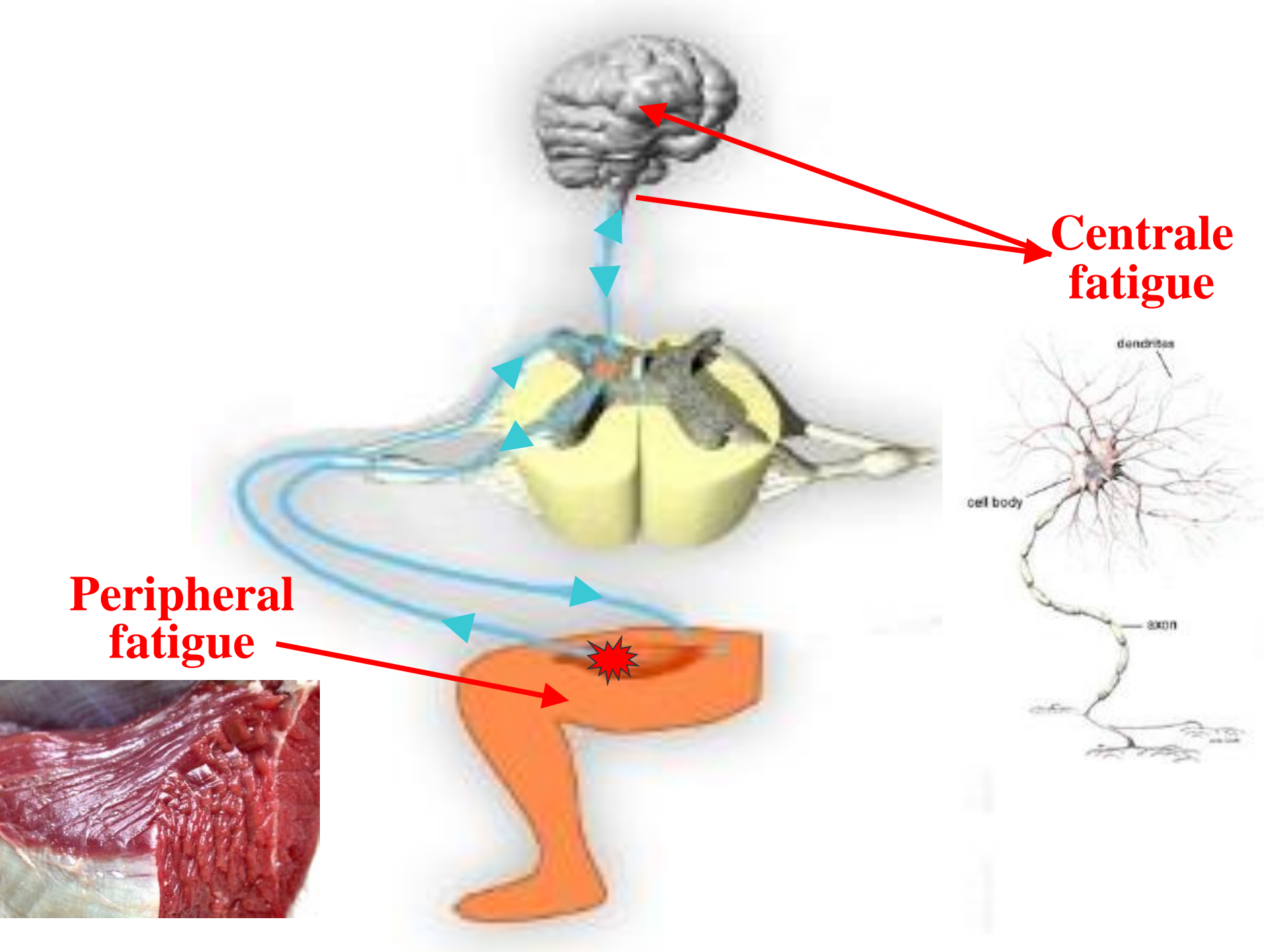
%VA_{NS}

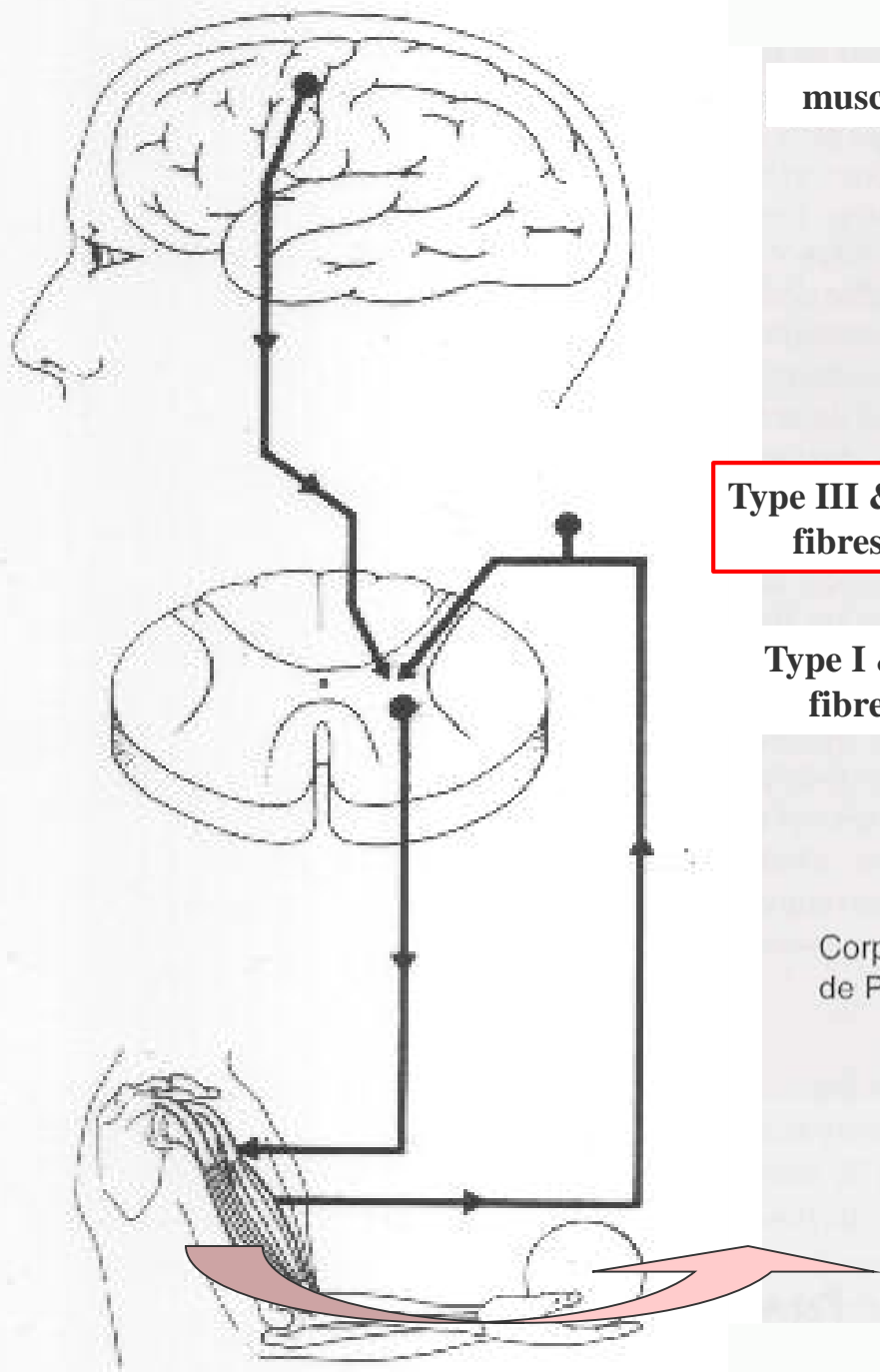


UTMB 2012: supraspinal fatigue









Type III & IV
fibres

Type I & II
fibres

Corpuscule
de Pacini

Tendon

muscle fibres

Fibre α

Fibres γ

Fibre Ia

Fibre II

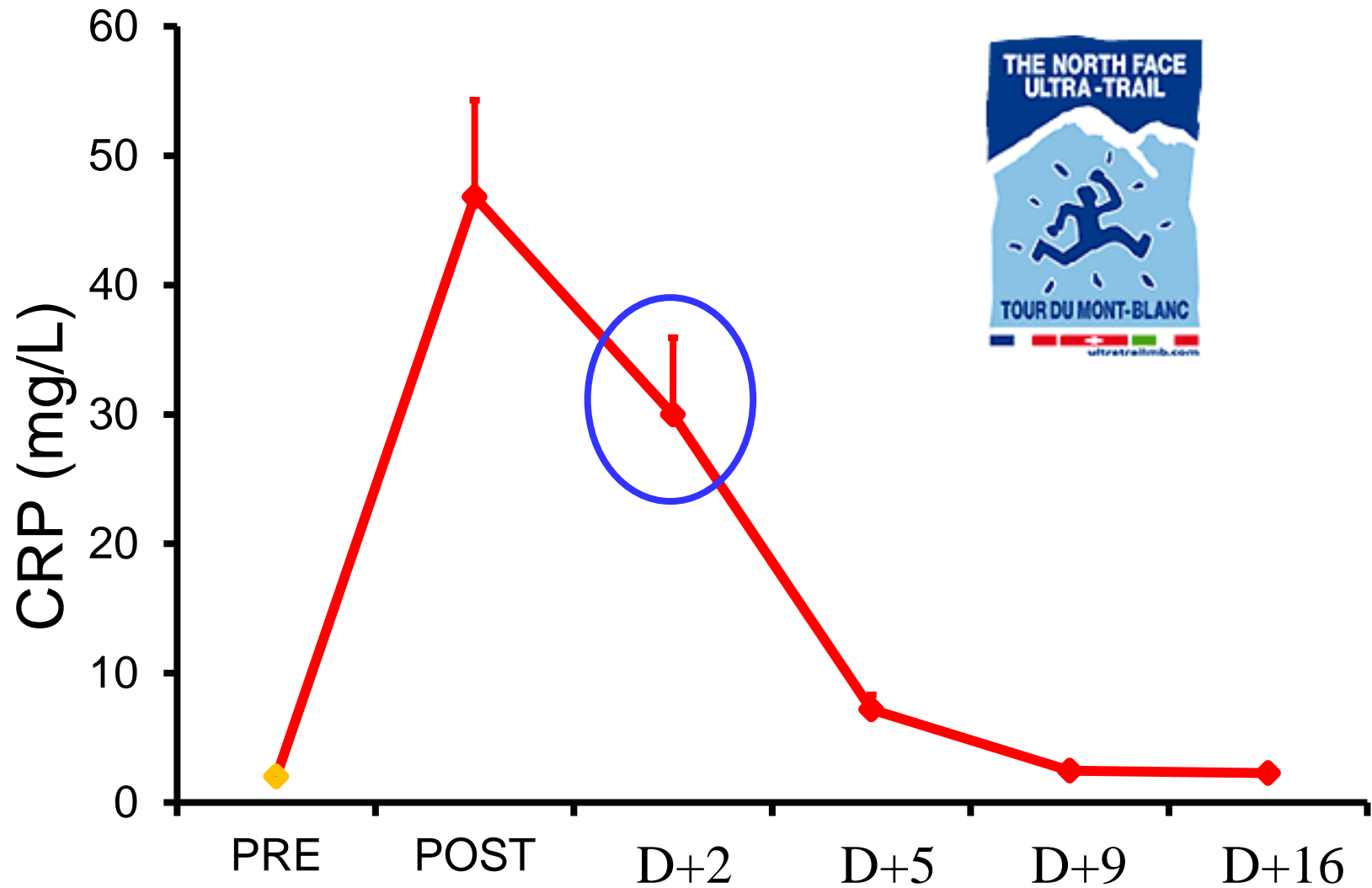
Spindles

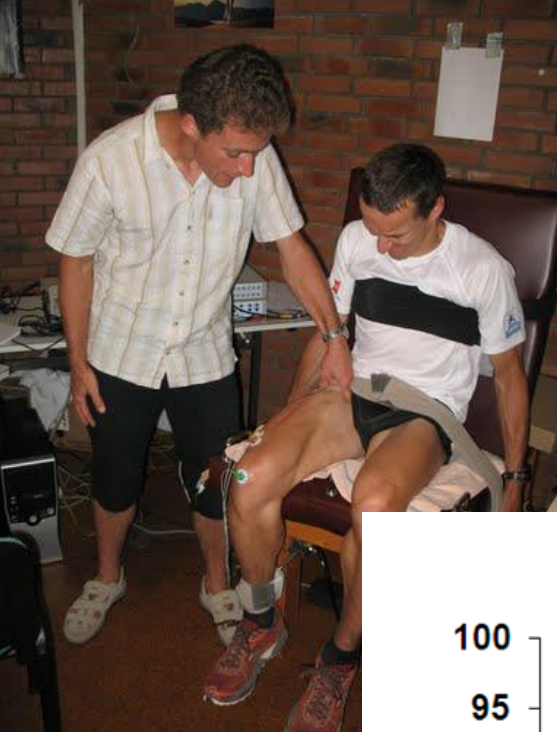
Type Ib fibres

Organe tendineux
de Golgi



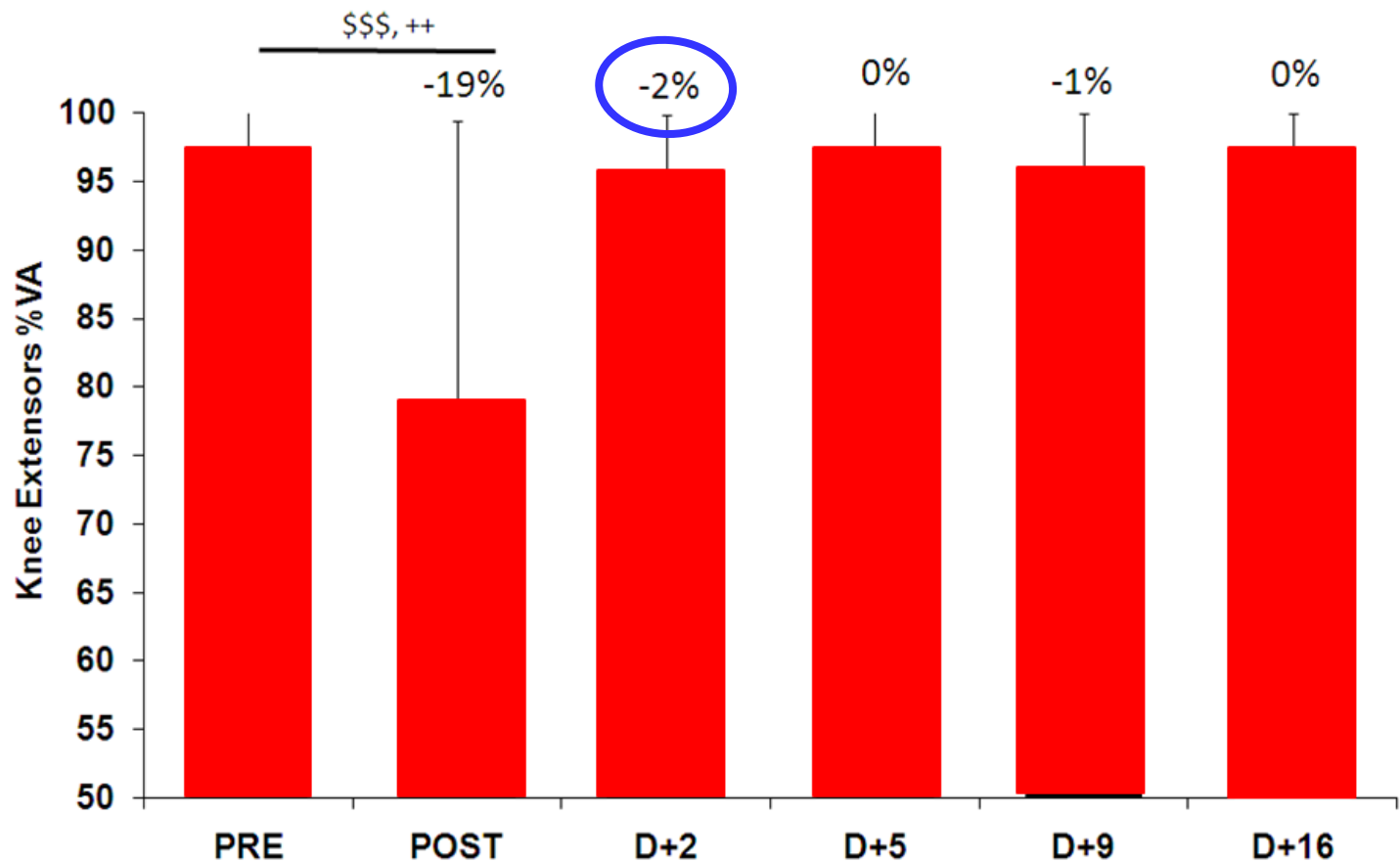
Inflammatory response at UTMB



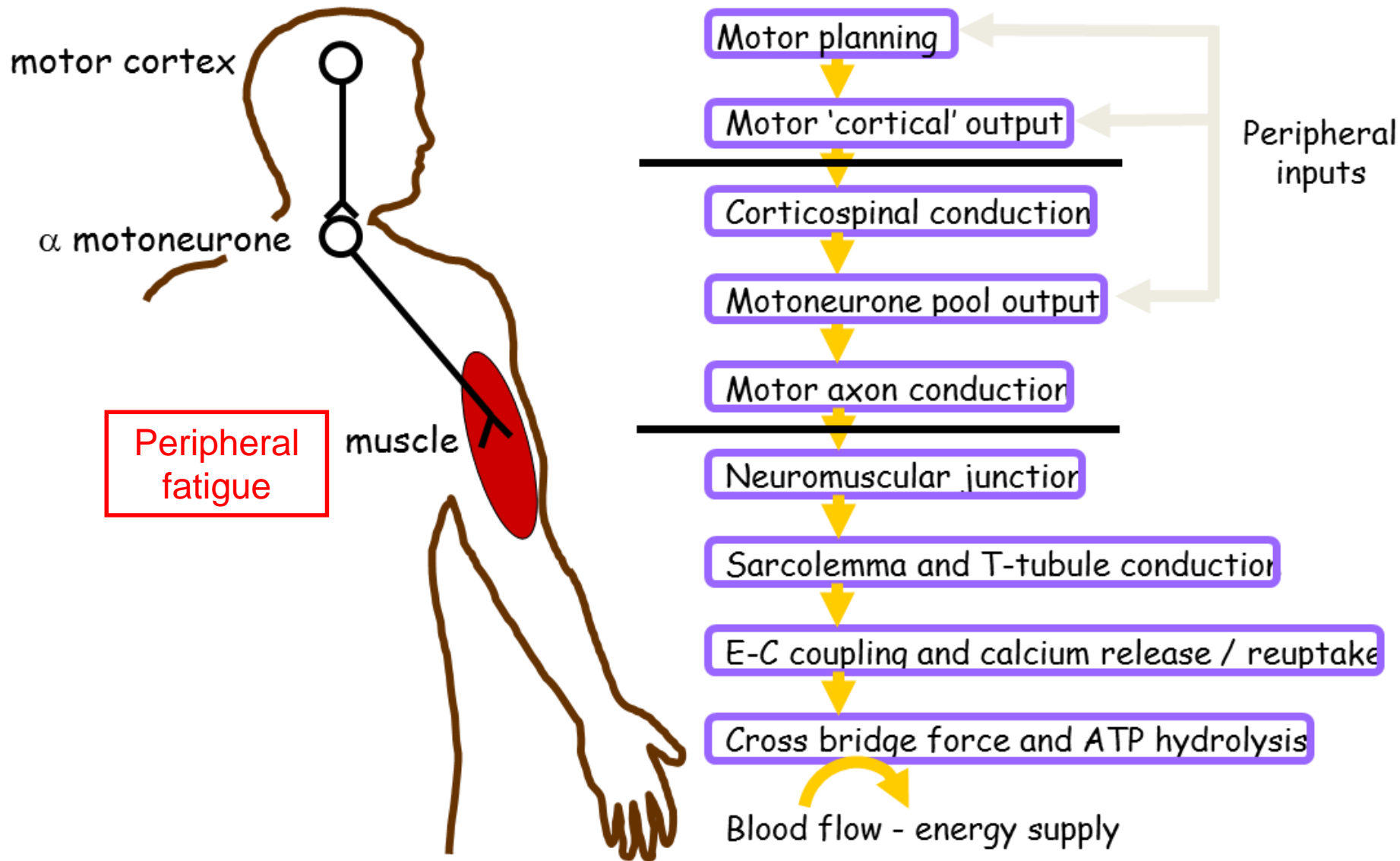


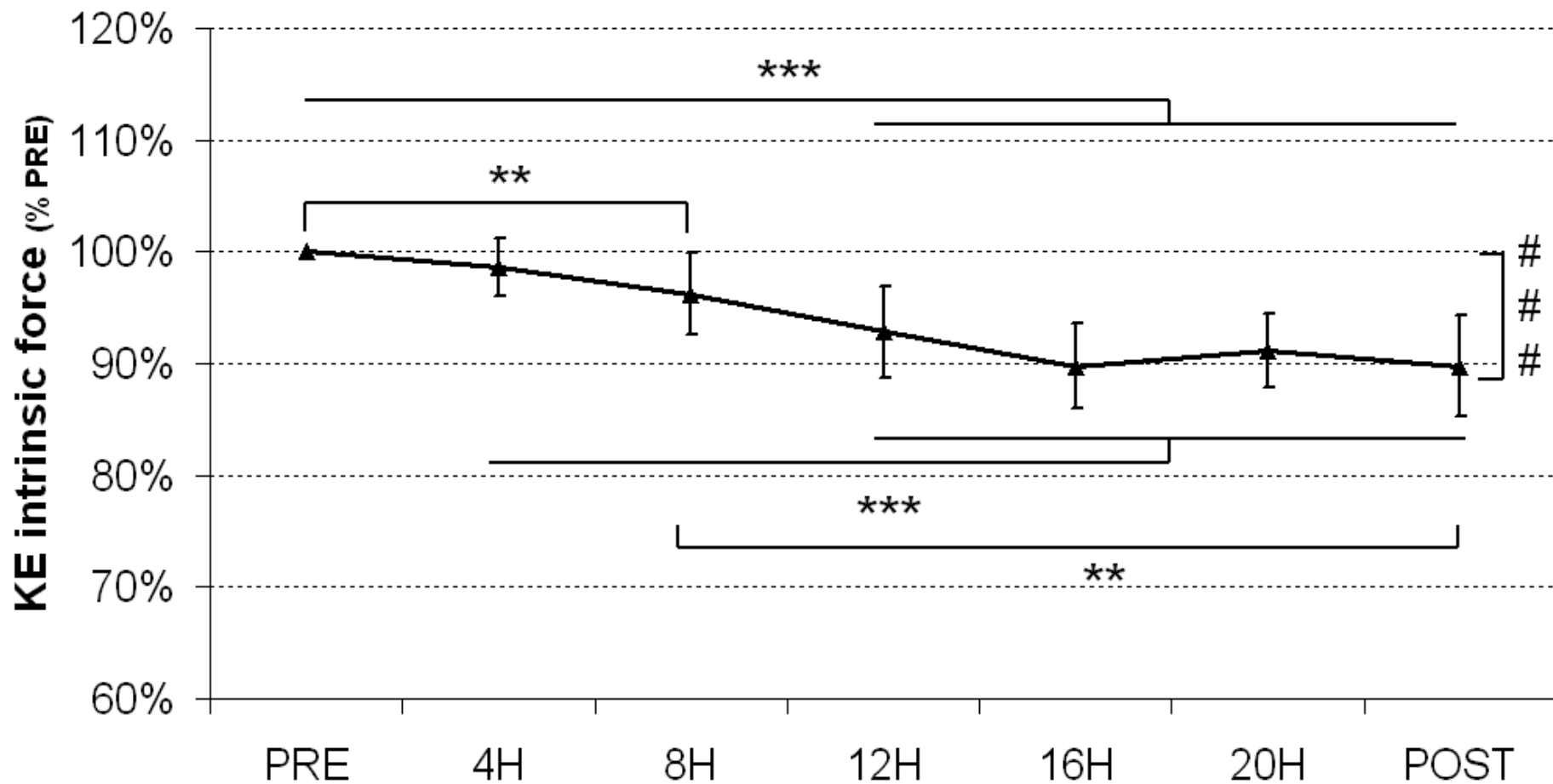
Ia disfacilitation?

Changes in the intrinsic properties of motoneurons?

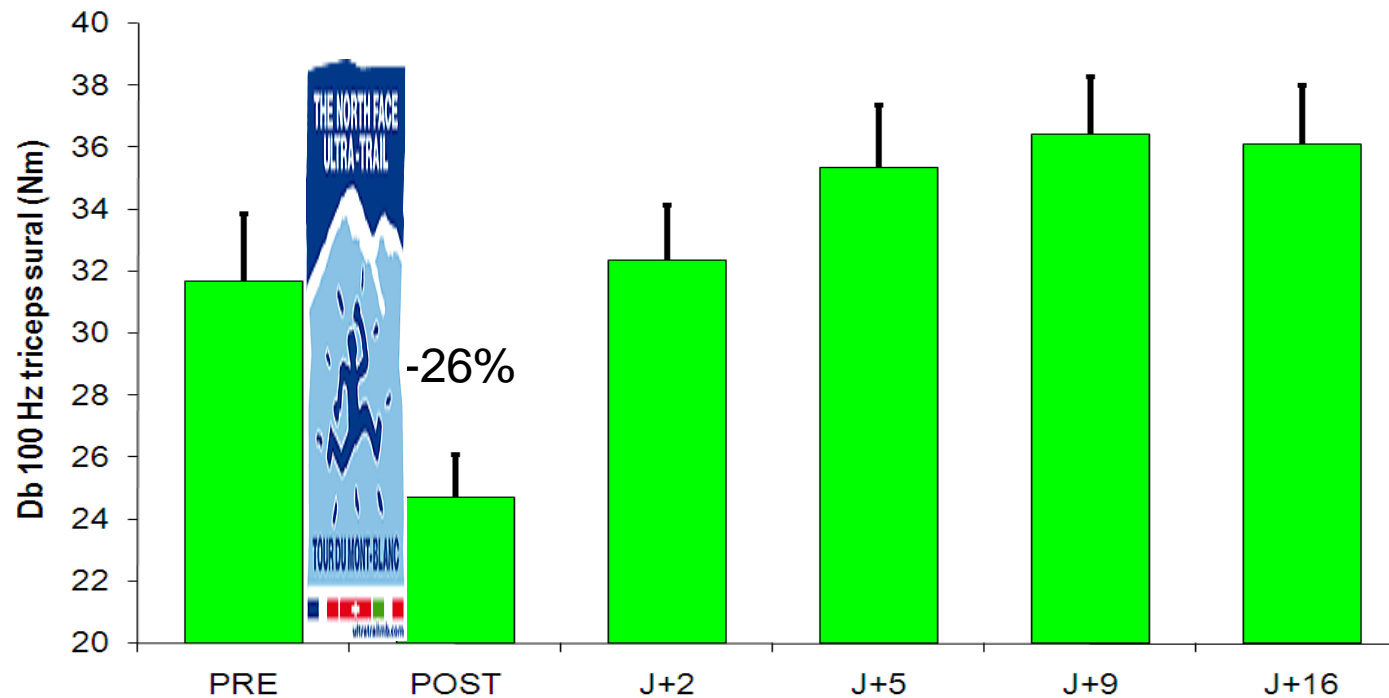
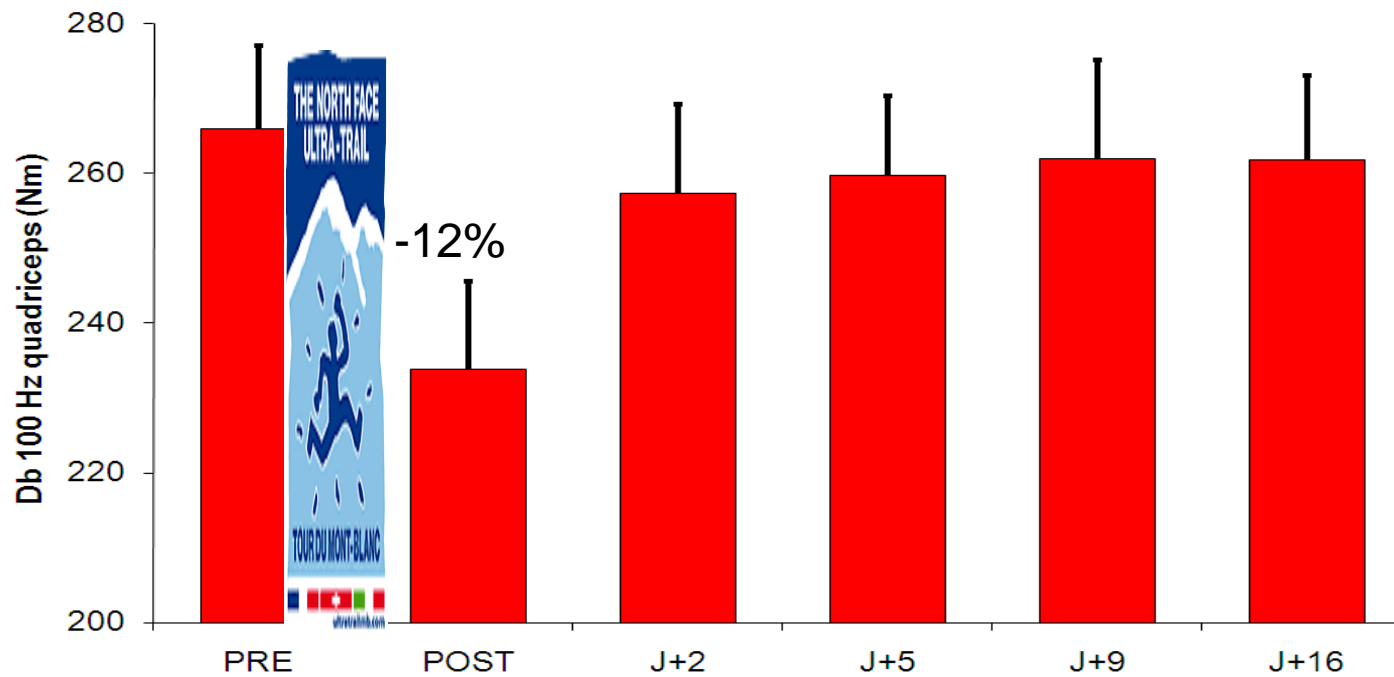


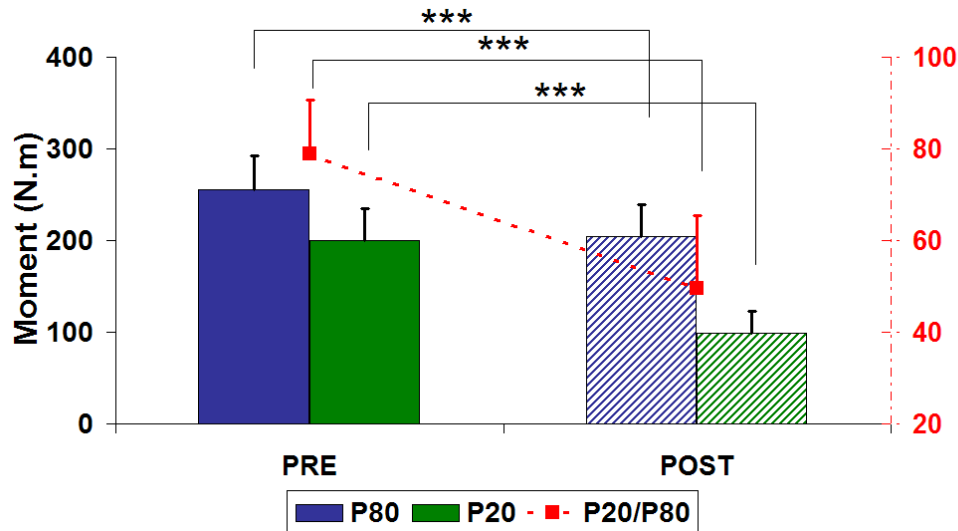
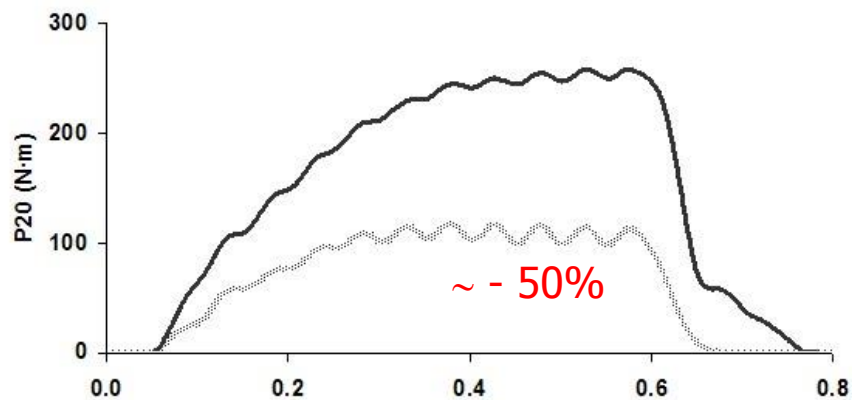
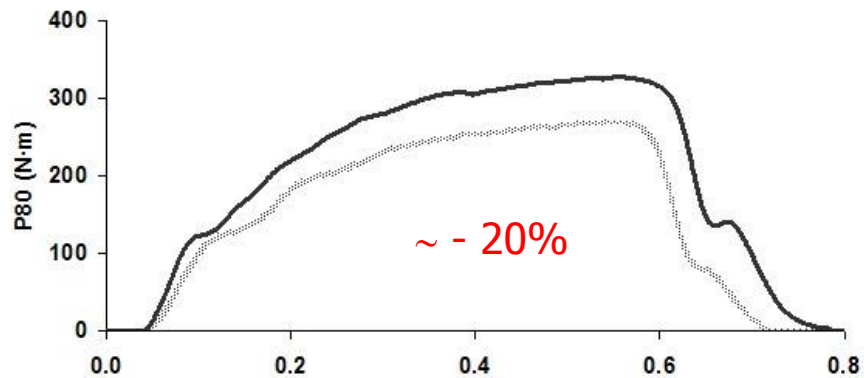
Potential reasons for NM fatigue





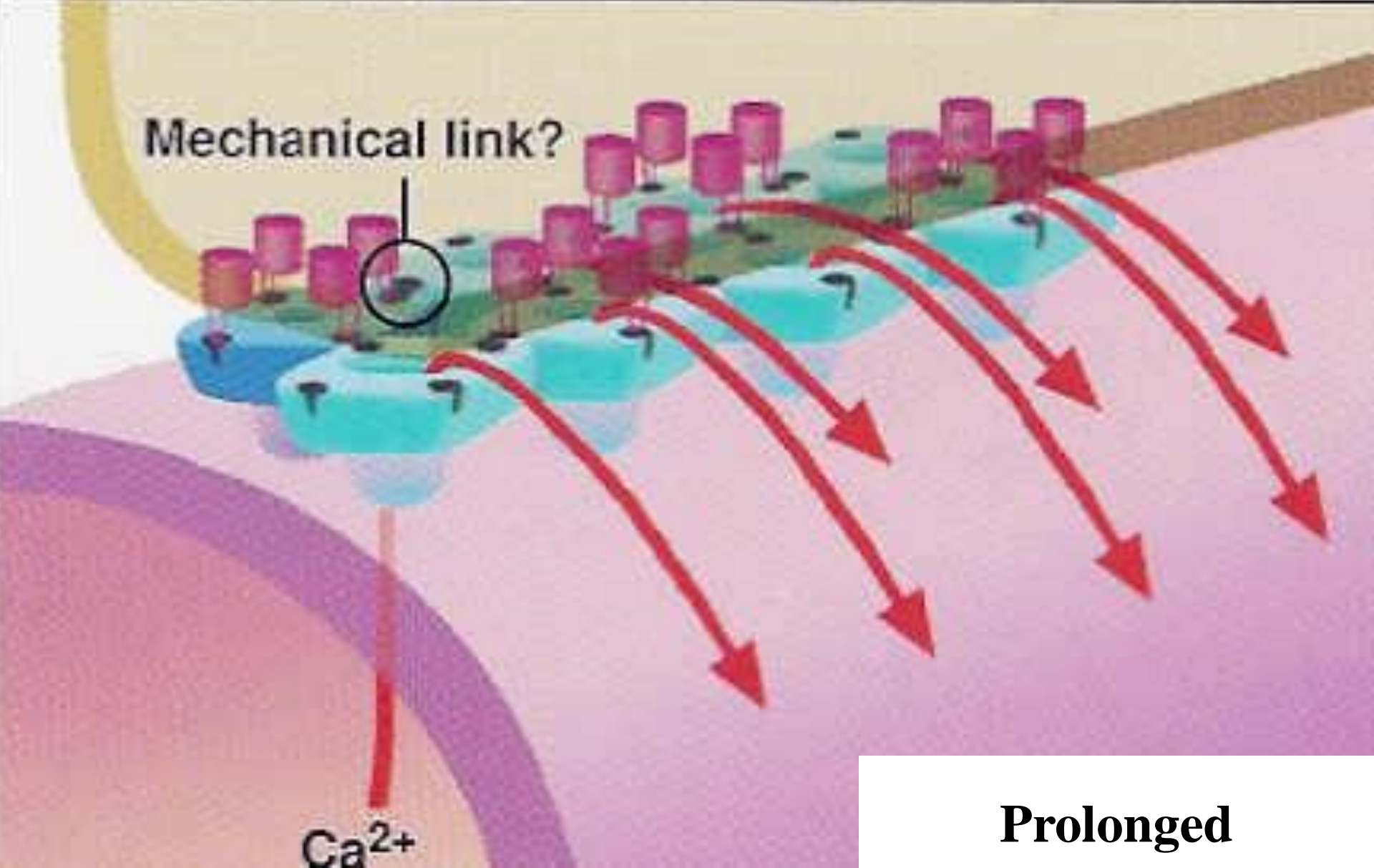
Intrinsic force: ~ -10%





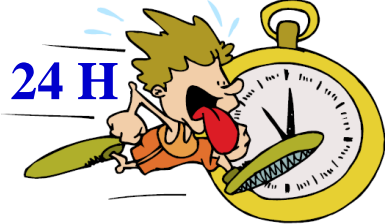
Low frequency fatigue

E-C coupling failure



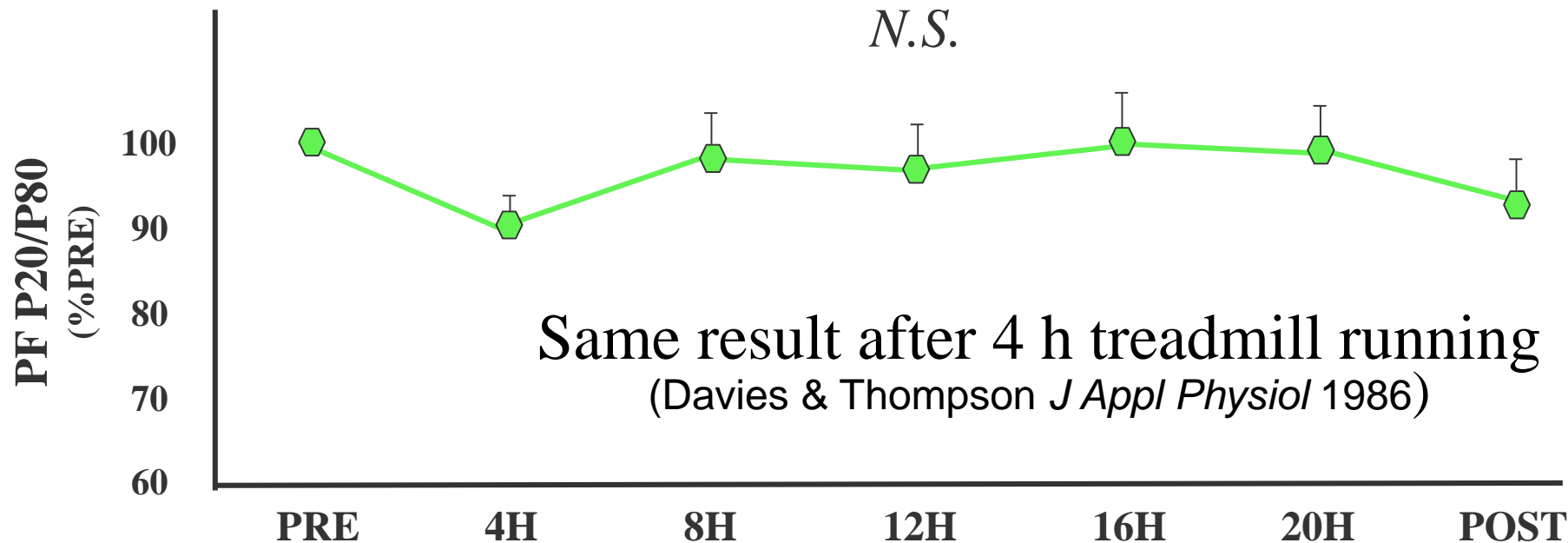
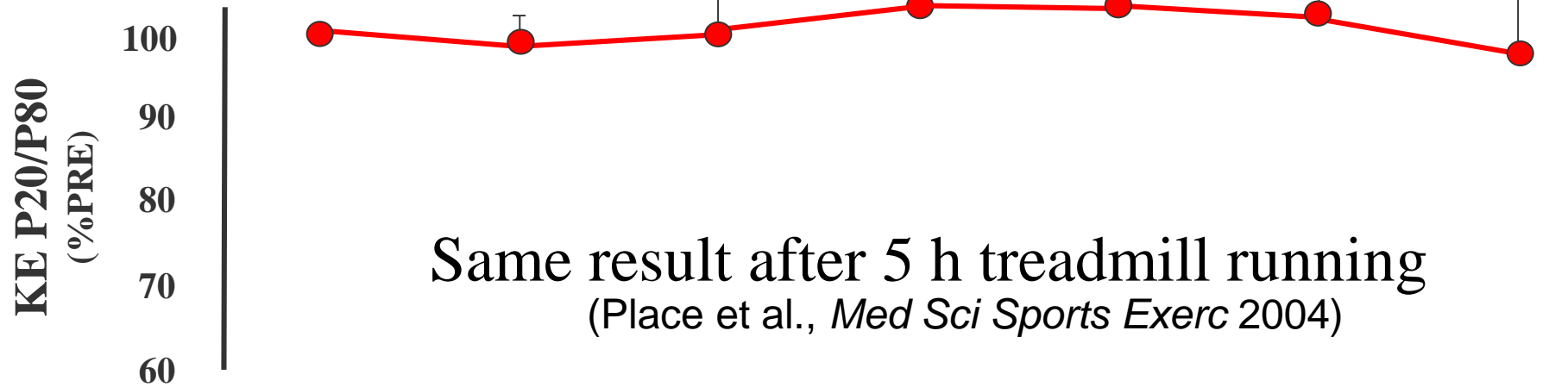
E-C Failure (Ingalls et al. 1998)

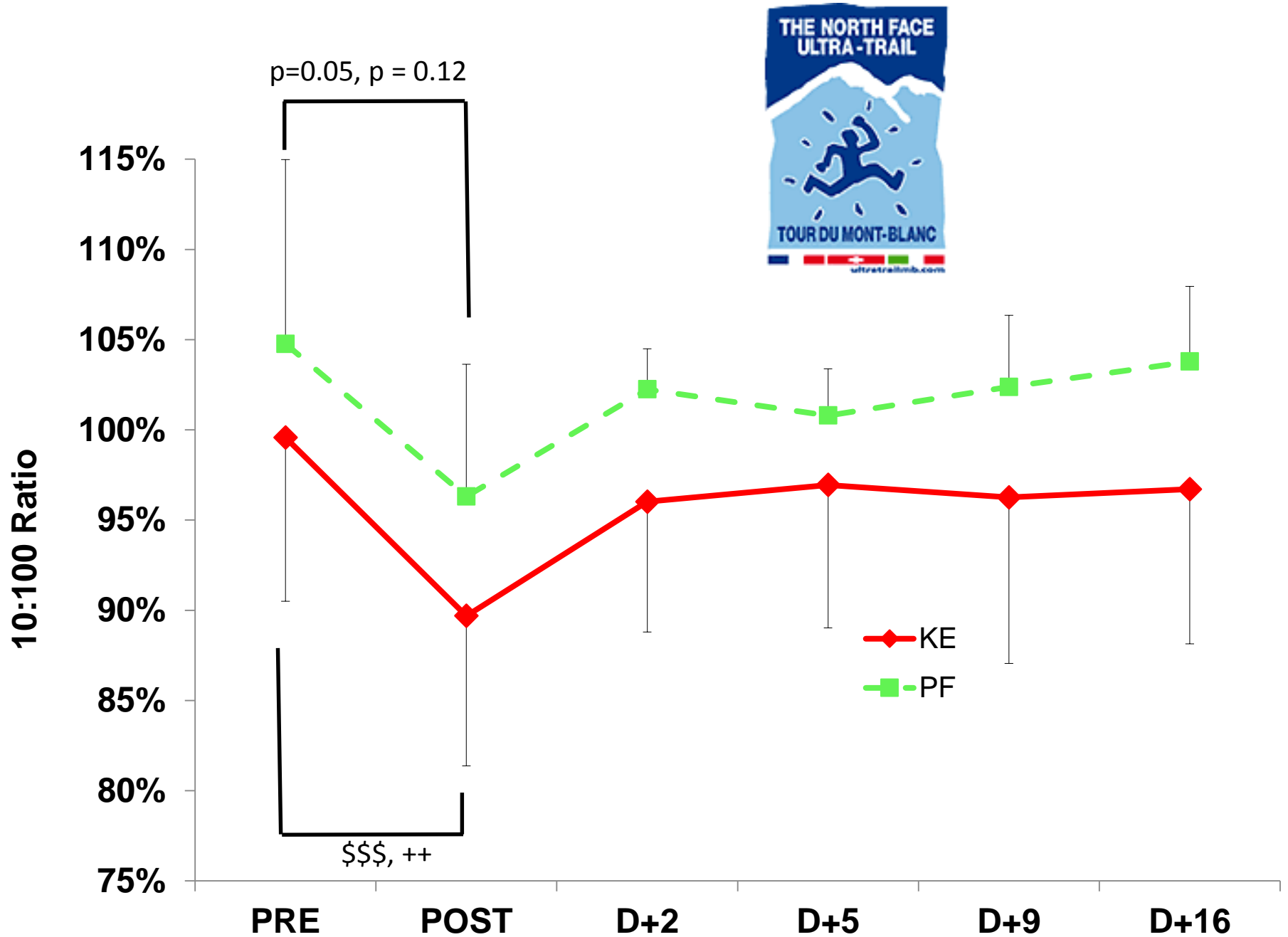
**Prolonged
running
exercises?**



Martin et al. *J Appl Physiol* 2010

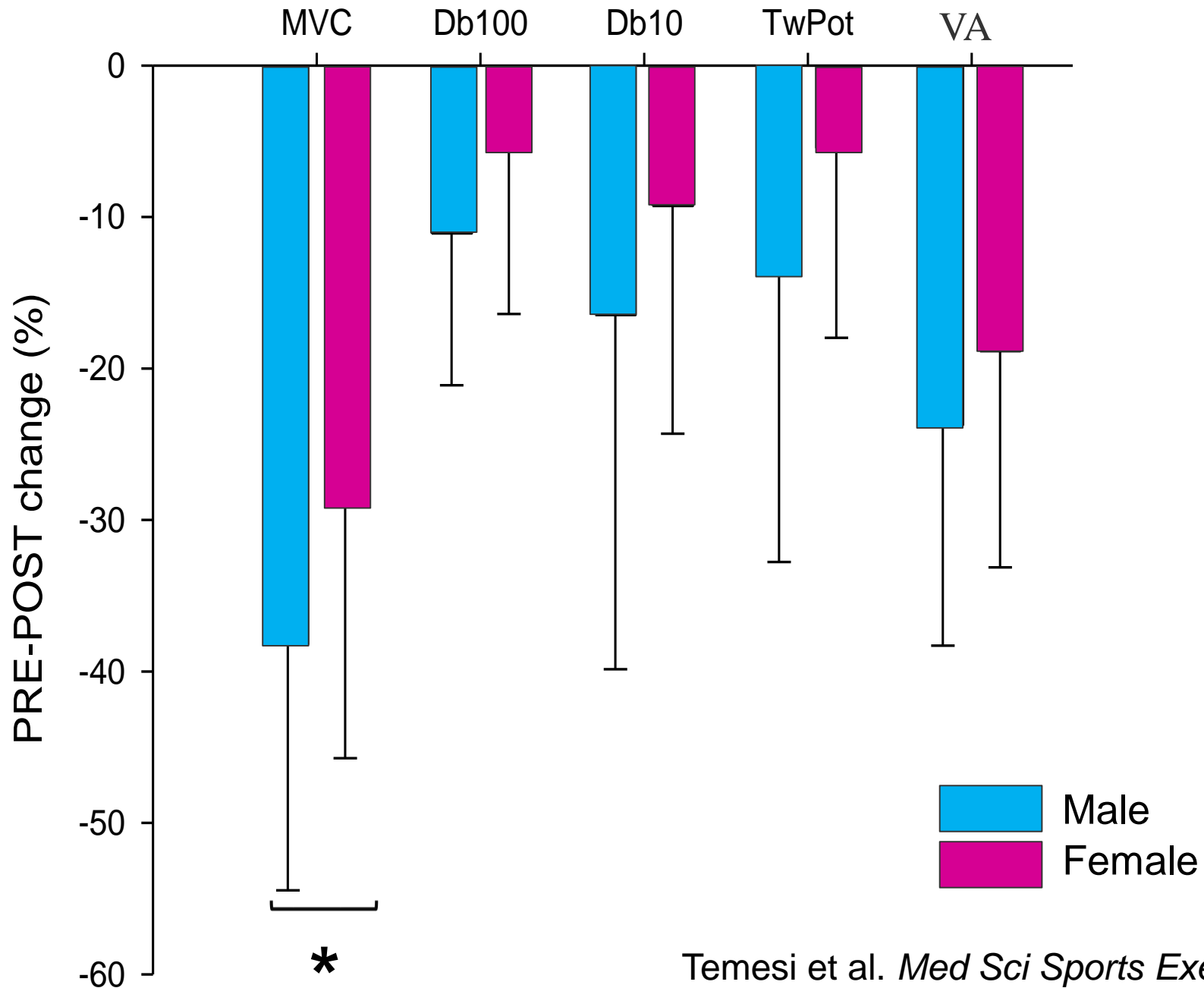
N.S.



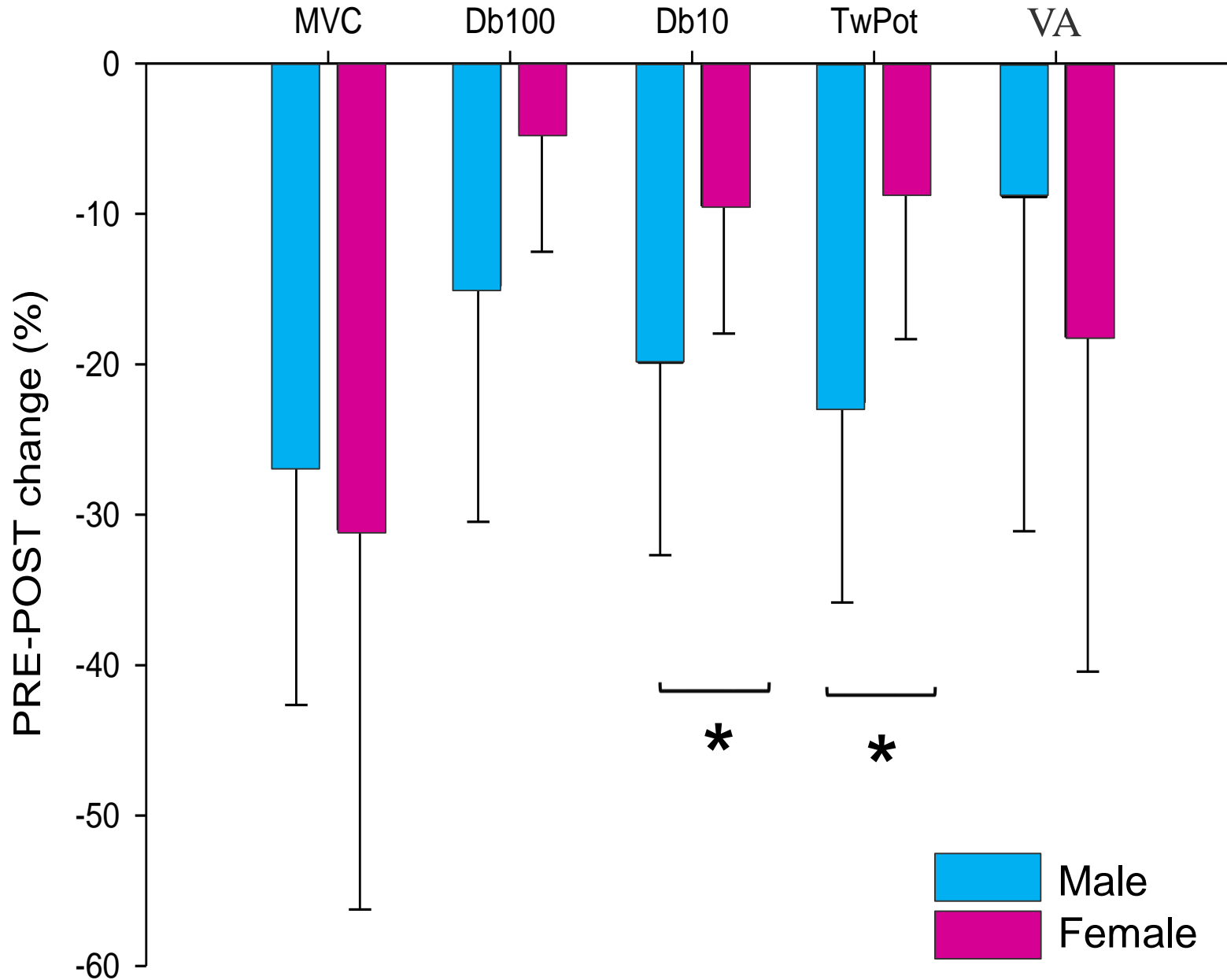


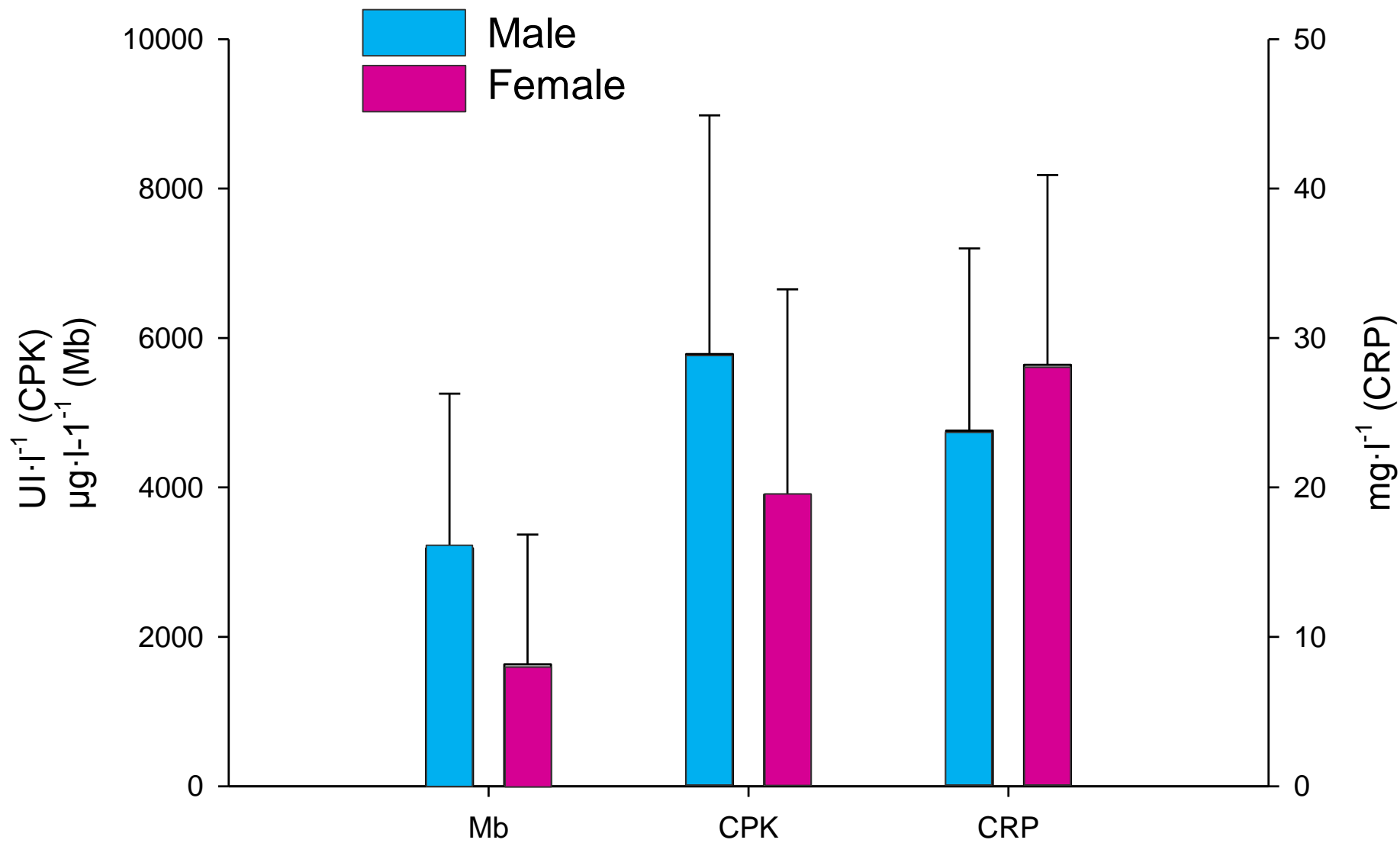
Women vs men?

Knee extensors

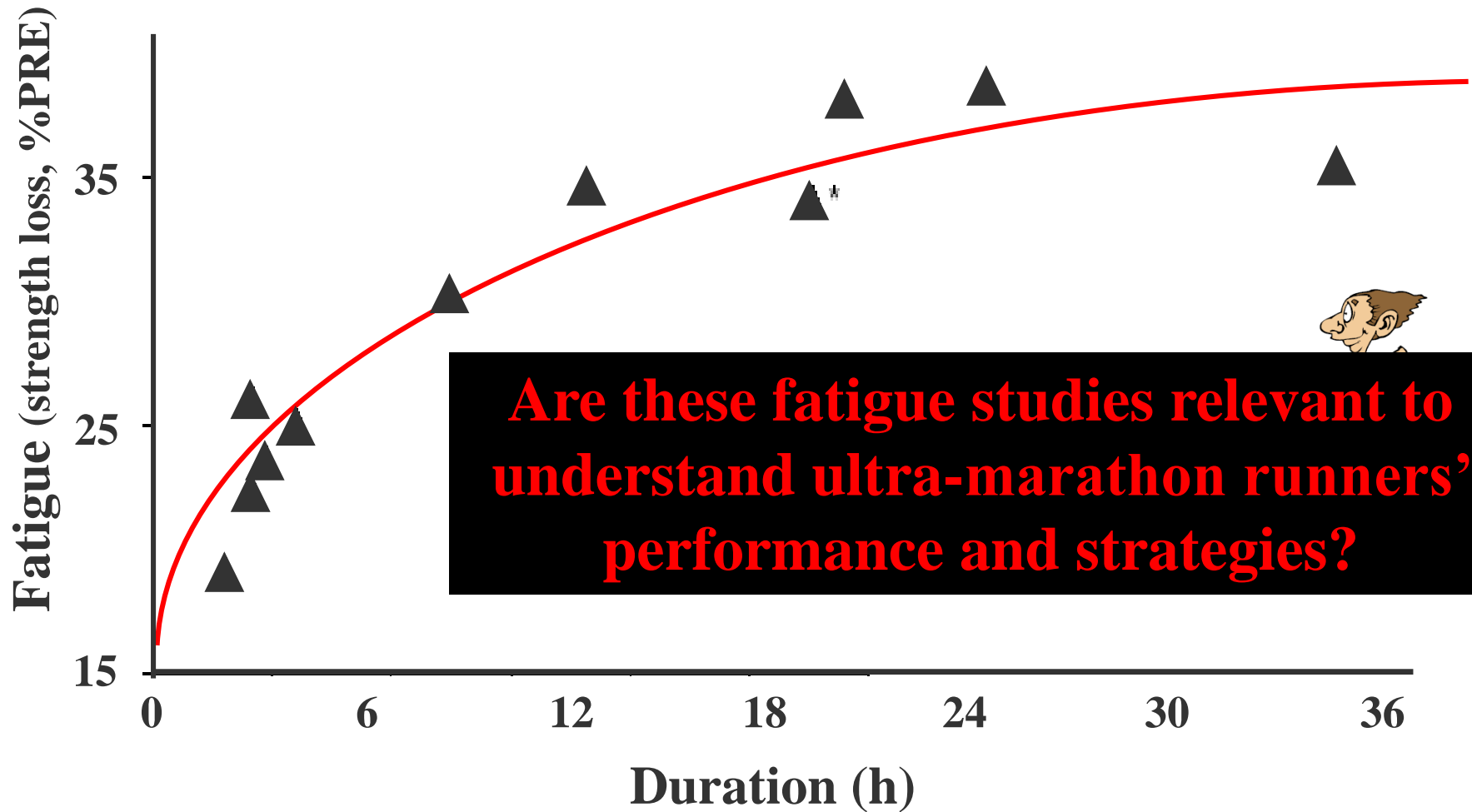


Plantar flexors





Knee extensors fatigue in prolonged running





NO... at least not directly

Can Neuromuscular Fatigue Explain Running Strategies and Performance in Ultra-Marathons?

The Flush Model

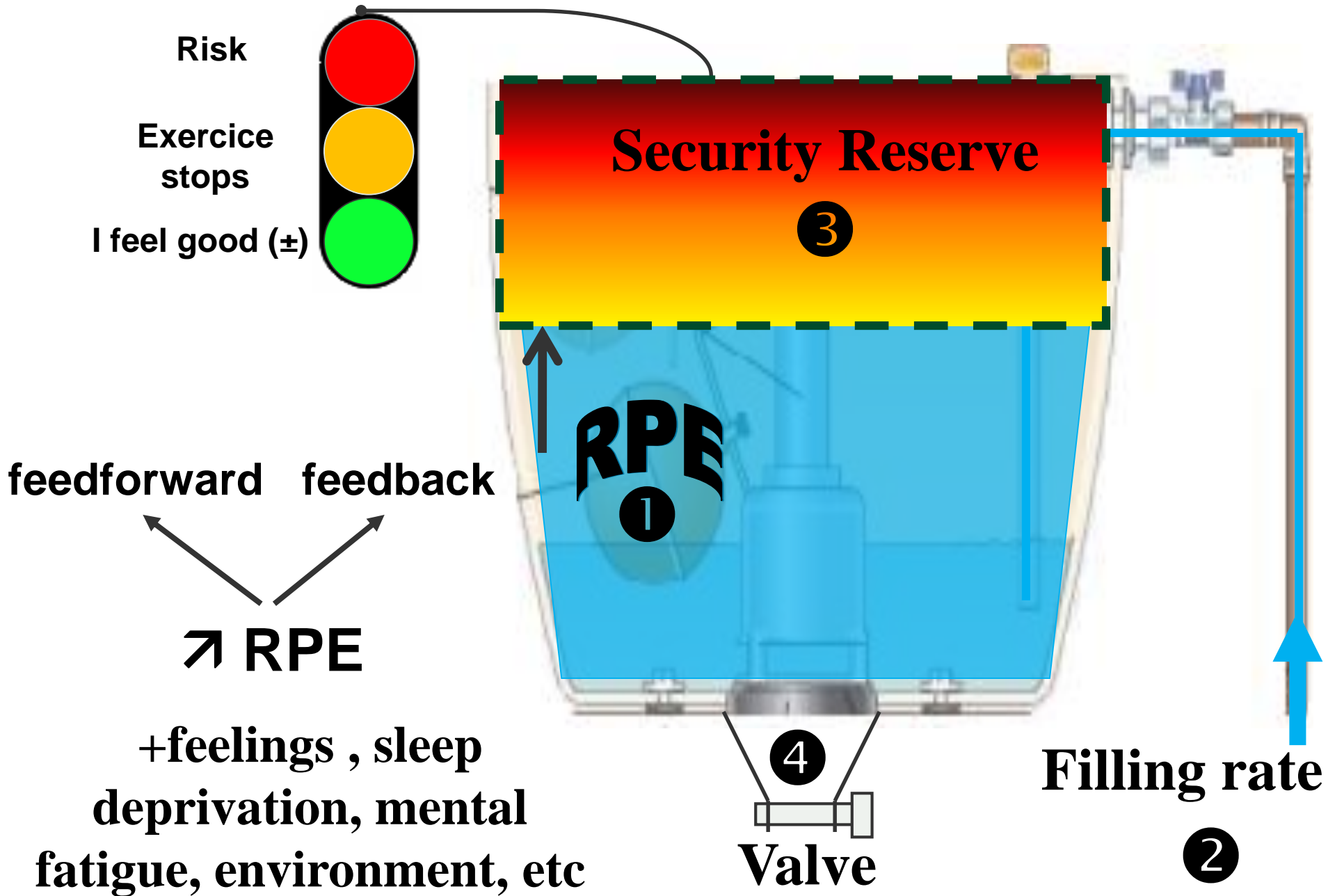
Guillaume Y. Millet^{1,2}

1 University of Lyon, Saint Etienne, France

2 Inserm U1042, Grenoble, France



The flush model



Security Reserve

3

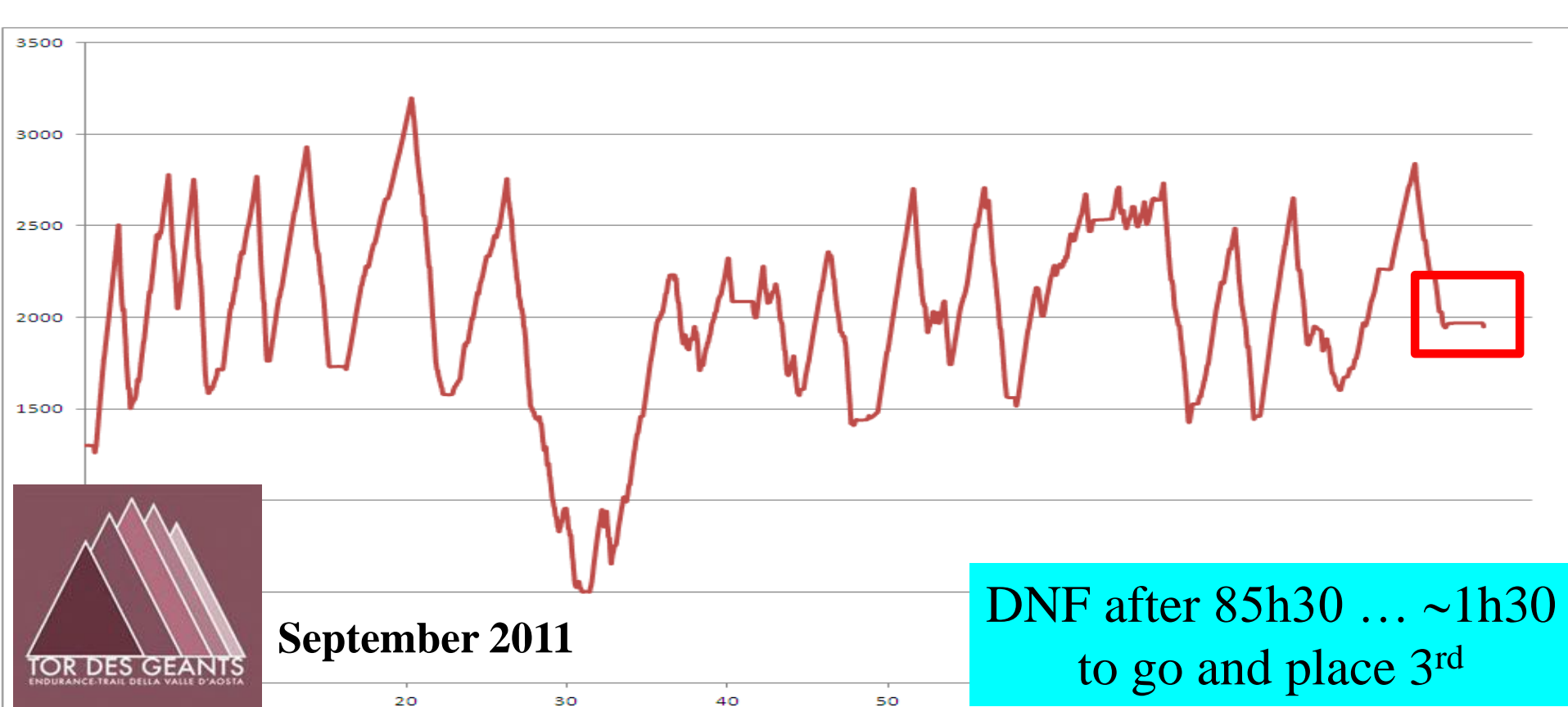


The « size of the **security reserve** » is a determining factor of performance
= being able to *hurt yourself*



Extreme exercise with large sleep deprivation





298	638	MARCIANDI	PAOLA	V1 F	SI	10:00	Dom 13:49	Dom 23:14	Lun 2:48	Lun 7:42	Lun 13:23	Lun 21:25	Mar 3:37	Mar 7:13	Mar 10:49	Mar 15:41
299	301	COGO	MASSIMILIA	V1 M	SI	10:00	Dom 13:27	Dom 23:52	Lun 2:50	Lun 8:17	Lun 14:19	Lun 23:36	Mar 2:51	Mar 7:05	Mar 11:06	Mar 15:51
300	325	GONZALEZ H	VICTOR	S2 M	SI	10:00	Dom 14:10	Lun 3:16	Lun 6:52	Lun 11:16	Lun 16:23	Mar 1:06	Mar 5:51	Mar 9:23	Mar 13:15	Mar 19:16
	Pett	Cognome	Nome	Categ.	Rit. Pett.	Courma START	La Thuile	Valgrisa IN	Valgrisa OUT	Rhemes	Eaux R.	Cogne IN	Cogne OUT	Sogno	Chard.	Donnas IN
301	206	SAVOIA	GIANNI	V2 M	SI	10:00	Dom 13:54	Dom 22:58	Dom 23:52	Lun 4:52	Lun 10:39	Lun 20:20	Mar 0:55	Mar 5:15	Mar 10:34	Mar 16:27
	Pett	Cognome	Nome	Categ.	Rit. Pett.	Courma START	La Thuile	Valgrisa IN	Valgrisa OUT	Rhemes	Eaux R.	Cogne IN	Cogne OUT	Sogno	Chard.	Donnas IN
I	37	COULEAUD	STEPHANE	V1 M	SI	10:00	Dom 12:22	Dom 17:44	Dom 17:57	Dom 20:50	Lun 0:39	Lun 7:45	Lun 8:17	Lun 11:11	Lun 13:12	Lun 16:32

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