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Innovations in hypoxic training

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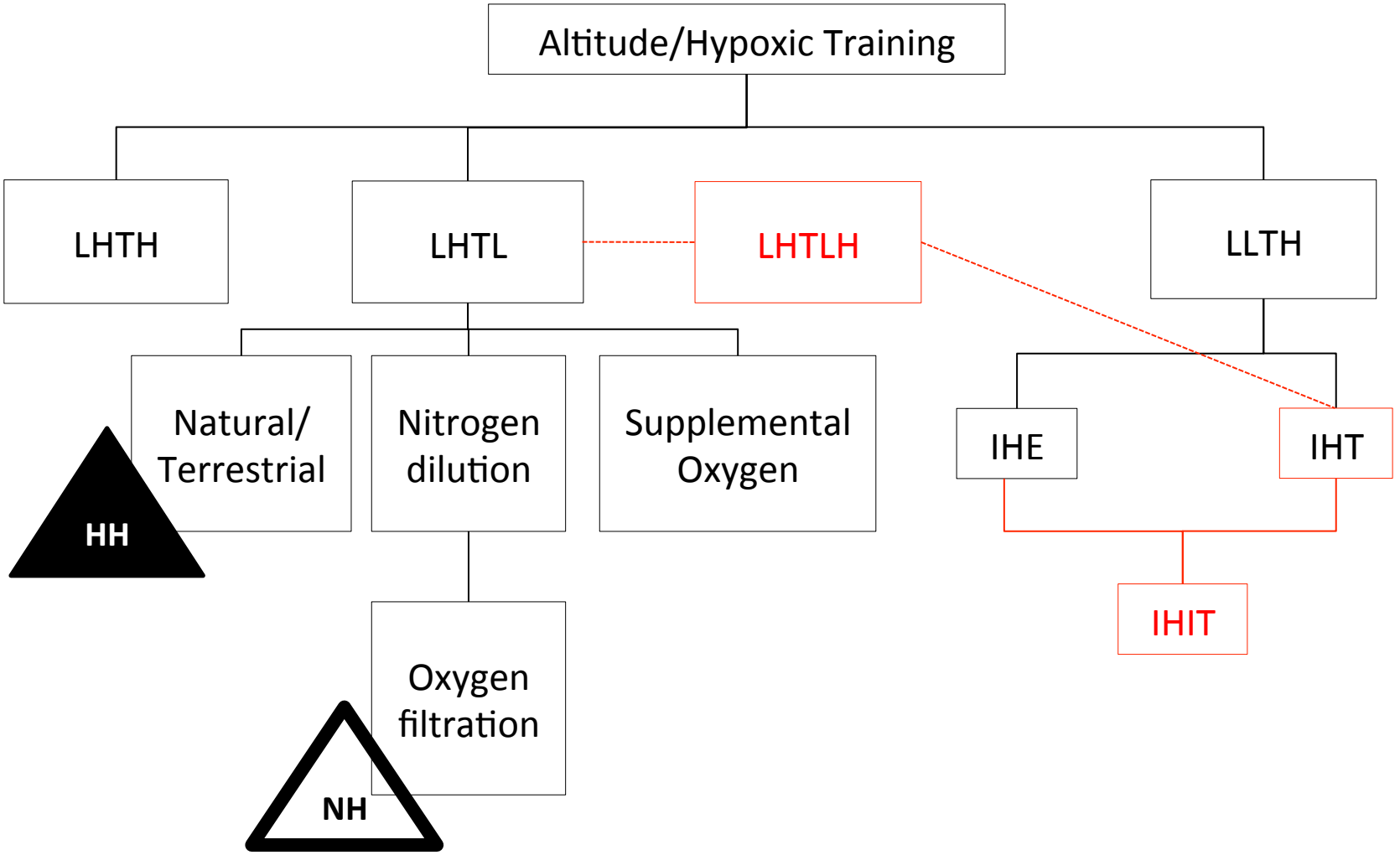
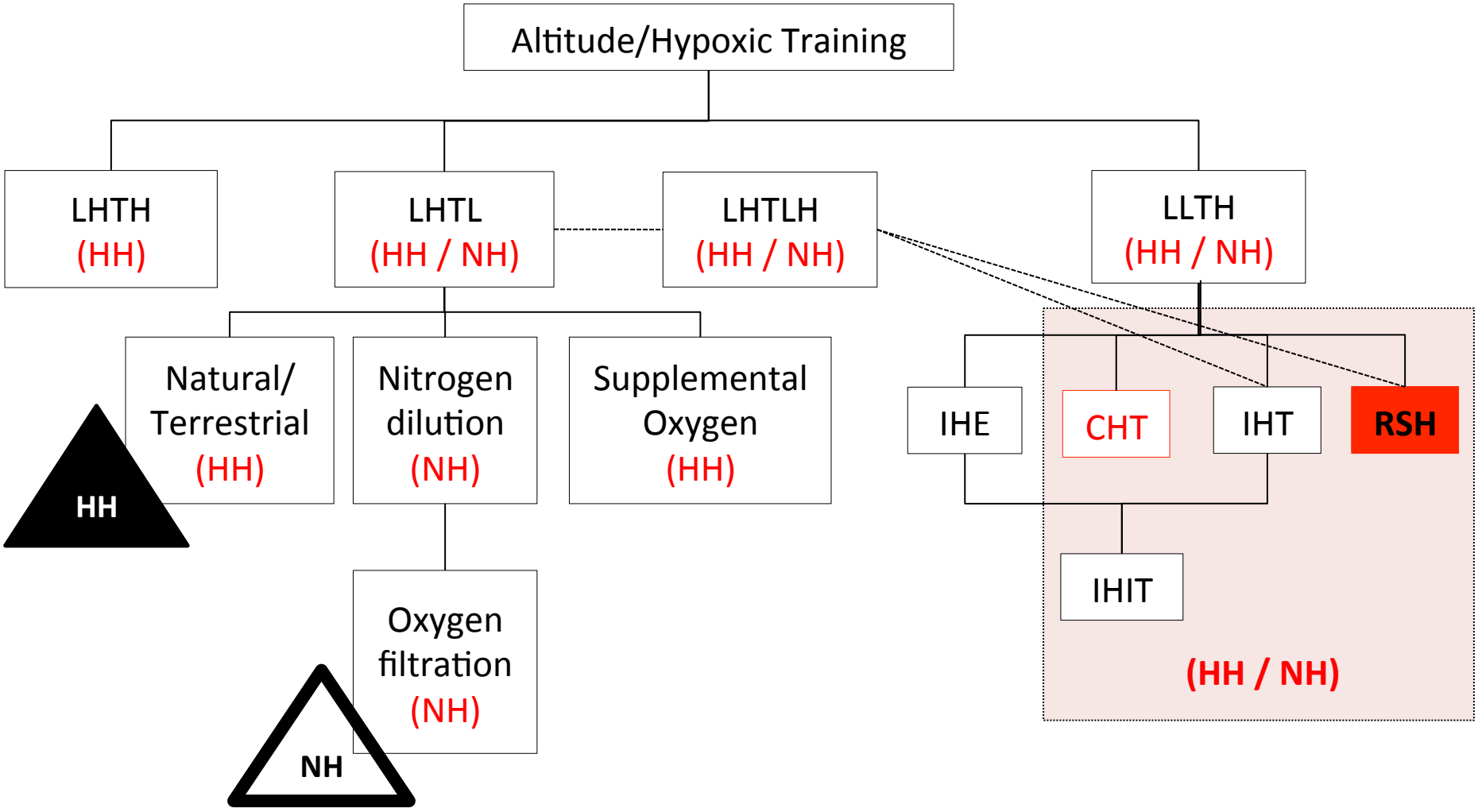
Panorama of contemporary altitude training strategies



Millet et al (2010) Combining hypoxic methods for peak performance. Sports Med

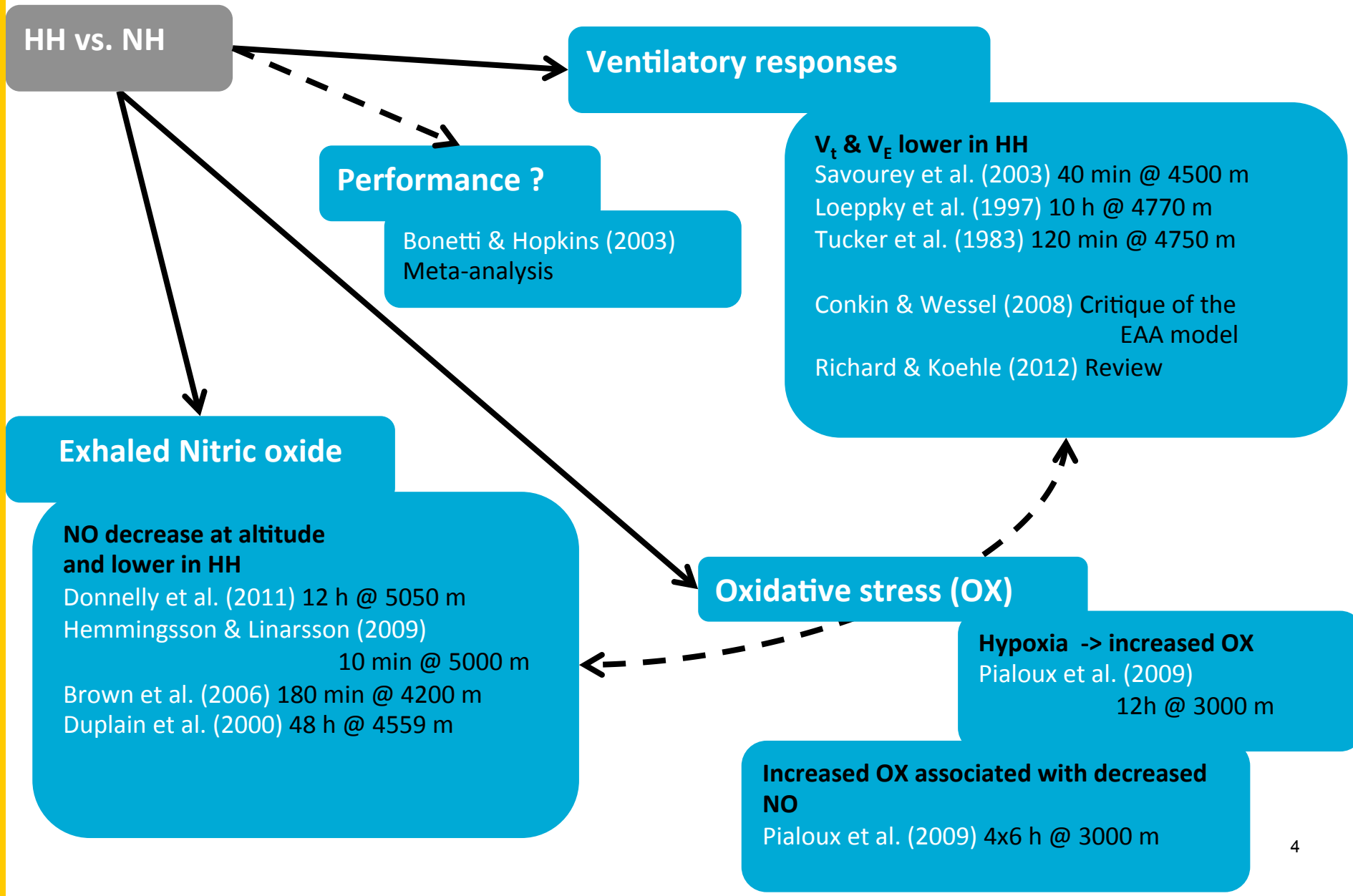
Wilber (2007) Application of altitude/hypoxic training by elite athletes. Med Sci Sports Exerc

Updated panorama of contemporary altitude training strategies



Millet, Faiss et al (2013) Hypoxic training and team sports: a challenge to traditional methods? Br J Sports Med
Millet et al (2010) Combining hypoxic methods for peak performance. Sports Med
Wilber (2007) Application of altitude/hypoxic training by elite athletes. Med Sci Sports Exerc

Hypobaric vs. Normobaric Hypoxia



HH vs. NH study: 2 x 24 h hypoxic exposure

HH

Hypobaric Hypoxia

NH

Normobaric Hypoxia

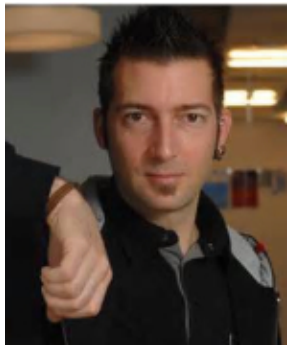
at 3000m &
randomized

PRE H+1 H+8 H+16 H+24

5 min at rest -> 6min cycling at 50% of normoxic PPO -> 10min at rest

Normoxia Hypoxia **HH vs. NH**

Normobaric Hypoxia (NH) vs. Hypobaric Hypoxia (HH)



Jonas Saugy

Performance alteration

HH (Jungfraujoch, 3540 m) vs. NH and NN (hypoxic chamber) during 26 h

Saugy et al. (in prep) Neuromuscular and cerebral responses to acute exposure to 3500 m hypobaric vs. normobaric hypoxia

HH vs. NH : published articles

1. **Ventilation, Oxidative Stress and Nitric Oxide in Hypobaric vs. Normobaric Hypoxia** Faiss R, Pialoux V, Sartori C, Faes C, Deriaz O & Millet GP. (2013). *Med Sci Sports Exerc*; 45(2):253-60

2. **Evidence for differences between hypobaric and normobaric hypoxia is conclusive.** Millet G, Faiss R & Pialoux V. (2013). *Exerc sport sci rev*;41(2):133

3. **Point:Counterpoint Hypobaric hypoxia induces different physiological responses from normobaric hypoxia**. Millet GP, Faiss R & Pialoux V. (2012). *J Appl Physiol*; 112, 1783-1784.

4. **Last word on Point: Counterpoint: Hypobaric hypoxia induces different responses from normobaric hypoxia**. Millet GP, Faiss R & Pialoux V. (2012). *J Appl Physiol*; 112, 1795.

5. **Hypoxic conditions and exercise:rest ratio are likely paramount.** Millet GP & Faiss R, Sports Med. 2012 Dec 1; 42(12):1081-3.

6. **Responses to exercise in normobaric hypoxia: comparison between elite and recreational ski-mountaineers.** Faiss R., von Orelli C., Dériaz O., Millet G.P. (2014) Int J Sports Physiol Perf; 9, 978 – 984
7. **Hypobaric versus normobaric hypoxia: same effects on postural stability?** Degache F, Larghi G, Faiss R, Deriaz O & Millet G. (2012). *High Alt Med Biol*; 13:40-45.

Hypobaric vs Normobaric Hypoxia

HH vs. NH

Saugy et al., in prep

Ventilatory responses

V_t & V_E lower in HH
Savourey et al. (2003) 40 min @ 4500 m
Loeppky et al. (1997) 10 h @ 4770 m
Tucker et al. (1983) 120 min @ 4750 m

Conkin & Wessel (2008) Critique of the EAA model
Richard & Koehle (2012) Review

Performance ?

Bonetti & Hopkins (2003)
Meta-analysis

Exhaled Nitric oxide

NO decrease at altitude and lower in HH
Donnelly et al. (2011) 12 h @ 5050 m
Hemmingsson & Linarsson (2009) 10 min @ 5000 m
Brown et al. (2006) 180 min @ 4200 m
Duplain et al. (2000) 48 h @ 4559 m

Oxidative stress (OX)

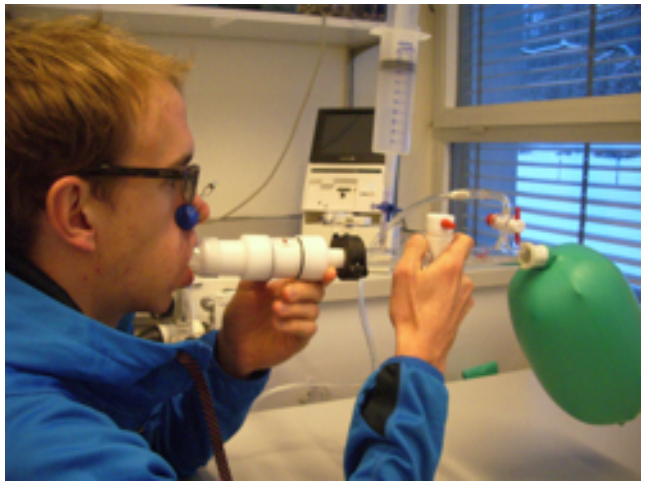
Faiss et al. 2013

Hypoxia -> increased OX
Pialoux et al. (2009) 12h @ 3000 m

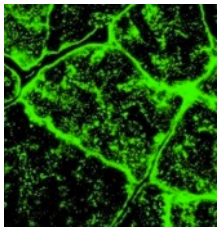
Increased OX associated with decreased NO
Pialoux et al. (2009) 4x6 h @ 3000 m

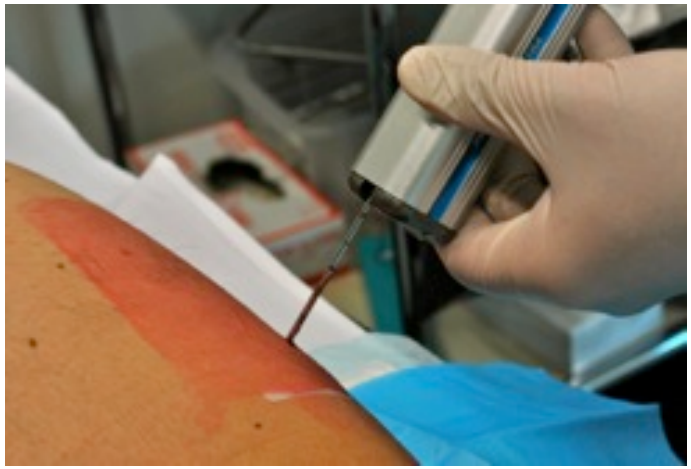
Altitude training: vectors for performance improvement

Augmented hemoglobin mass?



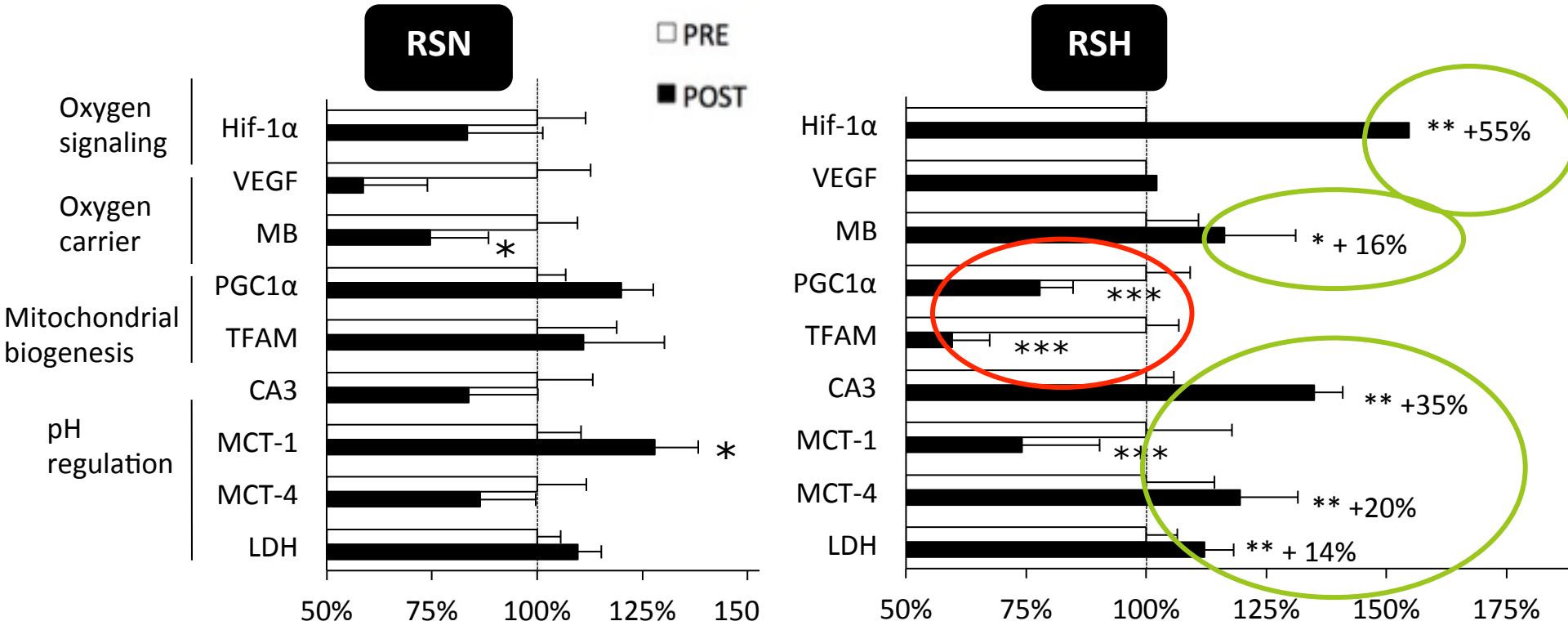
Modifications at the muscular level ?





Point:Counterpoint Positive effects of intermittent hypoxia (live high: train low) on exercise performance are/are not mediated primarily by augmented red cell volume.
Levine vs. Gore J Appl Physiol 2005 Nov; 99 (5): 2053-5

Muscle biopsies mRNA expression levels : significant modifications at muscular level after repeated sprint training in hypoxia (RSH)



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

Specificic molecular adaptations: shift towards increased glycolytic activity

Hoppeler & Vo*gt.* 2001 ; Dufour *et al*. 2006; He *et al*. 2011

Significant molecular and systemic adaptations after repeated sprint training in hypoxia. Faiss R. et al. (2013) PLoS One

Innovation: Repeated sprint training in hypoxia (RSH)

- 50 male cyclists
- Normobaric hypoxic chamber

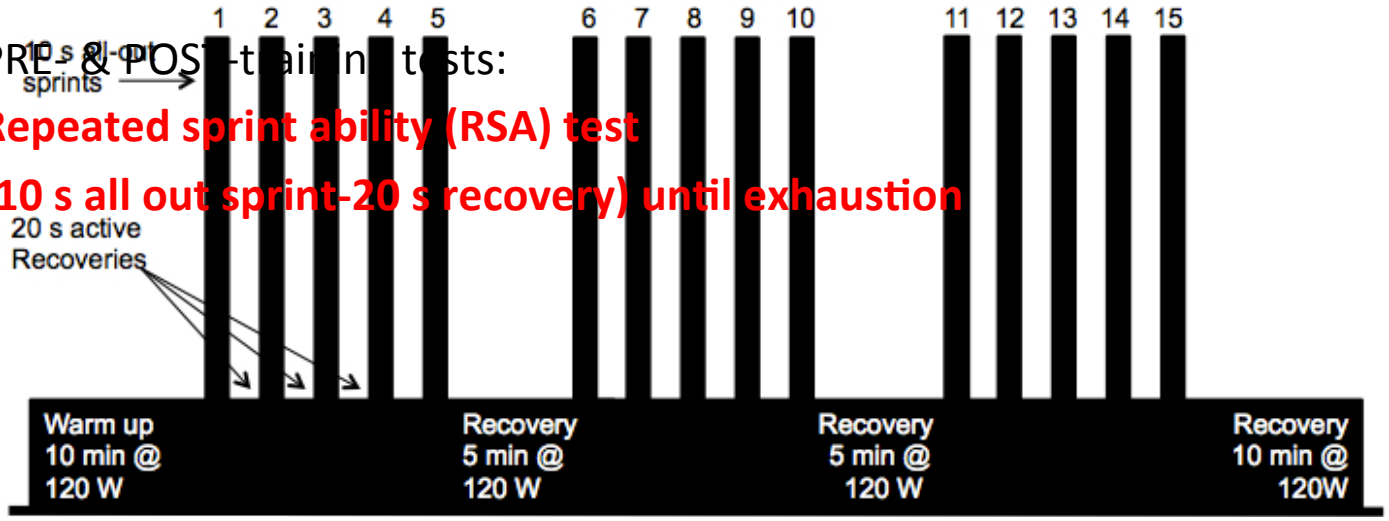
Hypoxic group (n=20, 3000 m, F_iO_2 =14.7%) **RSH**
Normoxic group (n=20, 485 m, F_iO_2 =20.9%) **RSN**
Control group (n=10, no training)

- 4 weeks of cycling training
- 120 sprints in 8 sessions

PRE- & POST-training tests:

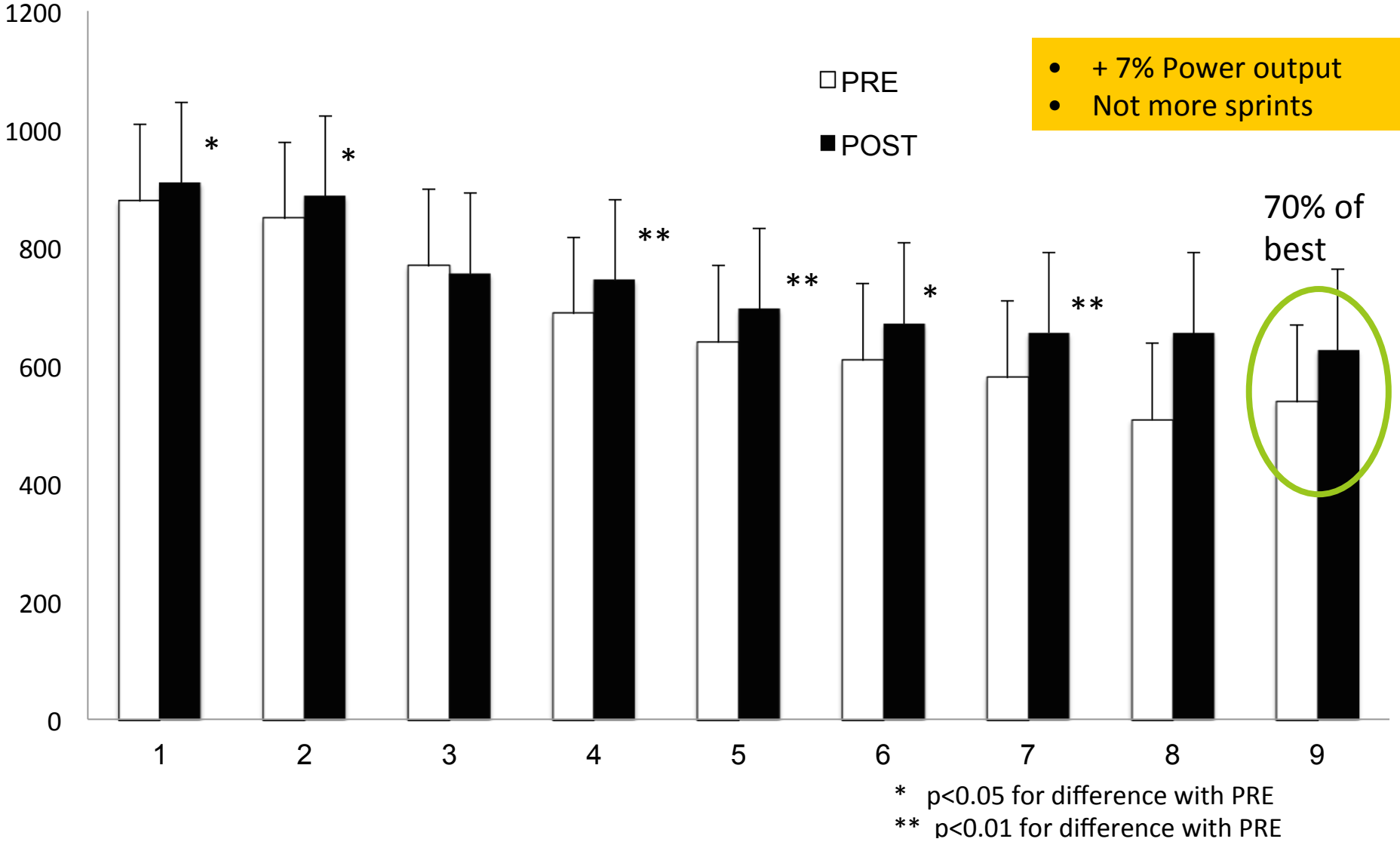
Repeated sprint ability (RSA) test

(10 s all out sprint-20 s recovery) until exhaustion



Significant molecular and systemic adaptations after repeated sprint training in hypoxia. Faiss R. et al. (2013) PLoS One

Results:
mean 10 s power of all sprints (W)

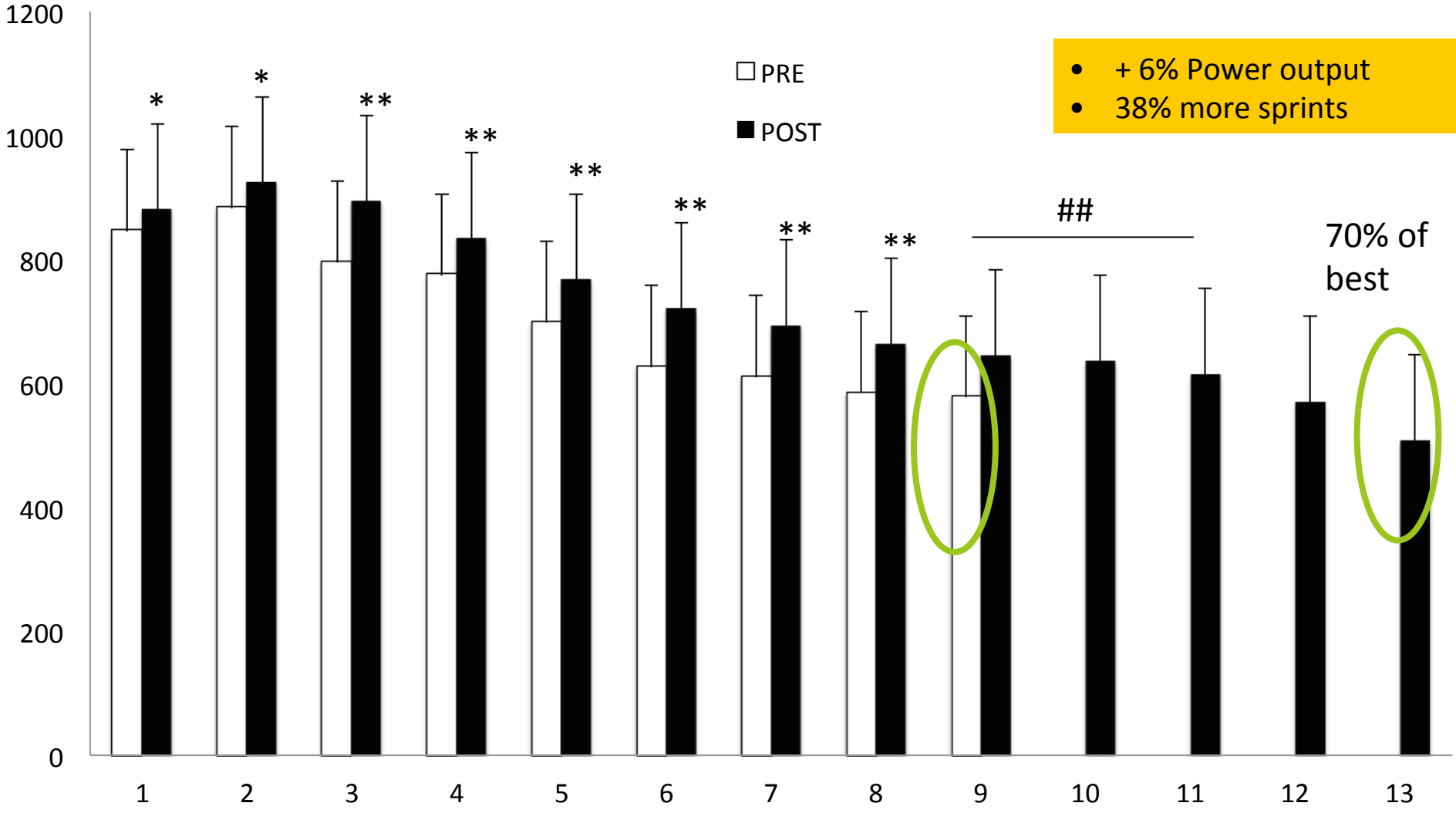


- + 7% Power output
- Not more sprints

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

Significant molecular and systemic adaptations after repeated sprint training in hypoxia. Faiss R. et al. (2013) PLoS One

Results:
mean 10 s power of all sprints (W)

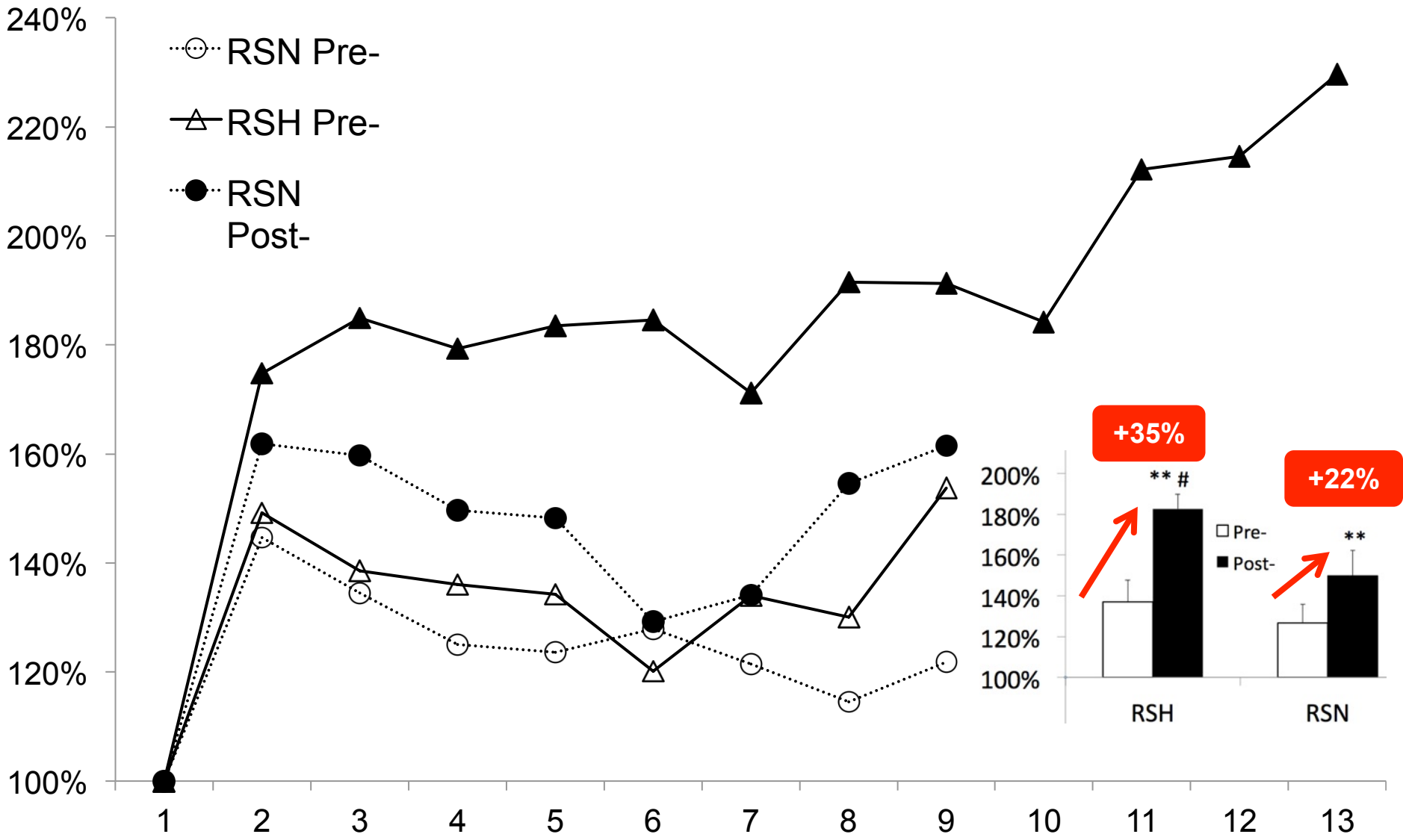


** p<0.01, * p<0.05 for difference with PRE
p<0.01 for difference with last sprint in PRE sprint #9

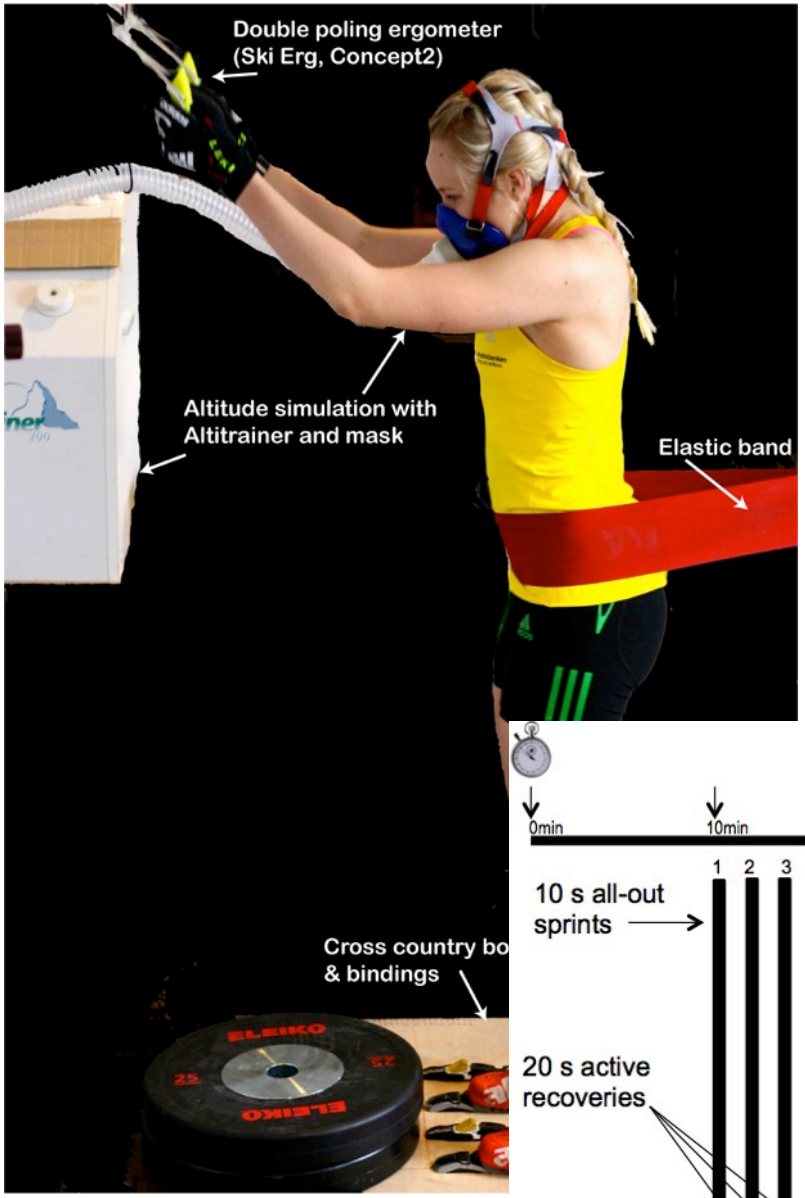
Significant molecular and systemic adaptations after repeated sprint training in hypoxia. Faiss R. et al. (2013) PLoS One

Muscle oxygenation

Muscle oxygenation during the successive sprints
->variations in total hemoglobin **Δ**tHb



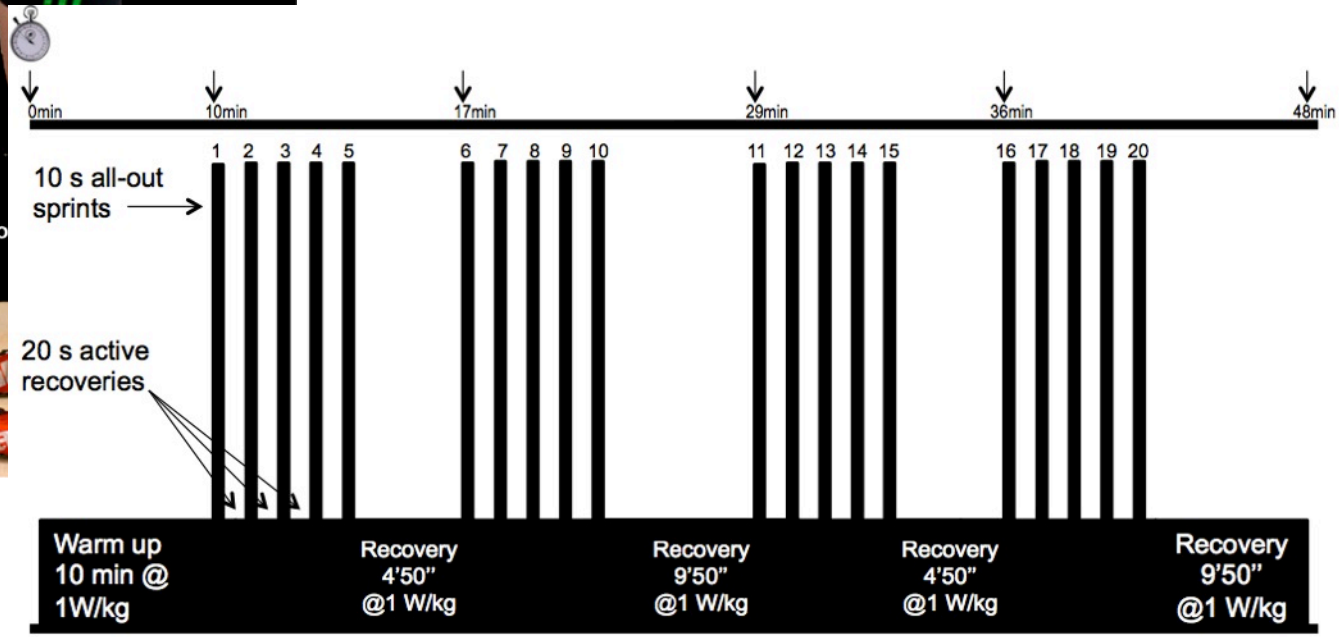
RSH in elite cross-country skiers



2 weeks of double poling training (6 sessions)
= 120 sprints

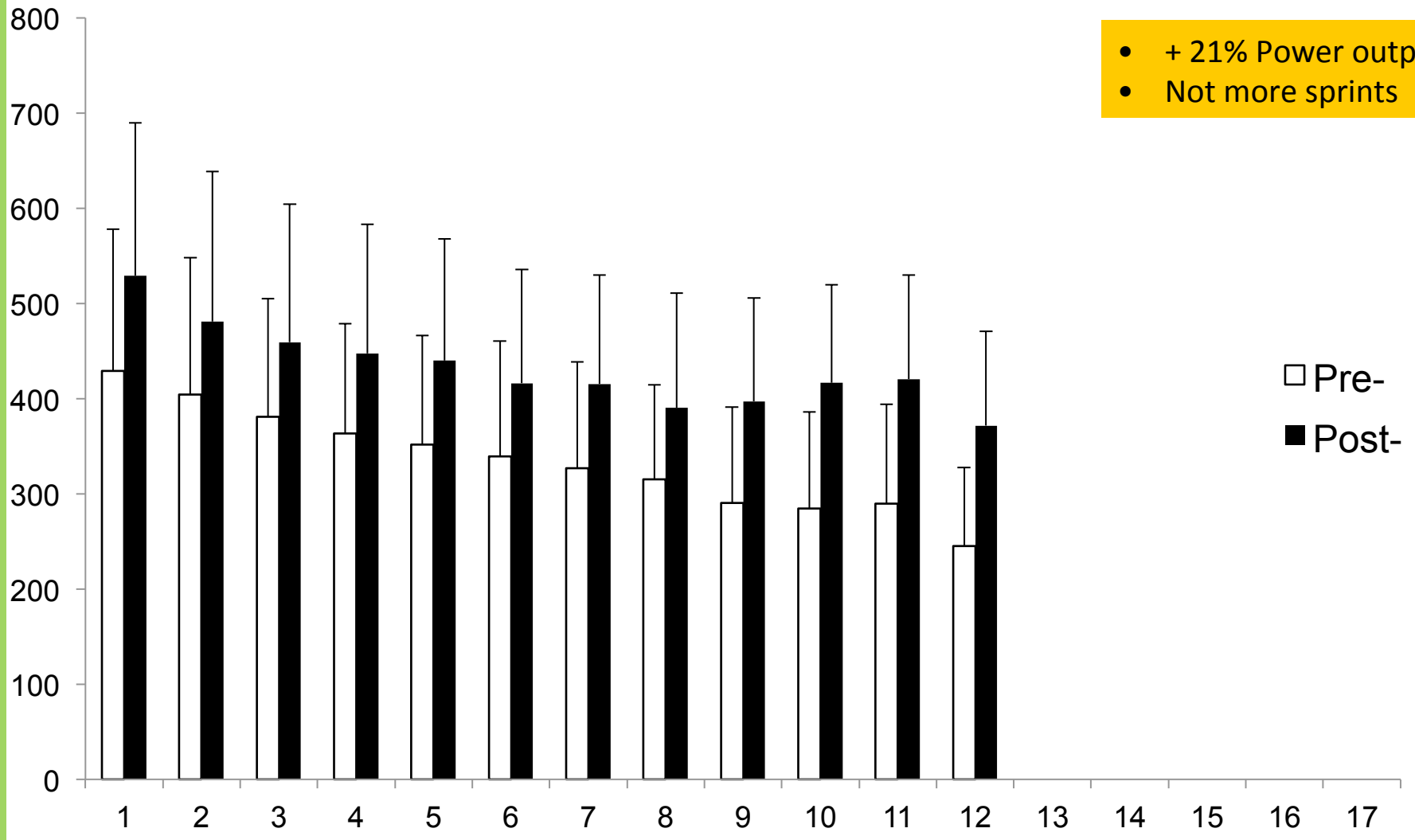
2 groups :
Repeated sprint training in normoxia (RSN, n=8)
Repeated sprint training in hypoxia (RSH, n=9)

Altitude simulated (double blinded): 350 m or 3000 m
Normobaric hypoxia (Altitrainer 200®)



RSH in elite cross-country skiers

Results: mean power of all sprints (W)

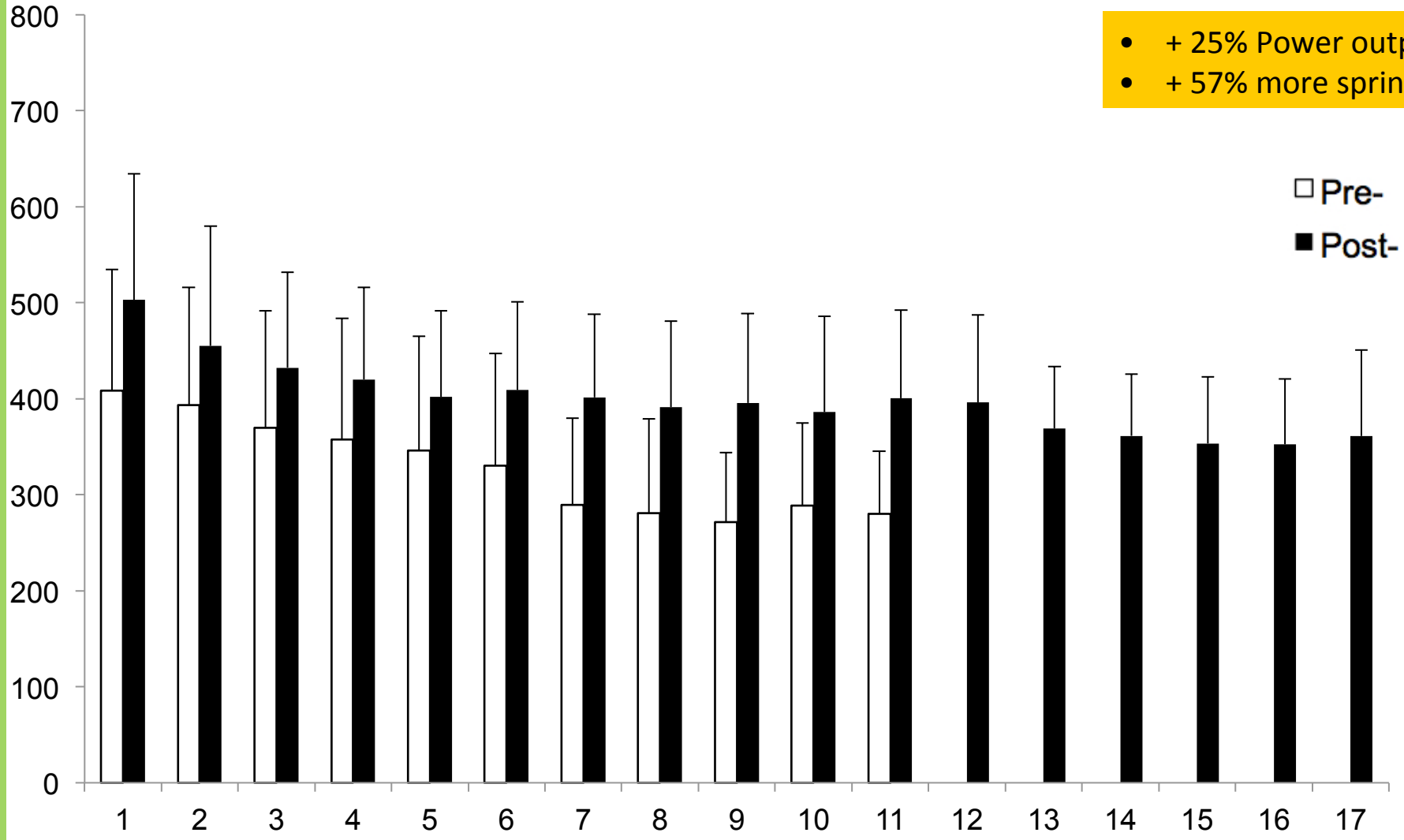


- + 21% Power output
- Not more sprints

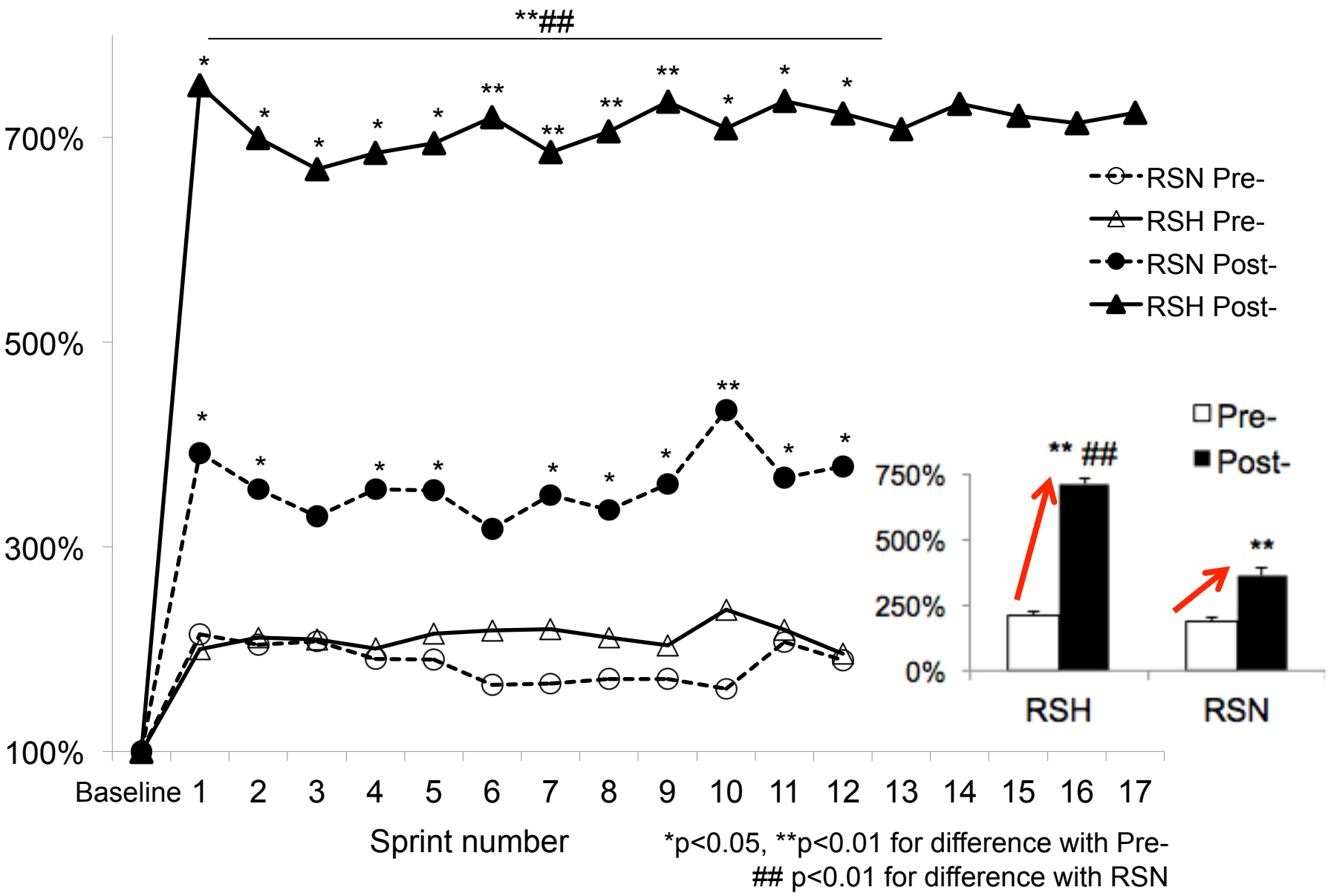
RSH

Results: mean power of all sprints (W)

- + 25% Power output
- + 57% more sprints

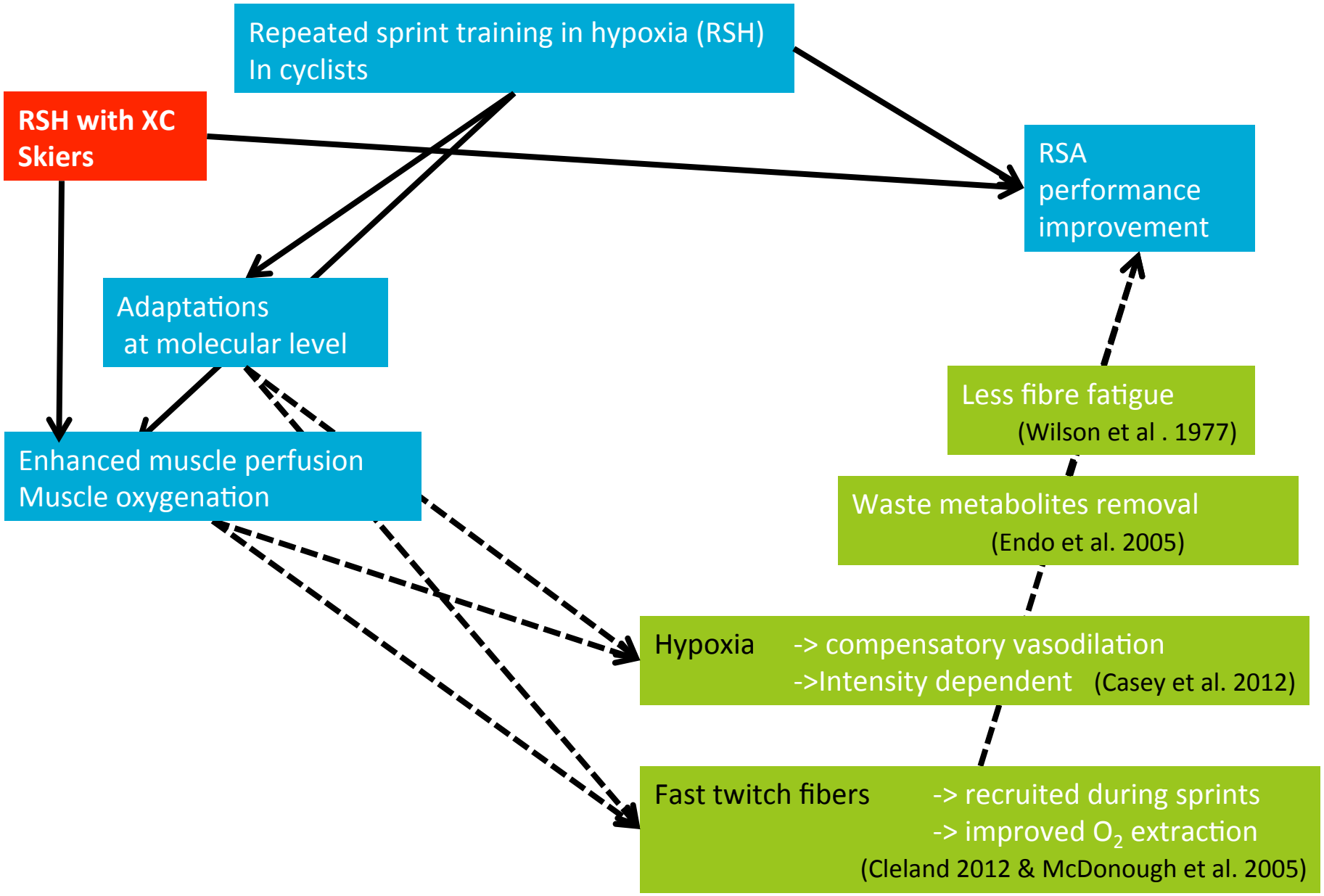


Muscle oxygenation during the successive sprints
->variations in total hemoglobin ΔtHb



*p<0.05, **p<0.01 for difference with Pre-
p<0.01 for difference with RSN

Conclusions after 2 RSH studies



RSH vs. IHT

- **Review of hypoxic training studies**

Additional benefits in
4 / 21 IHT studies
5 / 5 RSH studies

- RSH differ from IHT
- RSH more potent than RSN!
- RSH efficiency : fiber-type dependent


Review

OPEN ACCESS

Advancing hypoxic training in team sports: from intermittent hypoxic training to repeated sprint training in hypoxia

Raphaël Faiss,[1] Olivier Girard,[2] Grégoire P Millet[1]

(2013) Br J Sports Med

ABSTRACT
Over the past two decades, intermittent hypoxic training (IHT), that is, a method where athletes live at or near sea level but train under hypoxic conditions, has gained unprecedented popularity. By adding the stress of hypoxia during 'aerobic' or 'anaerobic' interval training, it is believed that IHT would potentiate greater performance improvements compared to similar training

- **Proposed mechanisms for further investigations**
- [PCr] resynthesis
  Hypoxic stimulus + training => modulation of [PCr] (Holliss et al. 2013)
- Exercise:rest ratio and direct application in team sports

RSH and innovation in altitude training: published articles

8. **Significant molecular and systemic adaptations after repeated sprint training in hypoxia**. Faiss R, Leger B, Vesin JM, Fournier PE, Eggel Y, et al. (2013) *PLoS One* 8: e56522.
9. **Hypoxic Conditions and Exercise-to-Rest Ratio are Likely Paramount.** Millet GP, Faiss R (2012) *Sports Medicine*; 42:1081-1083.
10. **Advancing hypoxic training in team sports: from intermittent hypoxic training to repeated sprint training in hypoxia?** Faiss R, Girard O, Millet GP (2013) *Br J Sports Med*; 47 Suppl 1:i46-50
11. **Hypoxic training and team sports: a challenge to traditional methods?** Millet GP, Faiss R, Brocherie F, Girard O (2013) *Br J Sports Med*; 47 Suppl 1:i6-7
12. **High-intensity intermittent training in hypoxia: a double-blinded, placebo-controlled field study in youth football players**. Brocherie F., Girard O., Faiss R., and Millet G.P. (2014) J Strength Cond Res. [Epub ahead of print]

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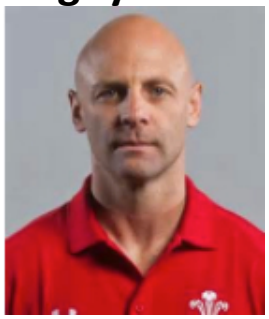
Immediate perspectives: RSH in team sports

Football

Franck Brocherie

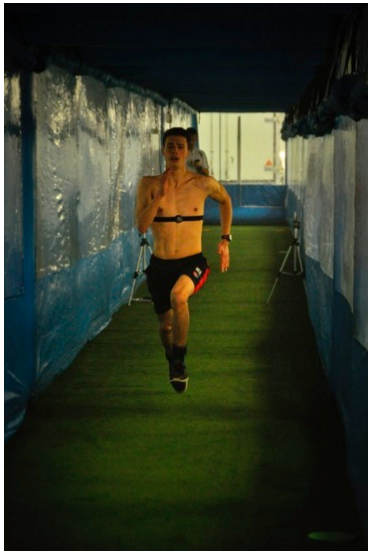
Rugby



Adam Beard

Basketball

Orlando Magic (NBA)



Thank you for your attention!

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