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Intermittent training
A must. And in hypoxia?

Raphael Faiss
Lifescience PhD Student, Institute of sport sciences,
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From the Fartlek to High-intensity intermittent training (HIT):

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1920 Paavo Nurmi
1930 Gösta Holmér -> Fartlek
1940 Gerschler and Reindel -> Interval training
1950 Zatopek -> Splits

Discontinuous physical training
->series of high-intensity exercise workouts
->interspersed with active/passive recovery periods

Scientific basis for the efficiency of HIT

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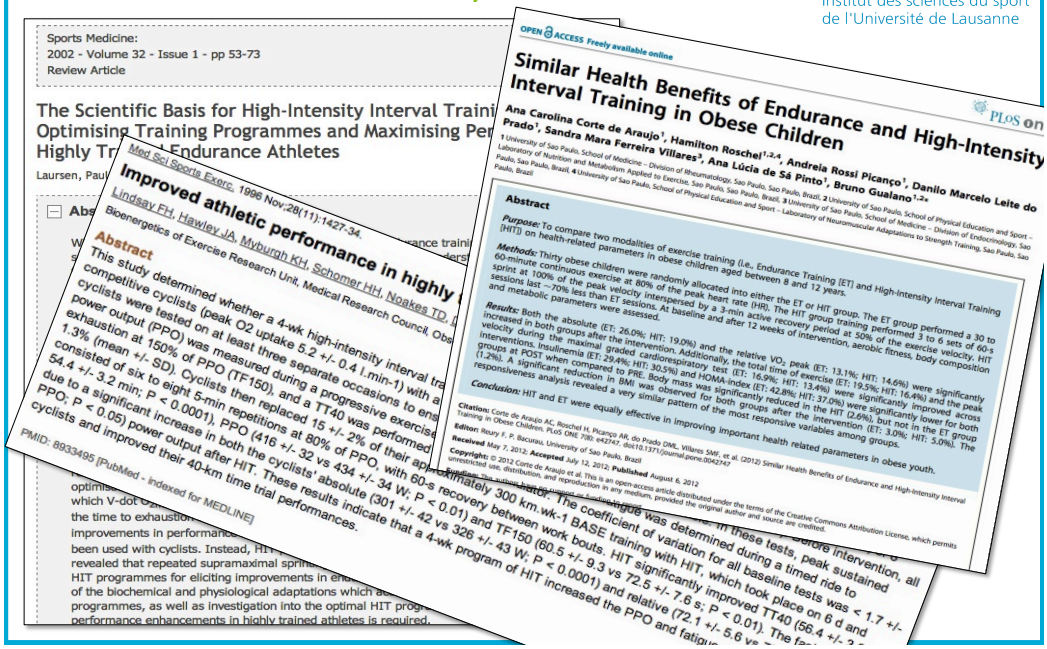

Exercise energetics: from oxygen to power

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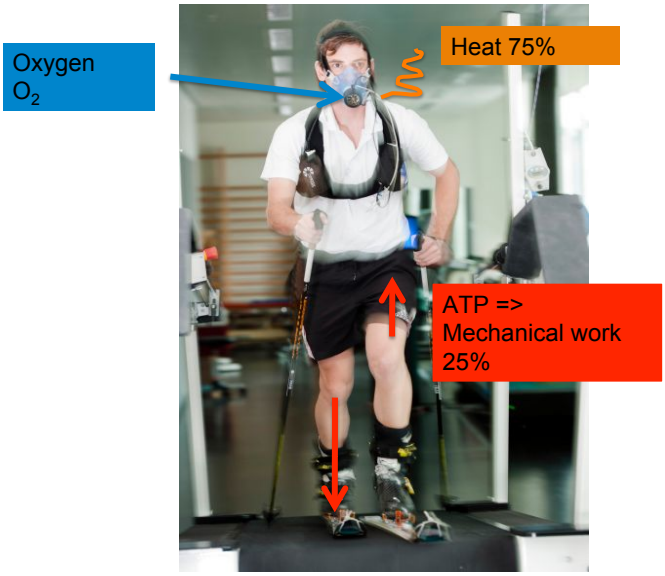

Energetics of muscular exercise

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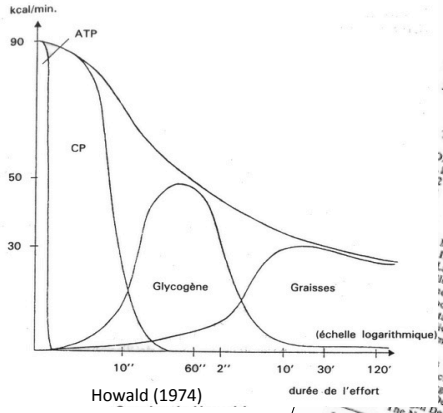
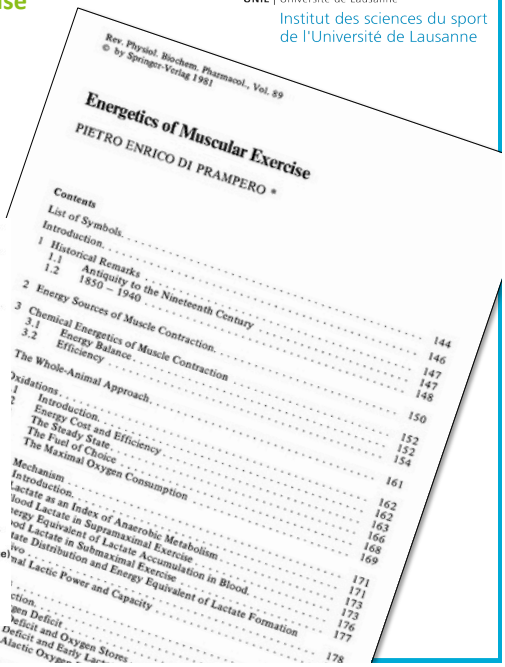
- Oxidative mechanism
- Lactate mechanism
- Transients (Oxygen deficit)



Howald (1974)



Energy systems
Aerobic glycolysis

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- Glucose ⟷ (11 reactions) 2 pyruvic acid +2 ATP
- Lipids → (ß-oxydation) Acetyl-CoA (with oxygen)
- Acetyl-CoA → Krebs Cycle → 36 ATP + CO_2 + H_2O
- Aerobic glycolysis
  - Aerobic = with oxygen
  - Limited power (linked to VO_2max 70 ml/kg/min = 6 W/kg, 50 ml/kg/min = 4W/kg)
  - Important capacity (5-10 min at VO_2max up to several hours)
  - Slowed availability (VO_2 kinetics)
  - Long recovery (12-72 h)

Oxygen consumption dynamics

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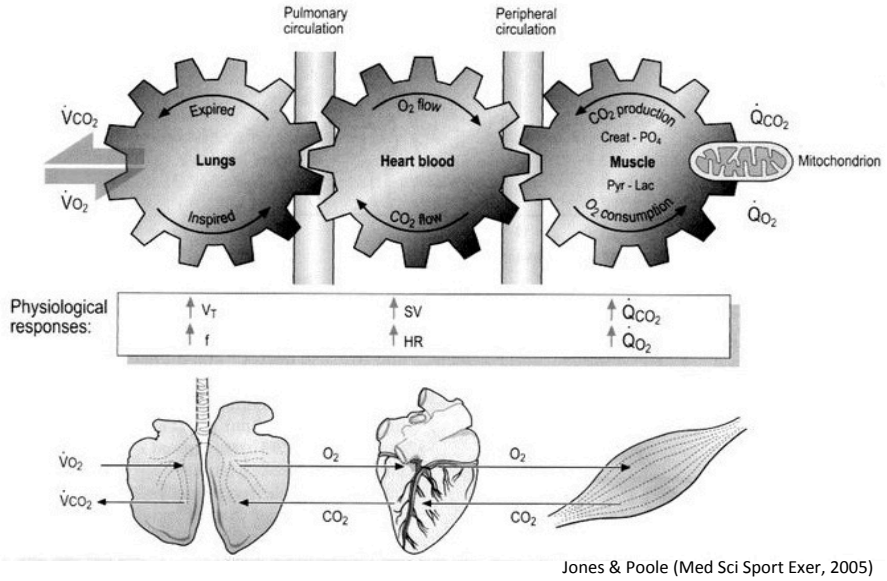

Jones & Poole (Med Sci Sport Exer, 2005)

Transient:; oxygen deficit

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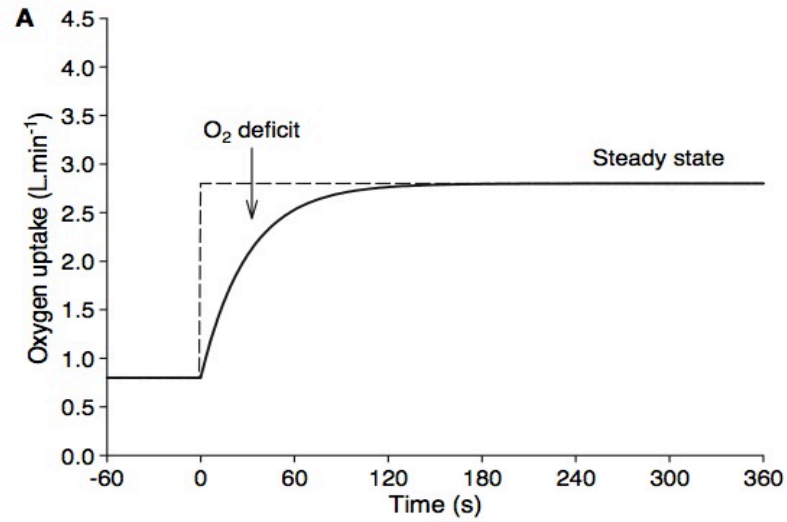

Burnley & Jones, Eur J Sport Sci 2007

Oxygen uptake dynamics to design innovative training

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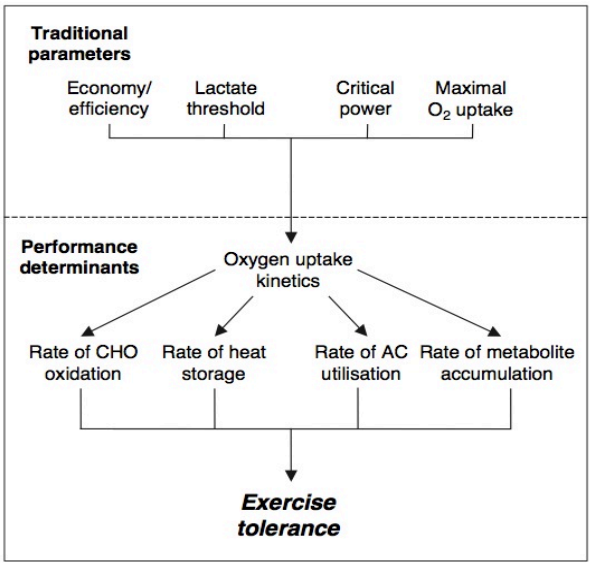

Burnley & Jones, Eur J Sport Sci 2007

Oxygen uptake dynamics

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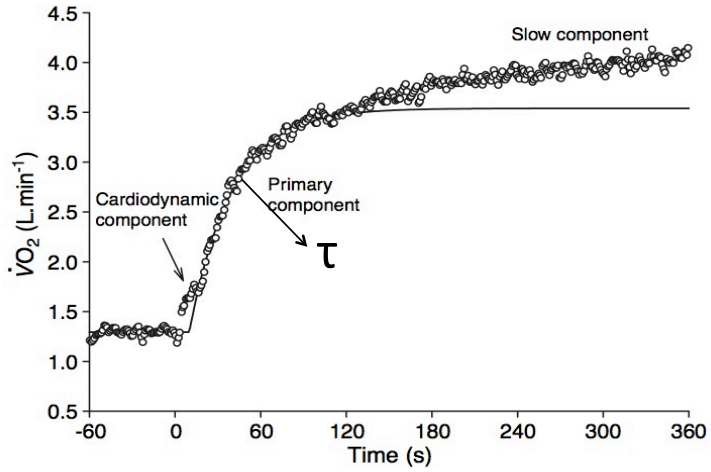

Burnley & Jones, Eur J Sport Sci 2007

Oxygen uptake kinetics: what makes the difference?

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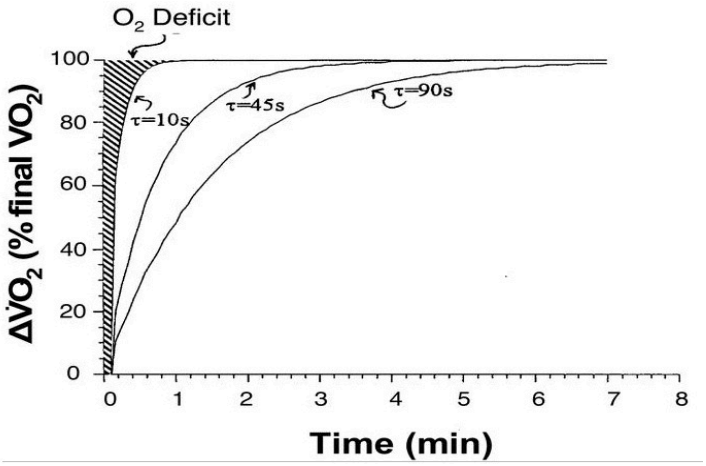

Jones & Poole (Med Sci Sport Exer, 2005)

Oxygen uptake dynamics: training effect (10x 2'-2' during 6 weeks)

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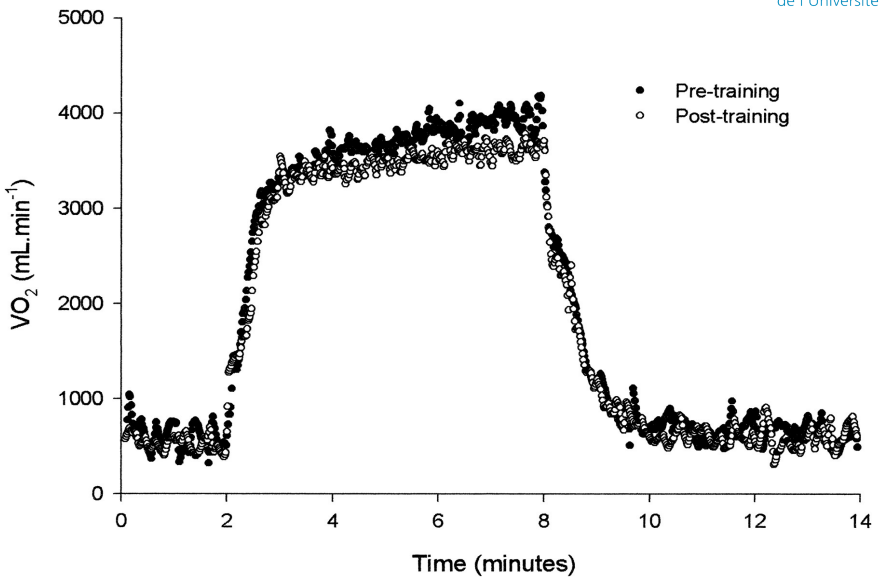

Carter H et al. J Appl Physiol 2000

Training advice : intermittent type

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Intermittent type	Time spent (seconds): > 90% VO2max	>90% FCmax
30-30	149 ± 133	441 ± 317
60-30	531 ± 187***	744 ± 207**
½ T_{lim}-1/2 T_{lim}	486 ± 176***	633 ± 153**

Millet et al. Eur J App Phys 2003

- Find the right work/rest ratio to optimize time spent near VO2max

Training advice : exercise intensity

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Intermittent intensity	Time spent (seconds): > 90% VO2max	>90% FCmax
IT 100% of vVO_{2max}	168 ± 131	430 ± 340
IT 105% of vVO_{2max}	338 ± 149**	844 ± 184***
T_{lim} test	135 ± 53	213 ± 38

Millet et al. Eur J App Phys 2003

- Adjust to the correct exercise intensity

Training advice

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- Individual training
- Based on VO_2 kinetics &T_{lim}
- Determine Intensity to reach VO_2max
- Amplitude exercise/recovery
  - (20-30% difference between exercise and recovery intensities)
    - Billat et al. 2001
  - Depends on goals (aerobic power or anaerobic capacity)
- Sport specific oxygen uptake kinetics (slower in Cycling)
    - Hill et al. 2003
- Specific tools to measure the right intensity

Real training with a powermeter

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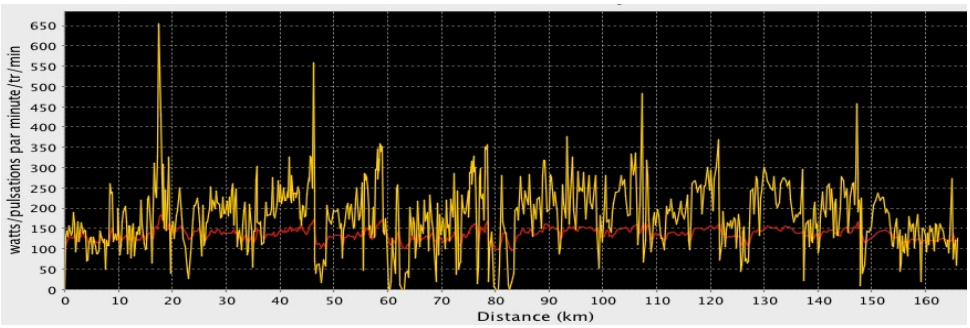

Real training: structured HIT session

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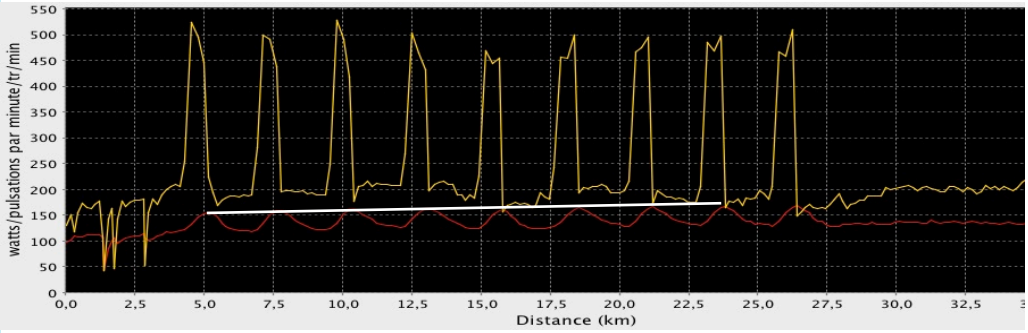

Real training: criterium race

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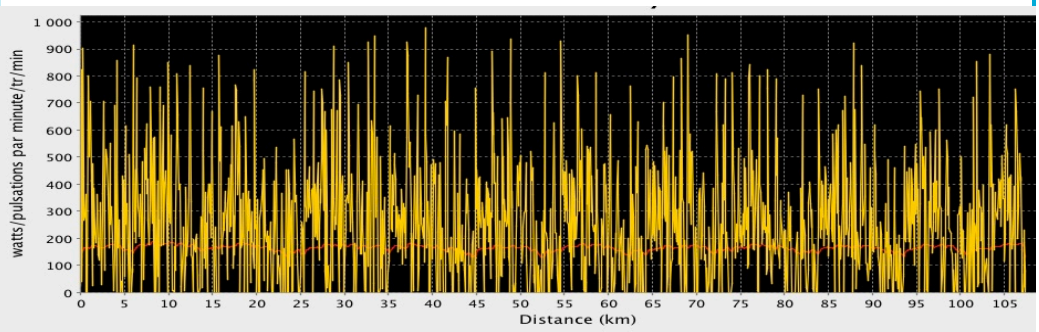

Total temps passé	02:29:29
Durée du parcours (Temps en mouvement)	02:29:30
Distance, km	107,42
Travail, kJ	2450
Température, °C	--
Puissance moyenne, Watts	273
Cadence moyenne	82
Vitesse moyenne, kph	43,12
Fréquence cardiaque moyenne	165
Poids, kg	72,0

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Intermittent training
A must. And in hypoxia?

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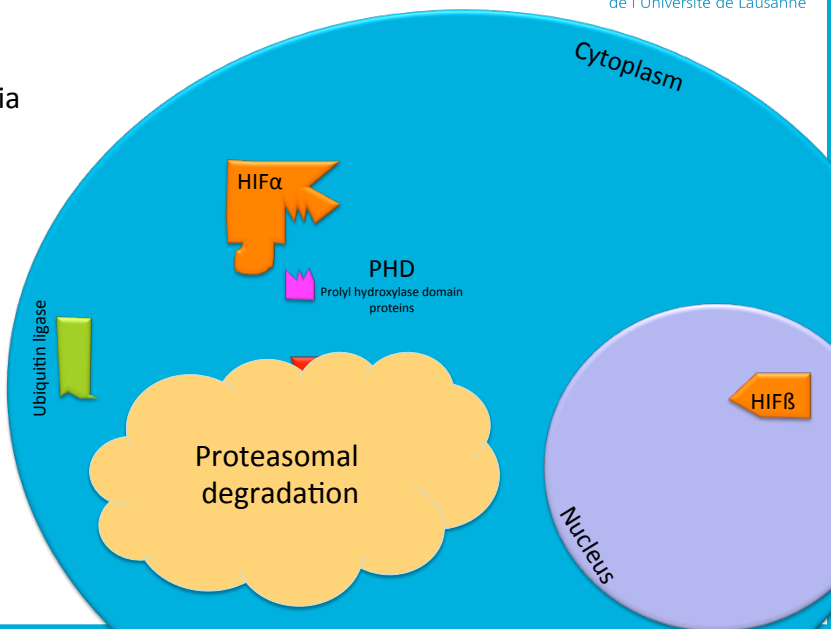
HIF signaling pathways (very simplified)

In normoxia



HIF signaling pathways (very simplified)

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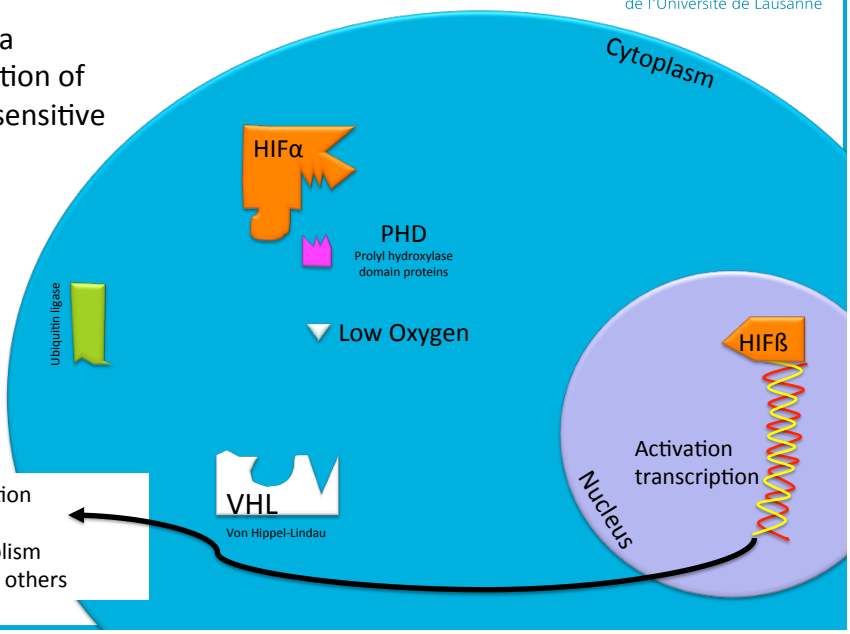
In hypoxia
Upregulation of
Hypoxia sensitive
genes



Hormonal regulation
Angiogenesis
Energetic metabolism
And a hundred of others

Hypoxic exercise and response at the muscular level

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(Vogt et al., 2001)

J Appl Physiol
91: 173–182, 2001.

Molecular adaptations in human skeletal muscle to endurance training under simulated hypoxic conditions

M. VOGT,[1] A. PUNTSCHART,[1] J. GEISER,[2] C. ZULEGER,[2,†]
R. BILLETER,[1] AND H. HOPPELER[1]
[1]*Institute of Anatomy, University of Bern, 3012 Bern; and* [2]*Institute of Physiology, University of Fribourg, 1700 Fribourg, Switzerland*

4 times 30 min.wk^{-1} during 6 weeks.
High (4-6 mM) vs. low-intensity (2-3 mM)

Altitude = 3850 m

IHT could modify the gene expression

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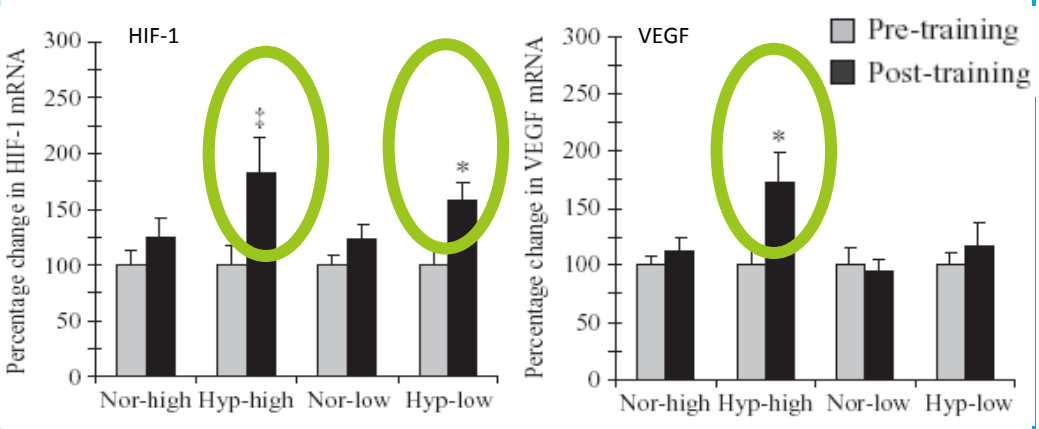
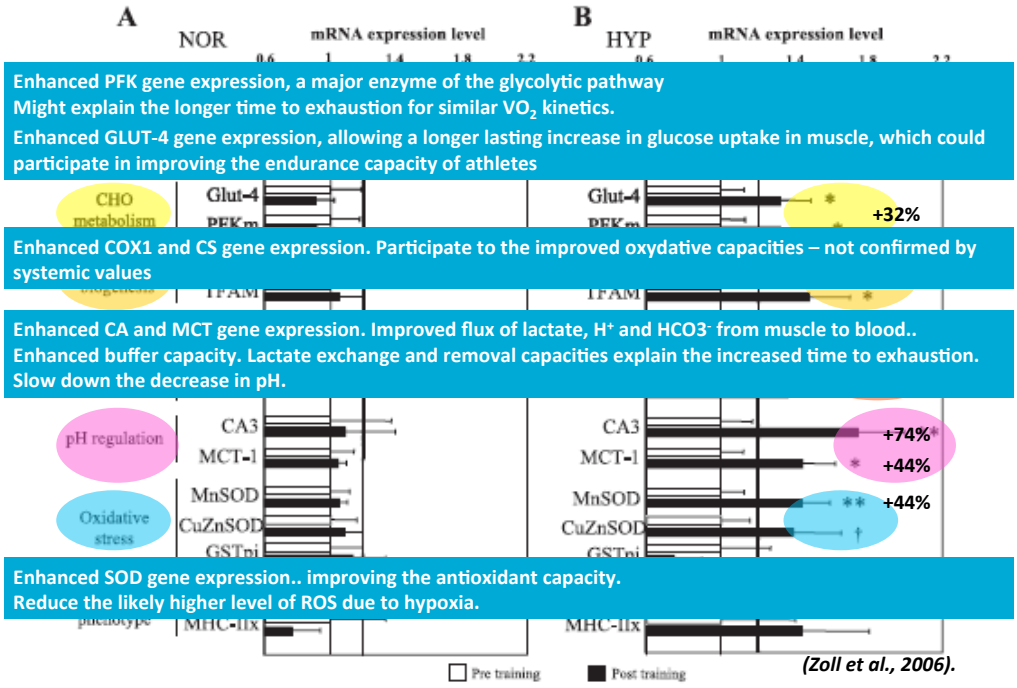
mRNA of Hif 1 and VEGF increased
but only after the high intensity training in hypoxia.



Hoppeler & Vogt, 2001



Enhanced PFK gene expression, a major enzyme of the glycolytic pathway
Might explain the longer time to exhaustion for similar VO_2 kinetics.
Enhanced GLUT-4 gene expression, allowing a longer lasting increase in glucose uptake in muscle, which could participate in improving the endurance capacity of athletes

Enhanced COX1 and CS gene expression. Participate to the improved oxydative capacities – not confirmed by systemic values

Enhanced CA and MCT gene expression. Improved flux of lactate, H^+ and $HCO3^-$ from muscle to blood..
Enhanced buffer capacity. Lactate exchange and removal capacities explain the increased time to exhaustion.
Slow down the decrease in pH.

Enhanced SOD gene expression.. improving the antioxidant capacity.
Reduce the likely higher level of ROS due to hypoxia.

(Zoll et al., 2006).

Repeated Sprint Training (RS) study

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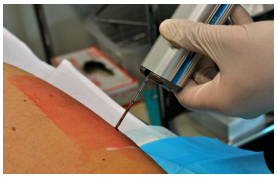
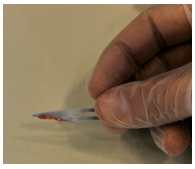
- 50 male subjects (35 ± 7 years, 75 ± 9 kg, 179 ± 5 cm)
- 4 weeks of RS training (8 sessions)
  - Hypoxic training group (3000m)
  - Normoxic training group (485m)
  - Control group
  - Cyclists

  - Hypoxic Group (3000m)
  - Normoxic Group (485m)
    (single blind)





Training sessions: 8 sessions of 37' over 4 weeks

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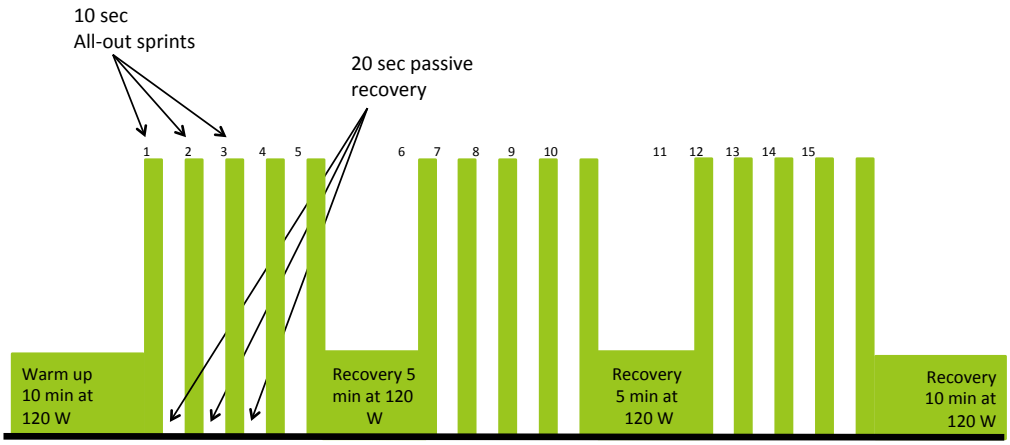

Results: number of sprints

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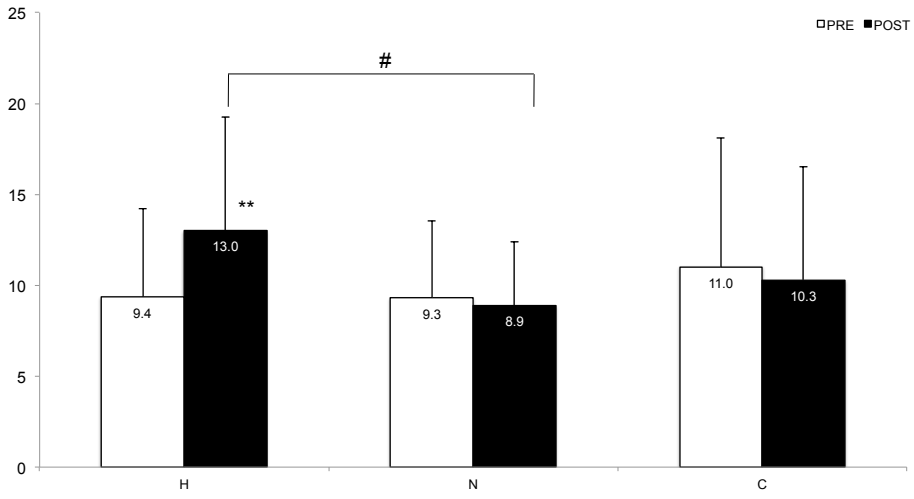

** p<0.01 for difference with PRE
# p<0.01 for difference with N

Results: mean power of all sprints

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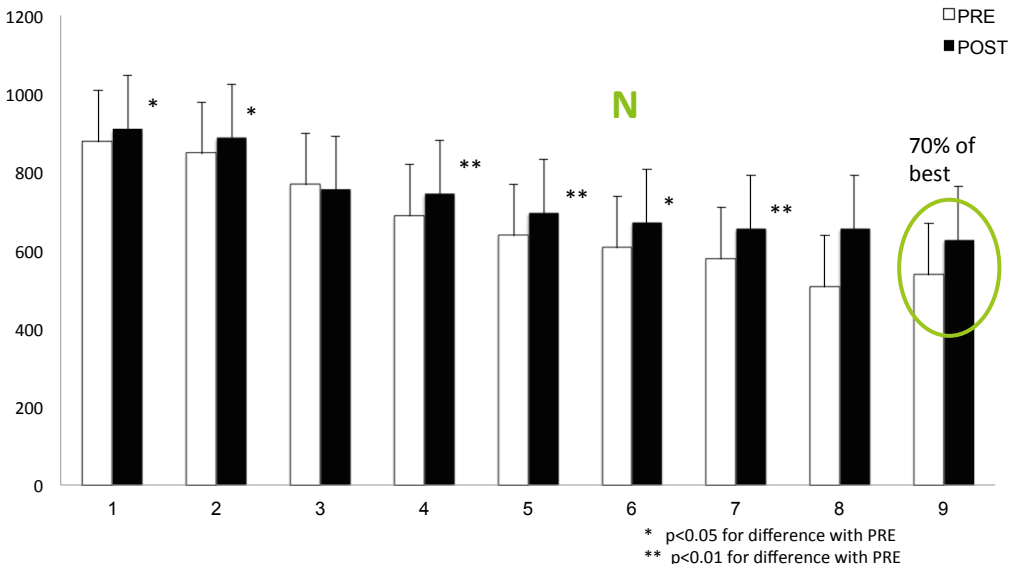

* p<0.05 for difference with PRE
** p<0.01 for difference with PRE

Results: mean power of all sprints

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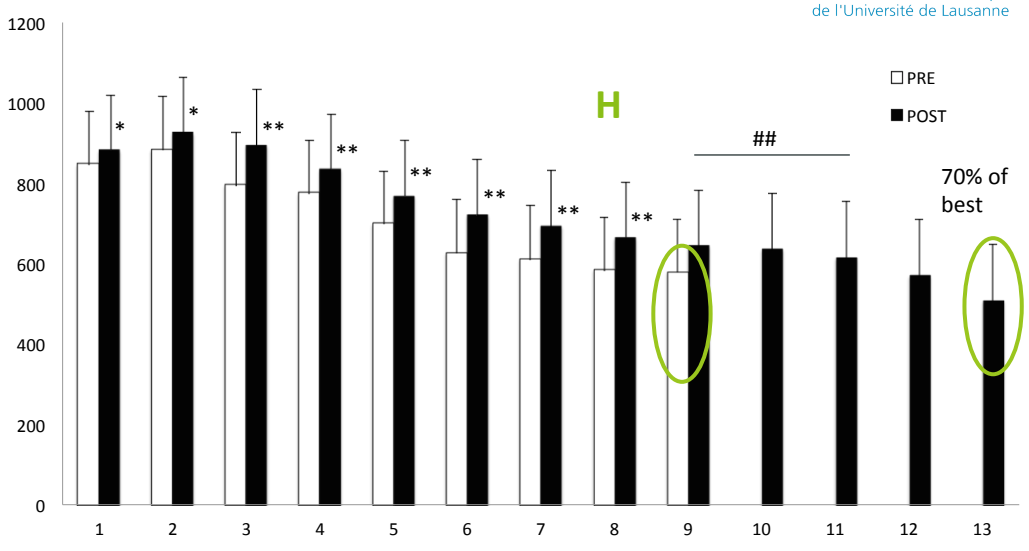

** p<0.01, * p<0.05 for difference with PRE
p<0.01 for difference with last sprint in PRE sprint #9

Résultats: muscle biopsies mRNA expression levels

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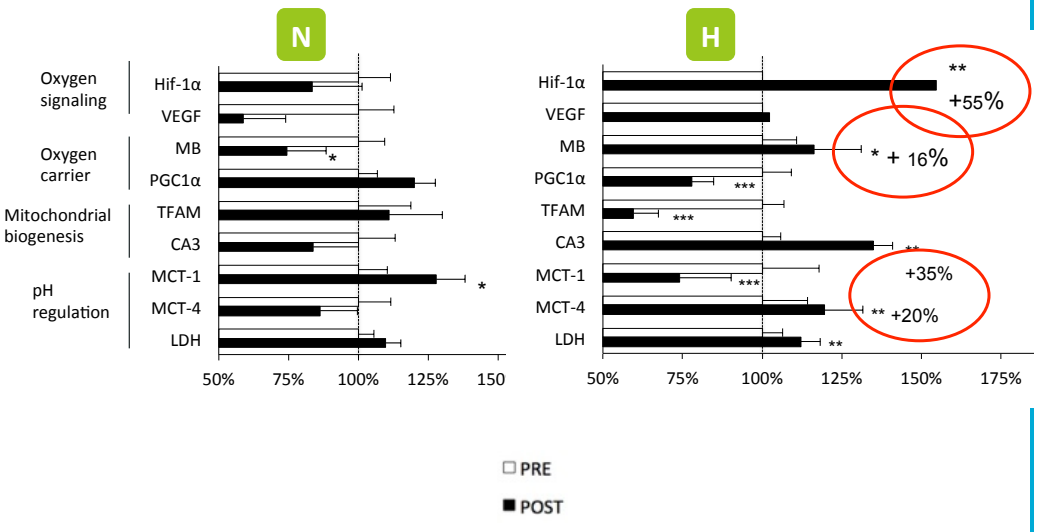

*** p<0.01, ** p<0.05, * p<0.1 for difference with PRE

Muscle oxygenation during the successive sprints

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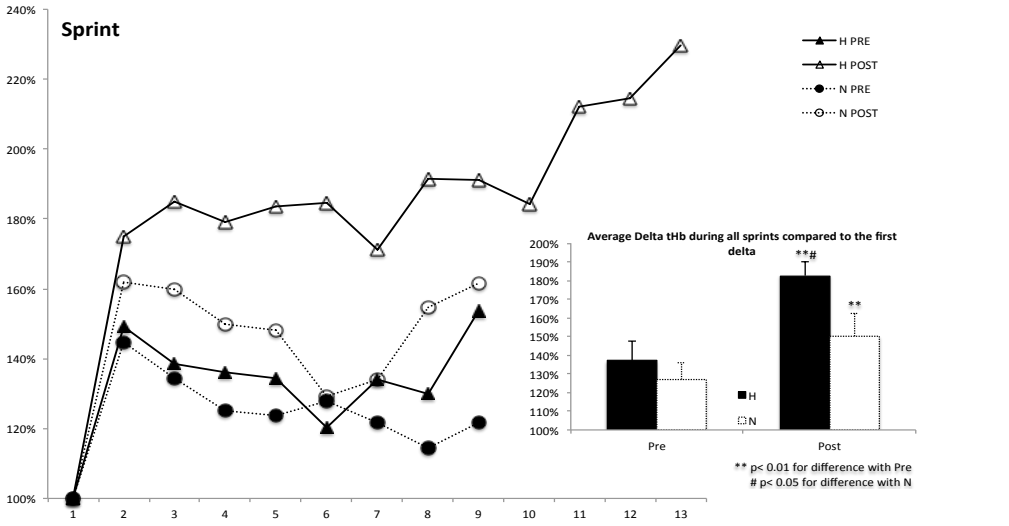

Repeated sprint study conclusions

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- The ability to repeat sprints is further enhanced by intensive training in hypoxia than in normoxia

Benefit of a high altitude high-intensity intermittent training for intermittent sports (e.g. team and racquet sports).

- Similar responses in
  - Aerobic performance (3min all-out test)
  - Glycolytic parameters (Wingate , [La])
  - Alactic parameters (single sprint)

Improvement in RSA observed in H can only be due to peripheral molecular adaptations at the muscular level with better substrate utilization and waste metabolites removal induced by high-intensity hypoxic training.

Ateliers pratiques

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- Test VO2max
- Temps limite
- Mesure de la VO2 pendant l'entrainement
- Outils d'analyse de la performance
  - Aérobie & anaérobie

Merci de votre attention!

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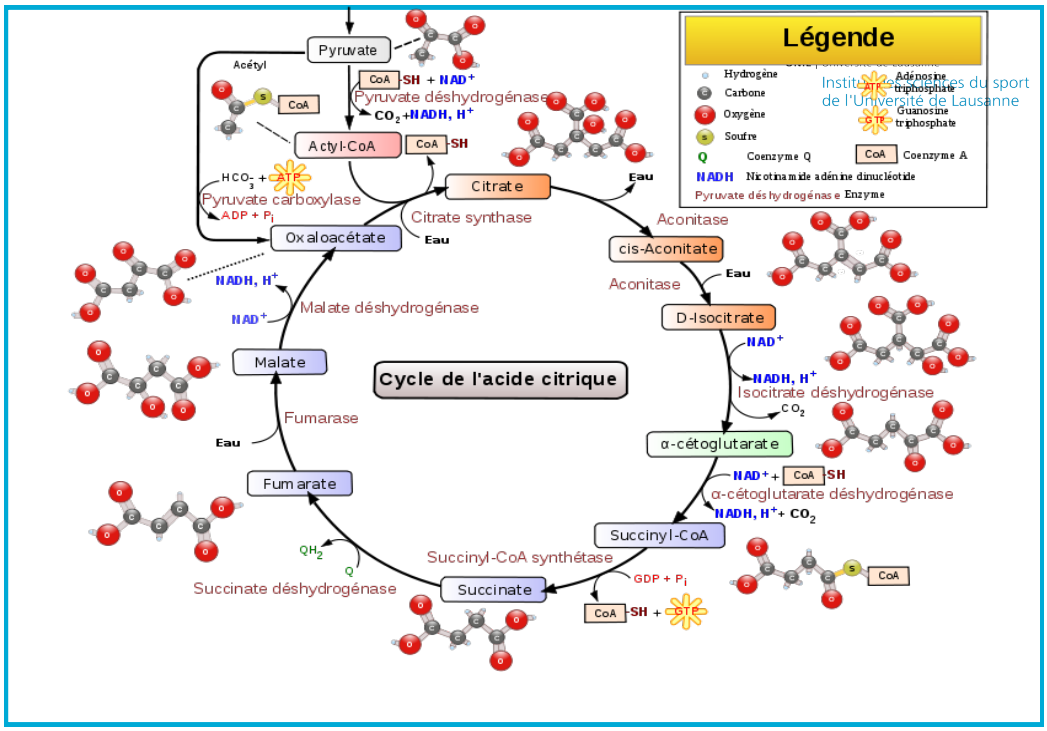
Institut de recherche en réadaptation-réinsertion

Contact:
Raphael.Faiss@unil.ch
www.unil.ch/issul

Clinique romande de réadaptation



Sprinting and the relative energy system contribution to ATP resynthesis

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