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Combining hypoxic methods for peak performance in intermittent sports

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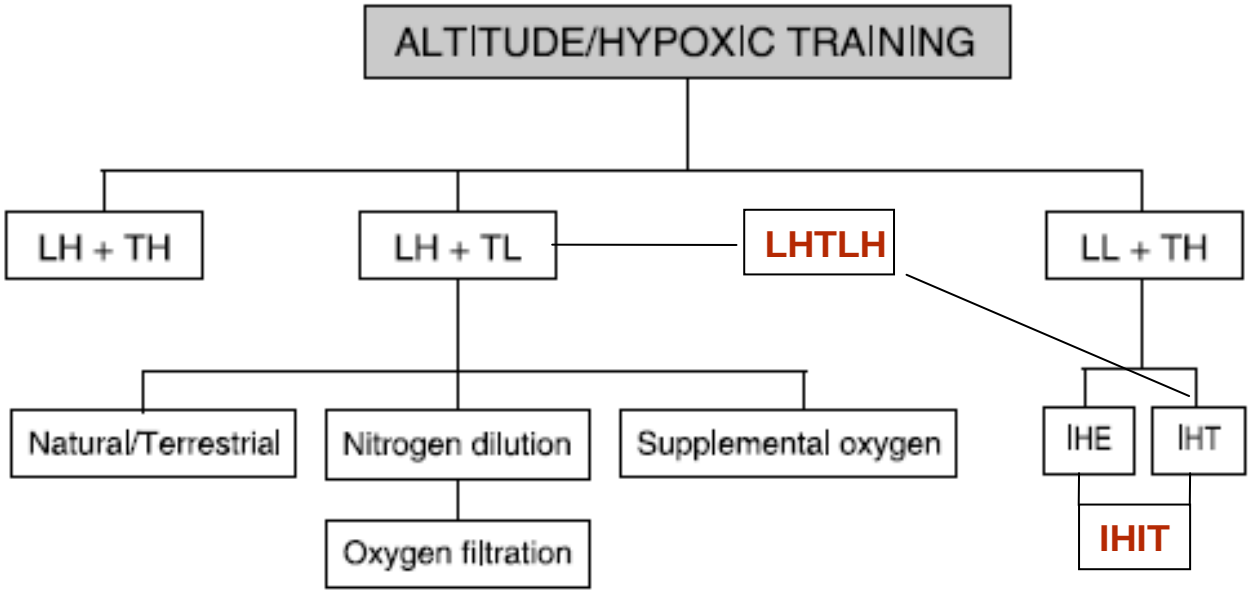

(Wilber, 2007)

(Millet et al., 2009)

Hypoxic methods

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Why ?

Underlying mechanisms
Erythropoiesis vs. non-hematological factors
Neuromuscular & Hemodynamic factors

How ?

LHTH vs. **LHTL** vs. *IHE/IHT* (IHIT and LHTLH)
Altitude / duration / *intensity*

For whom ?

Endurance vs. *"lactic"* vs. *intermittent* sports

When ?

Periodization in the yearly program

Team Sports and Altitude

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- Brisbane Lions FC – Australian Football League
- Collingwood FC - Australian Football League
- Melbourne FC - Australian Football League
- Fremantle FC - Australian Football League
- Queensland Roar – Football (Soccer)
- Liverpool FC – Football
- Tottenham Hotspur – Football
- English Institute of Sport – Varied teams utilise their facility
- English Rugby Union National Team
- Japanese Rugby Union National Team
- Manly Sea Eagles – Australian Rugby League

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Living high – Training low

Living high – Training low

HYPOXIC SITE	
Prémanon, XC national-center, France	***O2-extracted***
Japanese Sport Institute, Japan	***?***
BSU, Beijing, China	***O2-extracted***
Vuokatti, Finland	***Nitrogen***
Runaway Bay centre, Gold Coast, Australia	***?***
AIS, Canberra, Australia	***Nitrogen***
Aspetar, Doha, Qatar	***O2-extracted***

Living high – Training low
Multicentric project - IOC

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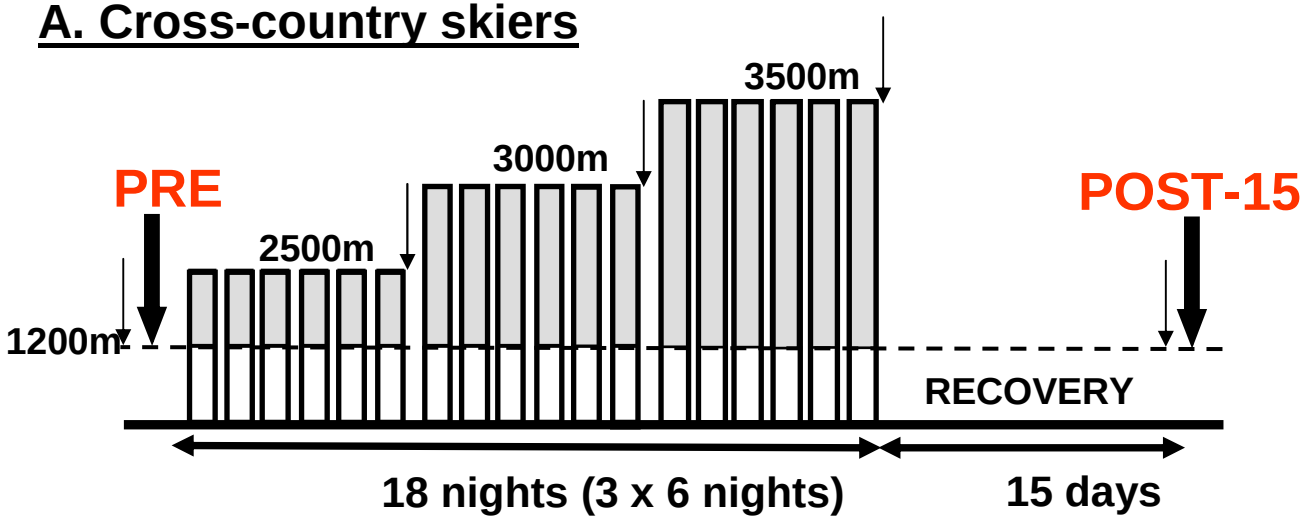
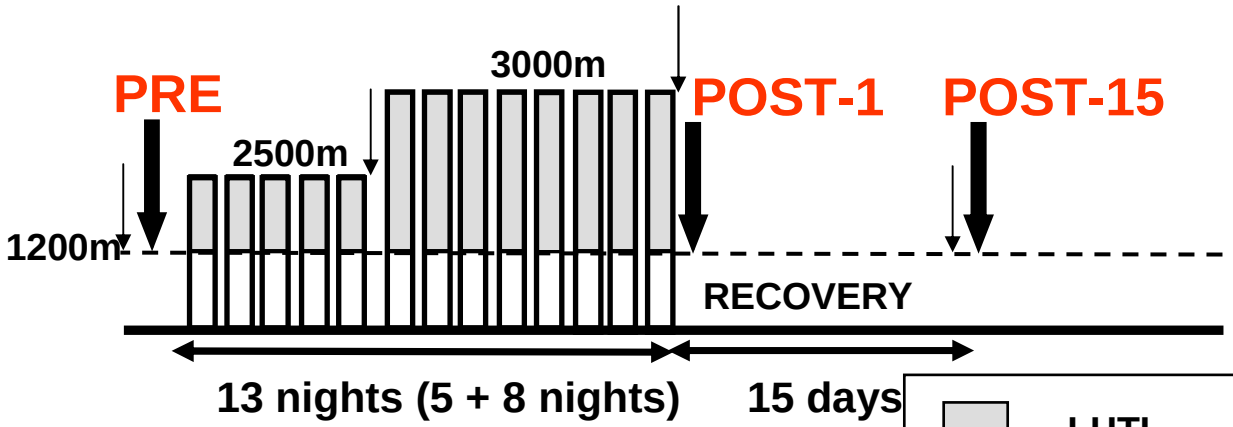
A. Cross-country skiers

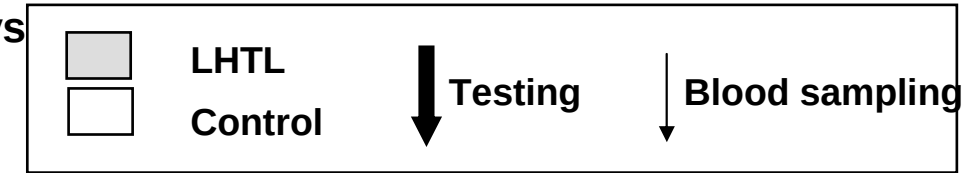


B. Swimmers



C. Runners

Id. 18 nights (6 at 2500 + + 12 at 3000)



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Living high – Training low

	group	pre- test	post-test1	post-test2
$\dot{V}O_{2max}$ ($ml.min^{-1}.kg^{-1}$)	hypoxic	60,71 ± 4,42	64,95 ± 5,90**	61,32 ± 5,54
	control	59,91 ± 6,27	62,31 ± 6,06*	60,10 ± 5,80
MAP (w)	hypoxic	303 ± 67	315 ± 54**	322 ± 72**
	control	286 ± 40	292 ± 37	291 ± 42#
performance (%)	hypoxic	0	1,80 ± 2,40*	3,40 ± 3,80**
	control	0	1,00 ± 2,80	2,50 ± 3,10**

Small 'additive effect' of LHTL on performance enhancement confirmed. These studies confirm the results of Levine where L training was performed at 1250 m. Delayed effect observed with LHTL (?)

NS difference in VO_{2max} increase.

Return to sea-level values after two weeks.

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Living high – Training low

	group	pre- test	post-test1	post-test2
$\dot{V}O_{2obla}$ (ml.min^{-1}.kg^{-1})	hypoxic	44,66 ± 4,99		48,74 ± 6,91**
	control	47,17 ± 6,16		48,44 ± 5,63
P_{obla} (w)	hypoxic	225 ± 44		248 ± 57***
	control	224 ± 29		228 ± 27
EC (%)	hypoxic	0	0.69±8.93	-5.48±11.36 *
	control	0	0.22±6.79	-5.88±10.47 *
EC_{bic} ($VO^2.w^{-1}$)	hypoxic	16.29 ± 1.80		15.69 ± 2.37*
	control	15.88 ± 3.28		15.45 ± 3.10
EC_{bic} (%)	hypoxic	0		-3.73±8.48*
	control	0		-2.10±9.79

Sub-maximal intensity parameters appear more changed by the LHTL method.

Obla is more increased with LHTL.

Delayed additive effect on economy.

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Living high – Training low

Comments :

Great differences observed between the three experiments:

Increased efficiency from swimmers to runners in term of performance enhancement by LHTL by:

- Limiting H to 3000 m (XC and runners)
- Introductory period at 2500 m (tbc)

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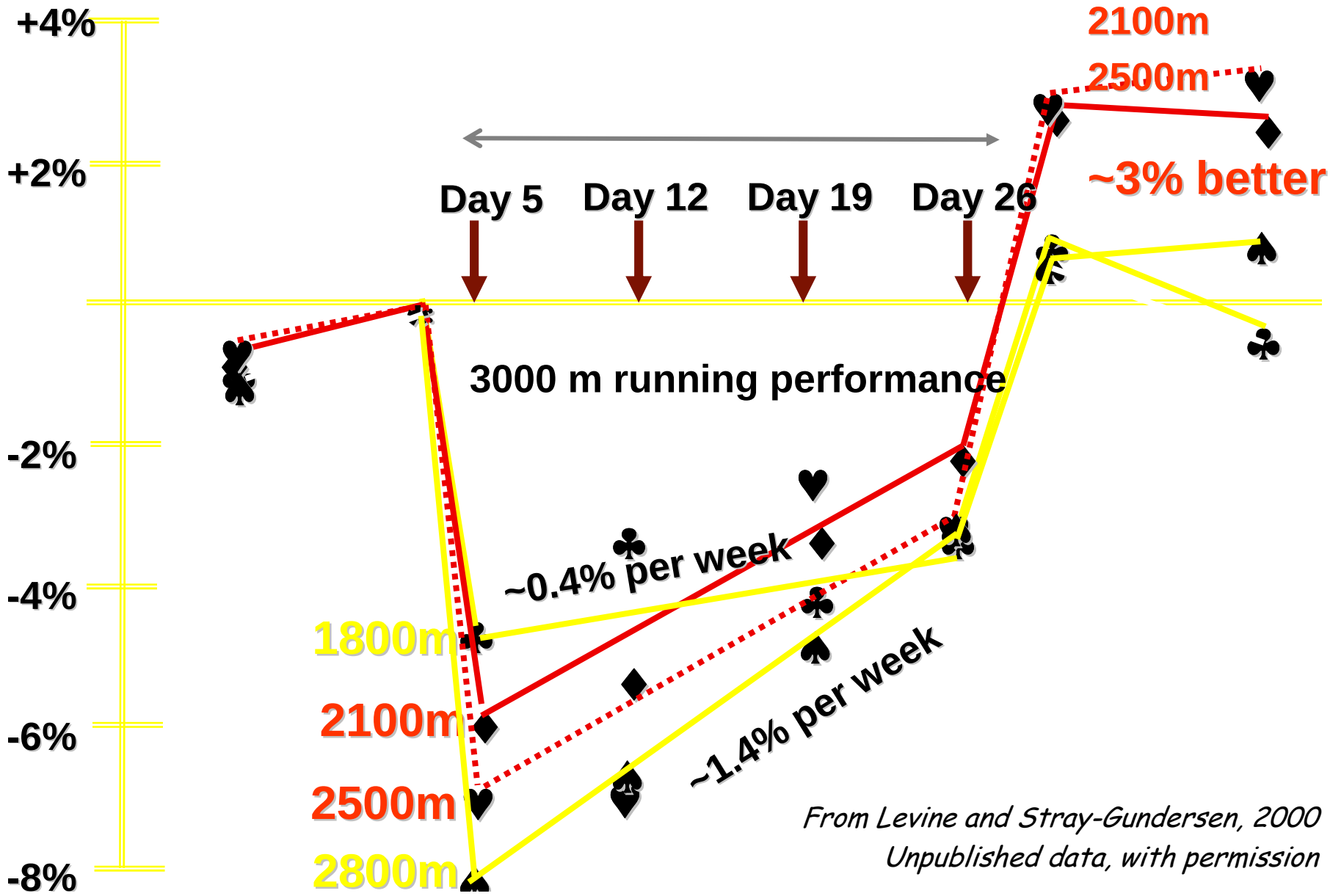
Living high – Training low : Optimal altitude



From Levine and Stray-Gundersen, 2000
Unpublished data, with permission

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Living high – Training low

Why ?

Augmented red cell volume vs non-hematological factors

- Economy *(Schmitt et al., 2006)*
- Muscle buffering capacity *(Gore et al., 2001)*
- Hypoxic ventilatory response *(Townsend et al., 2002)*

Performance increase by 1-3% vs. similar sea-level training.

How ?

Altitude : 2200 – 2500 m for erythropoietic effect (terrestrial)

Up to 3000 m for non-hematological factors *(Brugniaux et al. 2006)*

Duration :

4 wks for inducing accelerated erythropoiesis *(Ge et al., 2002)*

2 wks enough for non-hematological factors *(Gore et al., 2001)*

Hypoxic daily dose :

Beyond 16 h.day for erythropoietic effect *(Wilber, 2007)*

Shorter (?) for non-hematological changes.

For whom ? All

When ? Prior the major competitions

Advanced method
Living high – Training low interspersed

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Side effect of LHTL : **decrease in Na^+-K^+ ATPase activity**

Detrimental, especially in the exercises inducing impairments in excitation-contraction coupling properties like high-intensity intermittent sports *(Girard & Millet, 2008)*

To reverse this detrimental effect :

Alternate nights in hypoxia and nights in normoxia*; i.e.* for example, 5-nights LHTL interspersed with 2-nights in normoxia *(Aughey et al., 2006).*

Unknown ? The NOS influence on E-C coupling during repeated sprints

Improved LHTL method : LHTLi (LHTL interspersed).

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Intermittent Hypoxic Training

Intermittent Hypoxic Training

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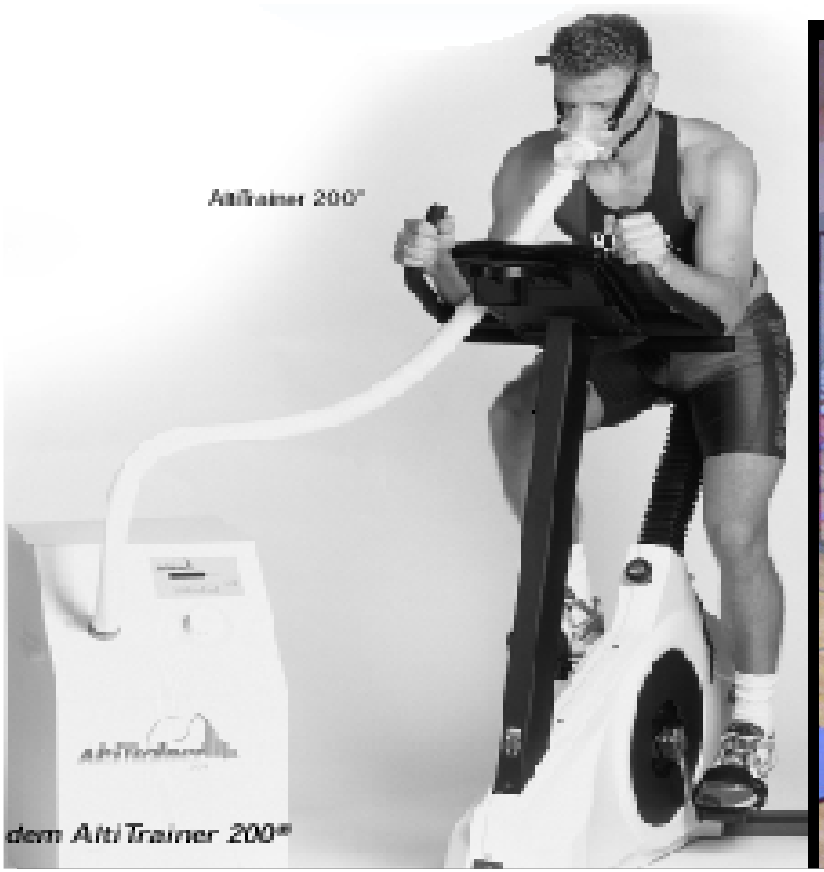
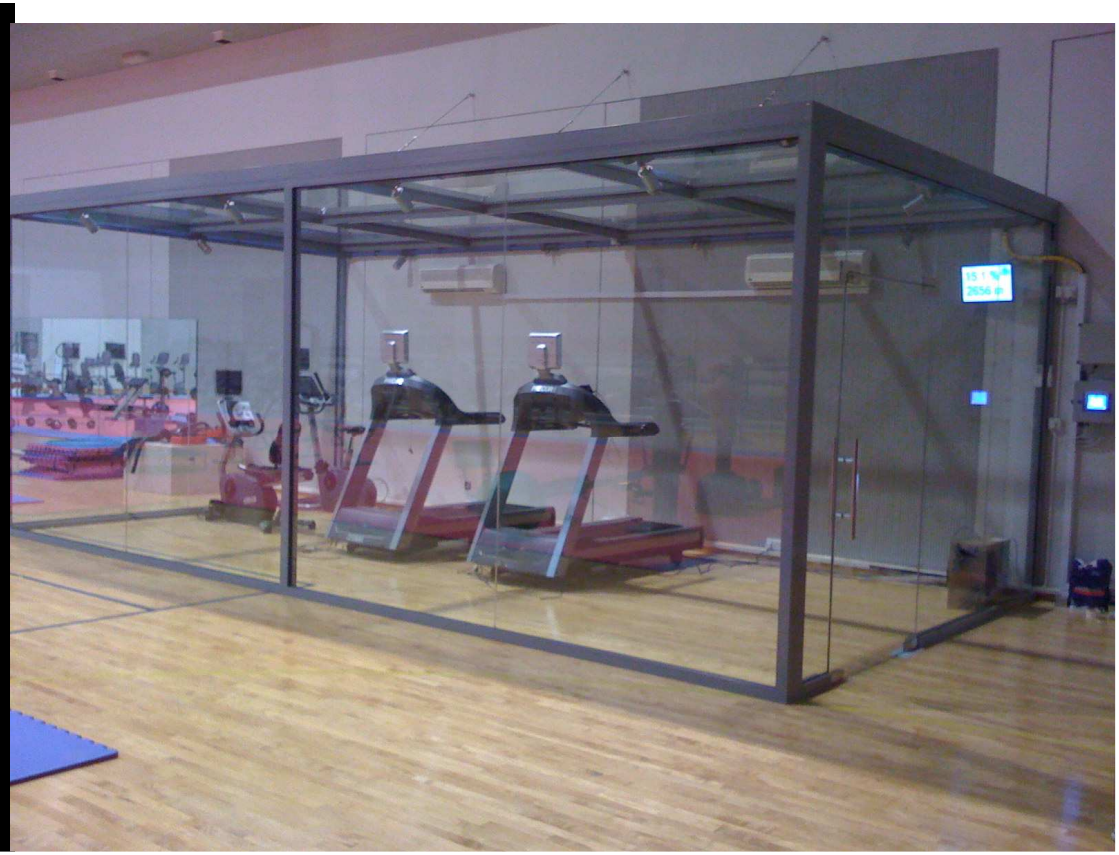
Altitrainer 200®:



Altitude chamber



Intermittent Hypoxic Training

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Time exposure to hypoxia to short for inducing any hematological adaptations.

How ? **Phenotypic and metabolic adaptations at muscle level**

Hypothesis : improved factors of performance in repeated sprints

IHT – Which exercise intensity ?

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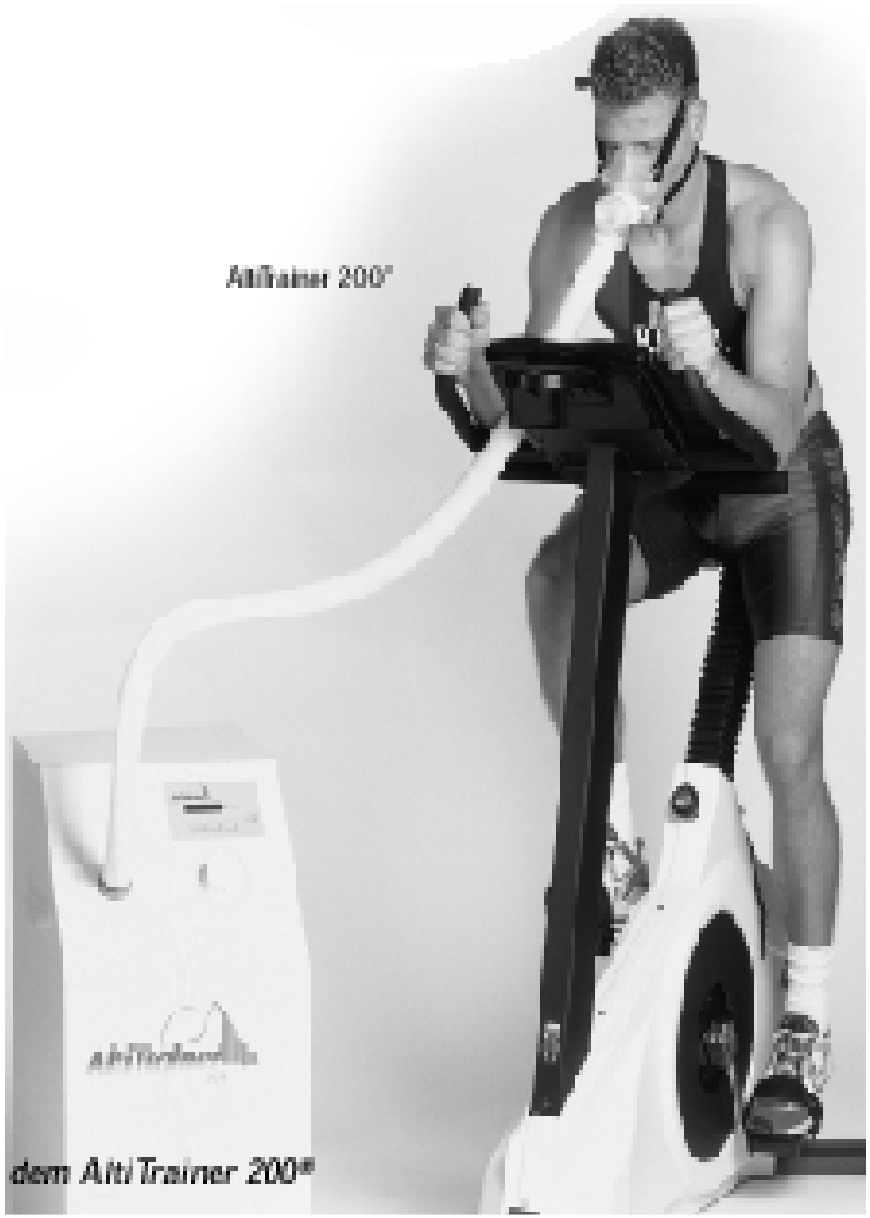
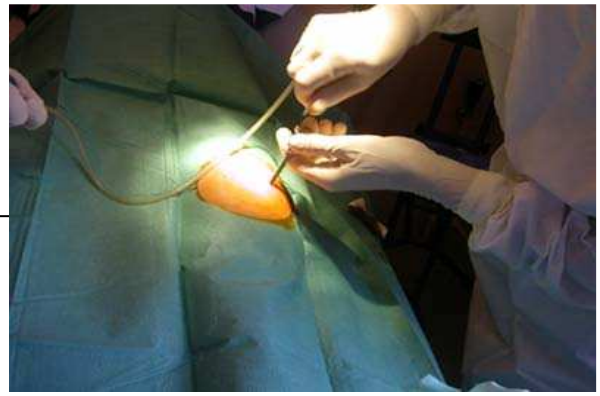


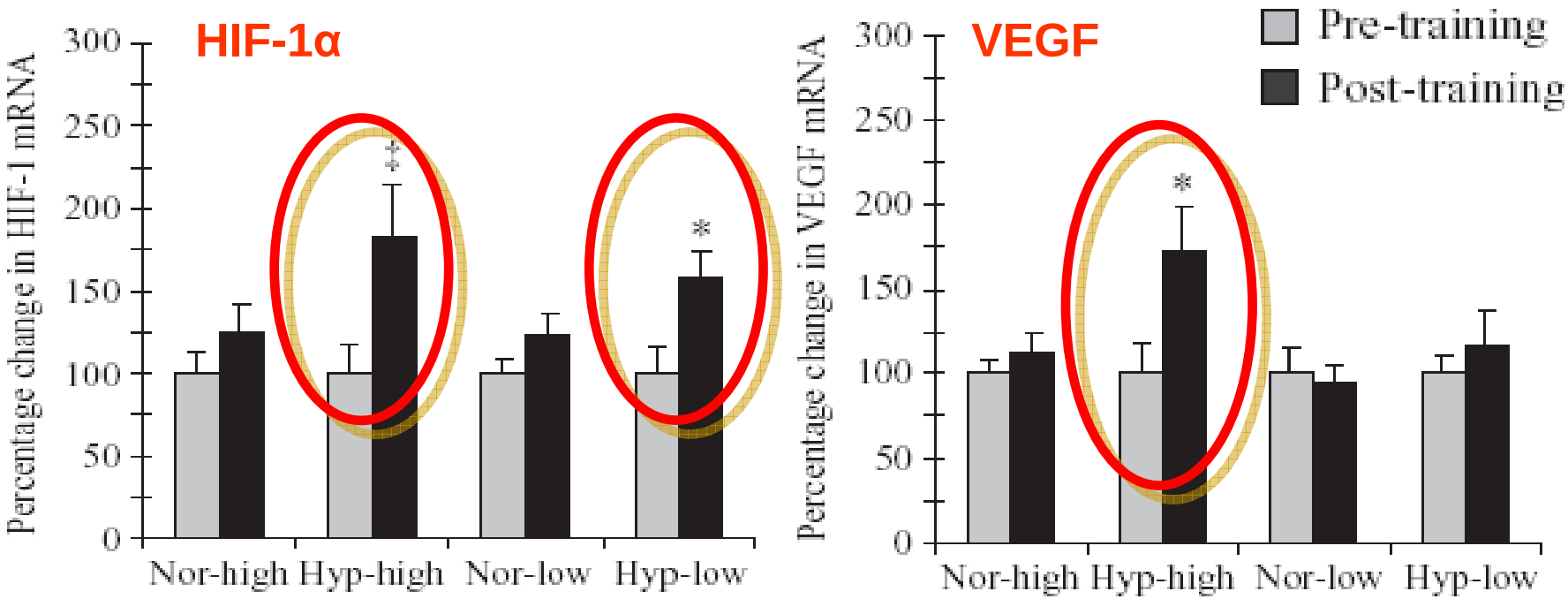
IHT - Gene up-regulation



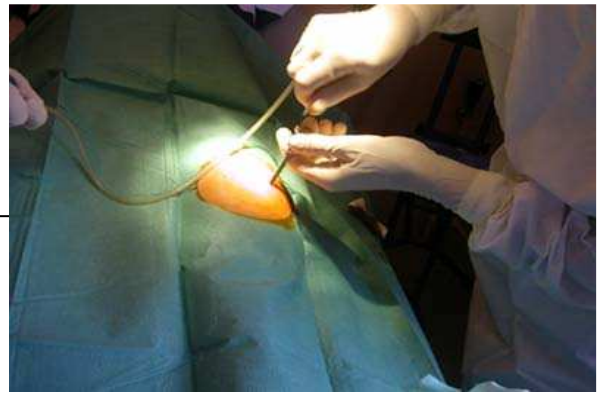
4 times 30 min.wk^{-1}. 6 weeks. High (4-6 mM) vs. low-intensity (2-3 mM). Altitude = 3850 m ***(Hoppeler & Vogt 2001)***

IHT could modify the gene expression.

Increase in HIF -1α mRNA of 82.4% and 78.4% after training in hypoxia at high and low intensity respectively. Both mRNA of VEGF and myoglobin also increased but only after the high intensity training in hypoxia.



IHT - Structural adaptations

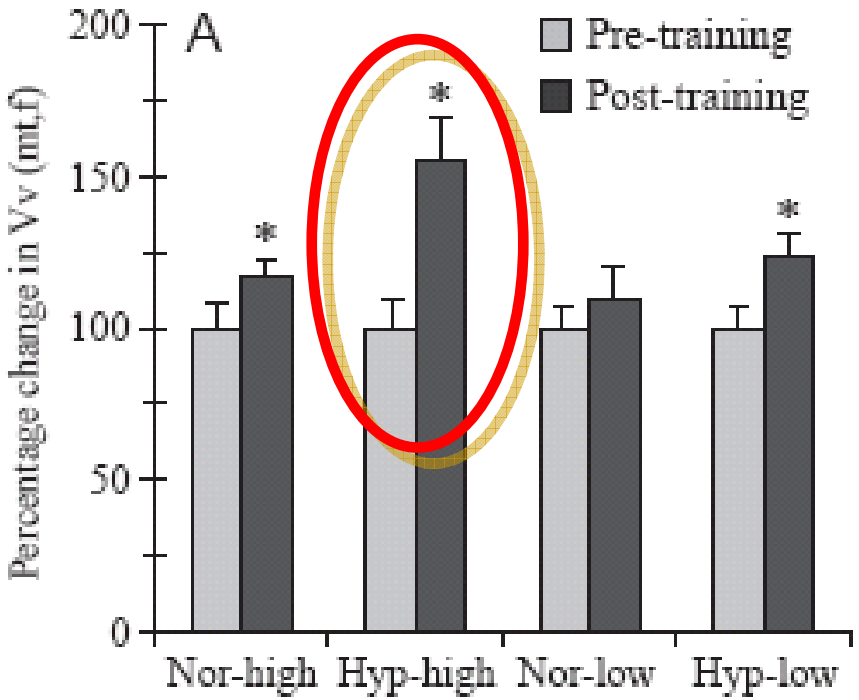


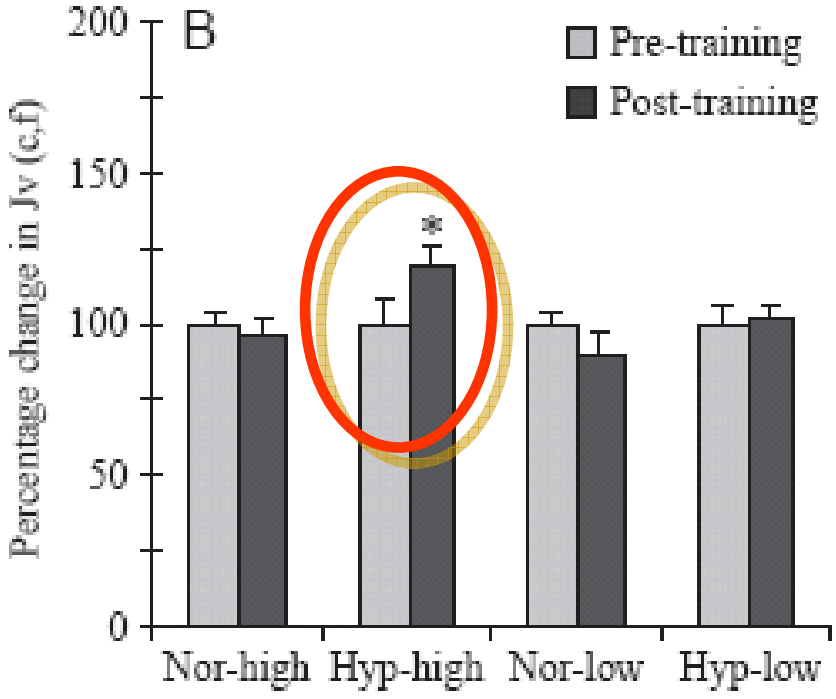
4 times 30 min.wk^{-1} 6 weeks. High (4-6 mM) vs. low-intensity (2-3 mM). Altitude = 3850 m ***(Hoppeler & Vogt 2001)***

High intensity IHT induced greater muscle adaptation to compensate the ↘ O_2 availability

↗↗ total mitochondrial volume density: 59%

↗↗ capillary length density: 17.2%





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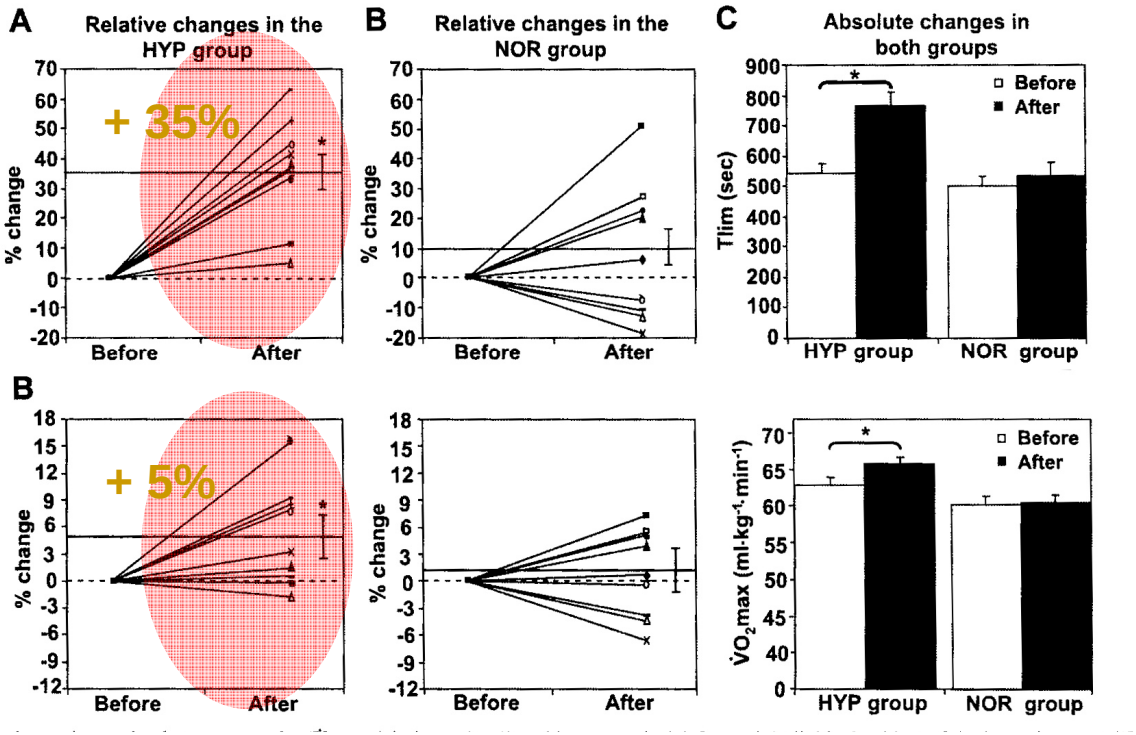
IHT - Training at vVT_2

6 wks with 2 sessions.wk. 24-40 min at vVT_2. Altitude = 3000 m

Time to exhaustion

VO_{2max}



(Dufour et al., 2006).

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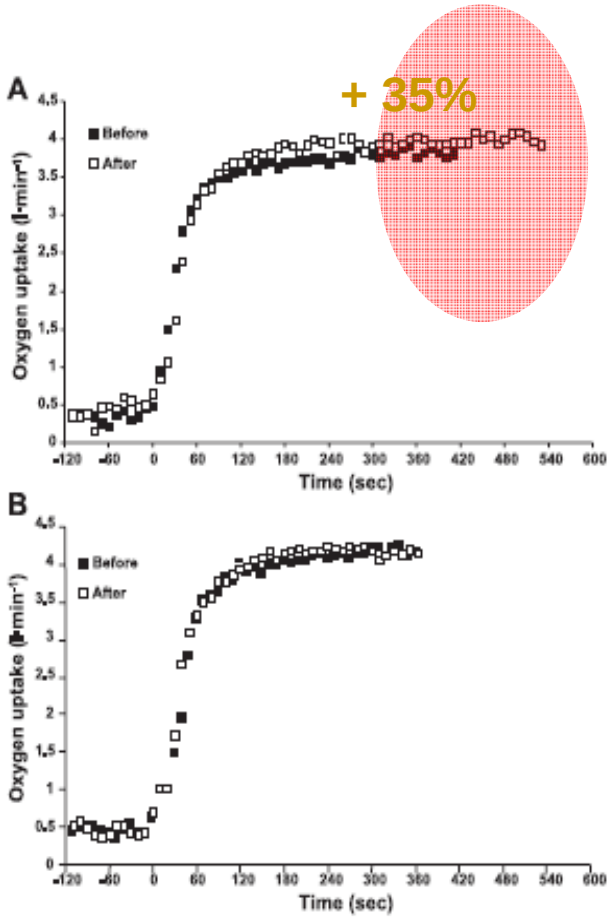
IHT - Training at vVT_2

6 wks with 2 sessions.wk. 24-40 min at vVT_2. Altitude = 3000 m

VO_2 kinetics



HYP group

NOR group

(Dufour et al., 2006)

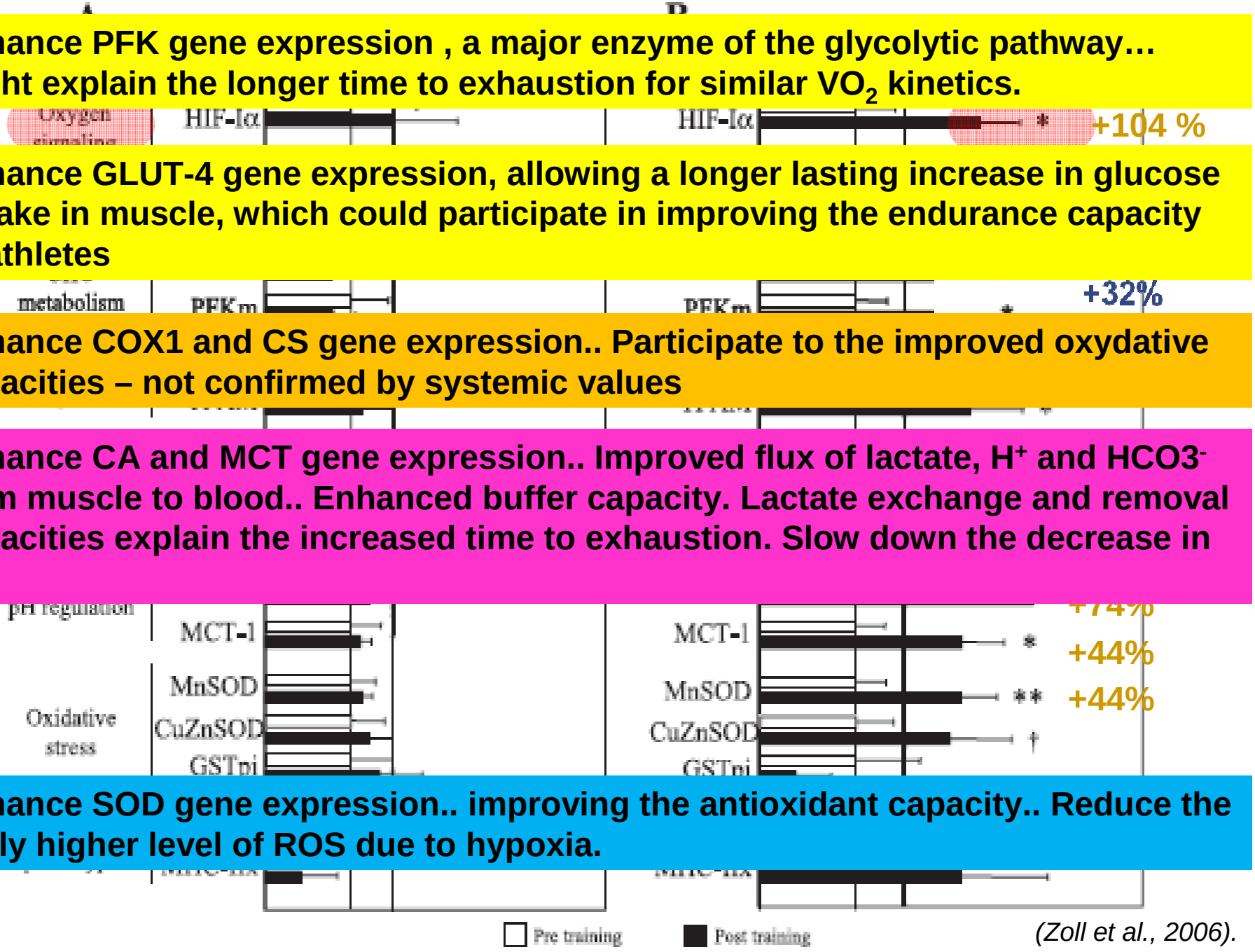
Enhance PFK gene expression , a major enzyme of the glycolytic pathway… Might explain the longer time to exhaustion for similar VO_2 kinetics.

Enhance GLUT-4 gene expression, allowing a longer lasting increase in glucose uptake in muscle, which could participate in improving the endurance capacity of athletes

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

Enhance 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.

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



(Zoll et al., 2006).

Intermittent Hypoxic Training in football

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Intermittent Hypoxic Training in football

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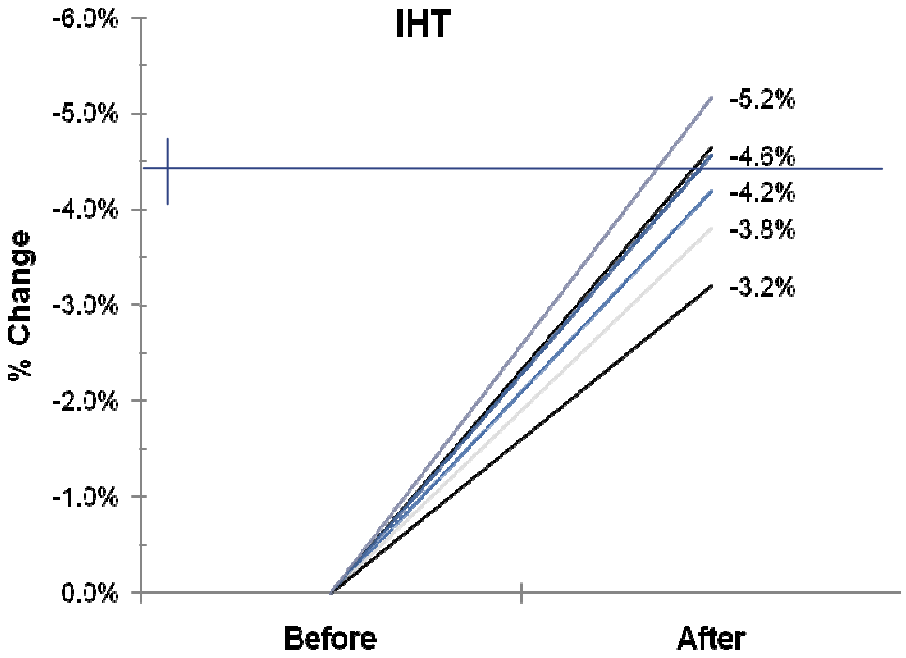
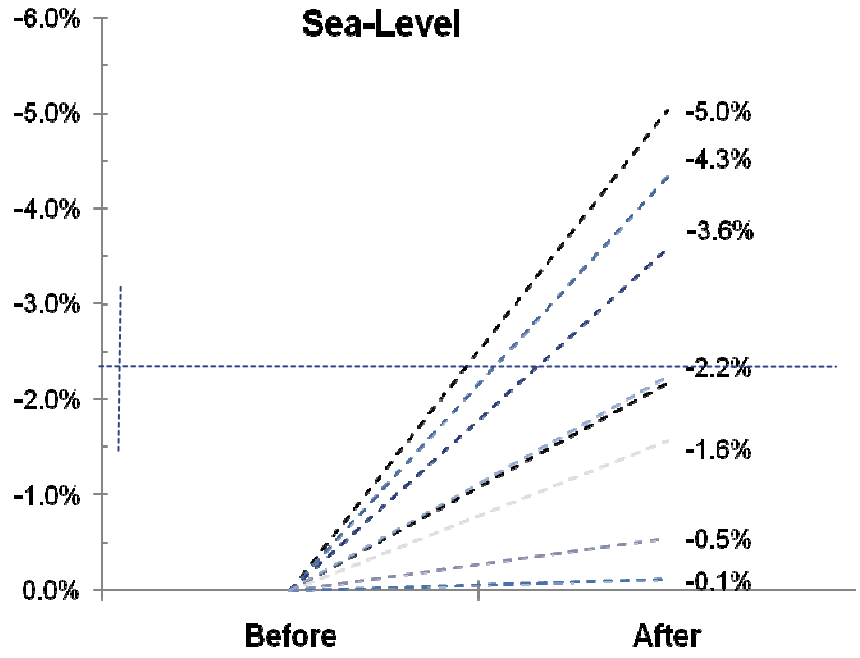
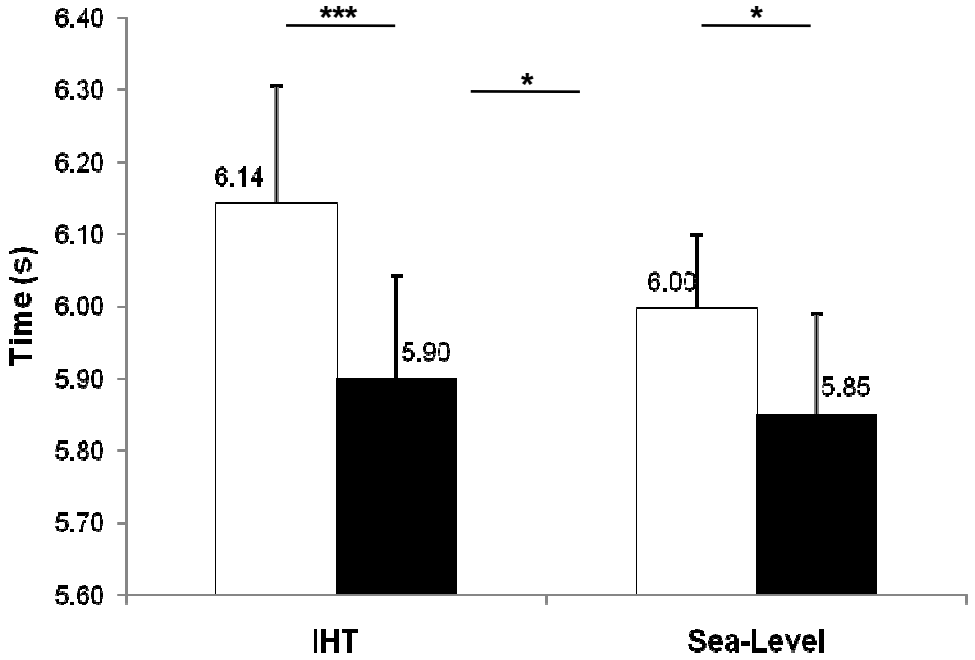
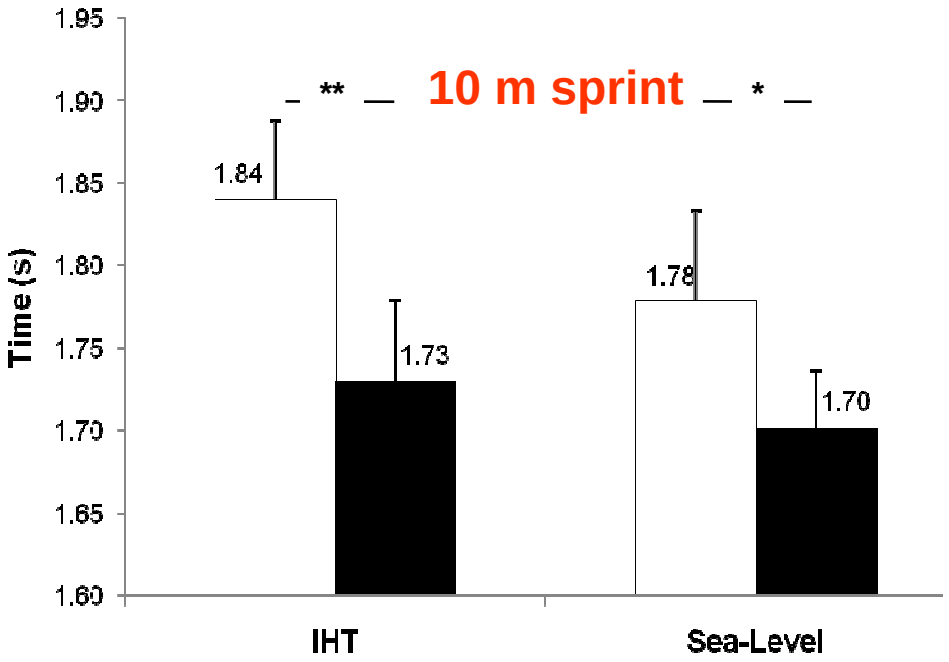
- Double-blind study with control group.
- Athletes, coaches and testers unaware of normoxic x hypoxic set-up
- 2 x 8 athletes (national team U17 yr): Sea-Level x IHT
- 5 wks – 10 sessions
- High-Altitude : 2500 – 2800 m
- High-Intensity : strength / sprint / agility / supra-max intermittent

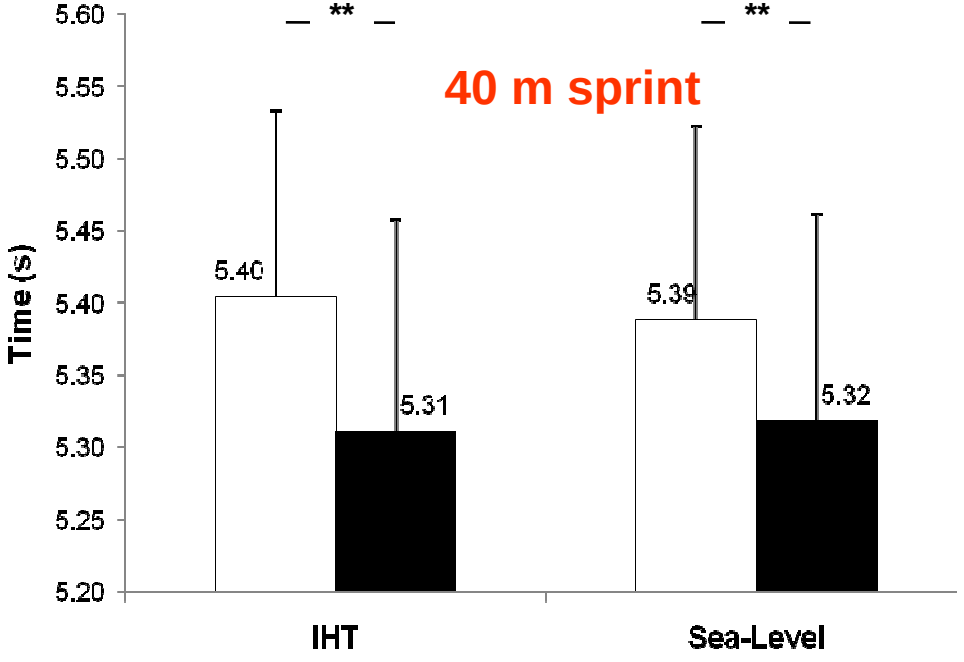


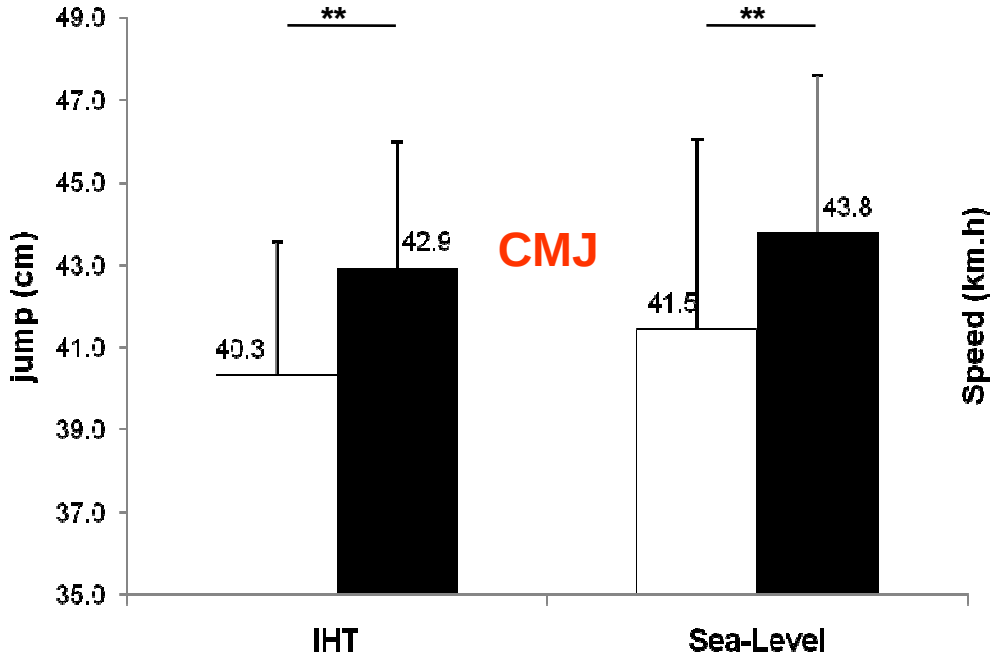


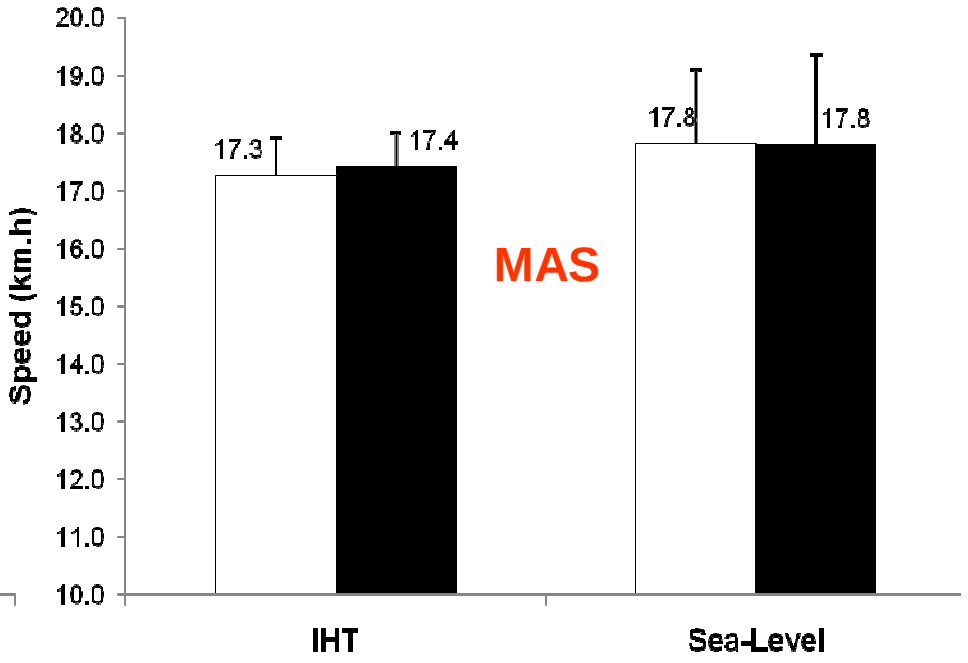
Repeated Agility




10 m sprint
** *
Time (s)
1.95
1.90
1.85
1.80
1.75
1.70
1.65
1.60
1.84
1.73
1.78
1.70
IHT
Sea-Level


40 m sprint
** **
Time (s)
5.60
5.55
5.50
5.45
5.40
5.35
5.30
5.25
5.20
5.40
5.31
5.39
5.32
IHT
Sea-Level


CMJ
** **
jump (cm)
49.0
47.0
45.0
43.0
41.0
39.0
37.0
35.0
40.3
42.9
41.5
43.8
IHT
Sea-Level


MAS
Speed (km.h)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
17.3
17.4
17.8
17.8
IHT
Sea-Level

Innovating
Intermittent Hypoxic Training

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- Additional effect of IHT on Repeated Sprint Ability

- ✓ Repeated pattern – significant : 2%- 2.5%
- ✓ Sprint & Explosiveness – non significant : ~ 1%
- ✓ Aerobic Speed : None.

Intermittent Hypoxic Training in intermittent sports

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Mechanisms ?

Increased mRNA levels of factors :

Carbohydrate and mitochondrial biogenesis

Glycolitic ands oxidative pathways.

Oxidative stress defense.

pH and lactate regulation.

How – training methods ?

Intermittent **supra-maximal** training > aerobic power

Circuit-training including **repeated** agility exercises at **intensity max**

Repeated sprints on force treadmill

Living High – Training Low and High, interspersed
The optimal combination ?

We proposed to use a modified LHTL by alternating nights high and nights low (LHTLi ; for example, 5-2 or 6-1)

Intense exercise in high altitude stimulates more the muscle adaptations for both aerobic and anaerobic exercises and limit the decrease in power.

Coupling LHTLi and IHT might be the optimal combination

LHTLHi

5 nights at 3000 m and two nights at sea-level with training at sea-level except 2 sessions.wk^{-1} at supra-threshold intensity might be very efficient, especially in team sports (e.g. football).

Inclusion of explosive – agility - sprints

Intermittent Hypoxic Training

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Why ?

Improved buffer capacity

Increase in mitochondrial efficiency

Improved pH / lactate regulation

Metabolic factors of high-intensity intermittent exercises

How ?

Altitude :

Start at 2500-3000 m… higher ??

Training intensity :

Higher second ventilatory threshold and/or repeated sprints

Hypoxic dose :

Cycles of 3-6 wks with 2 sessions.wk^{-1}

for Whom ?

When ?

+ + Intermittent sports :

+ others : pre-acclimatization

maintenance

IHT : winter

LHTLHi : pre-competition

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Hypoxic training Periodization

Endurance sports

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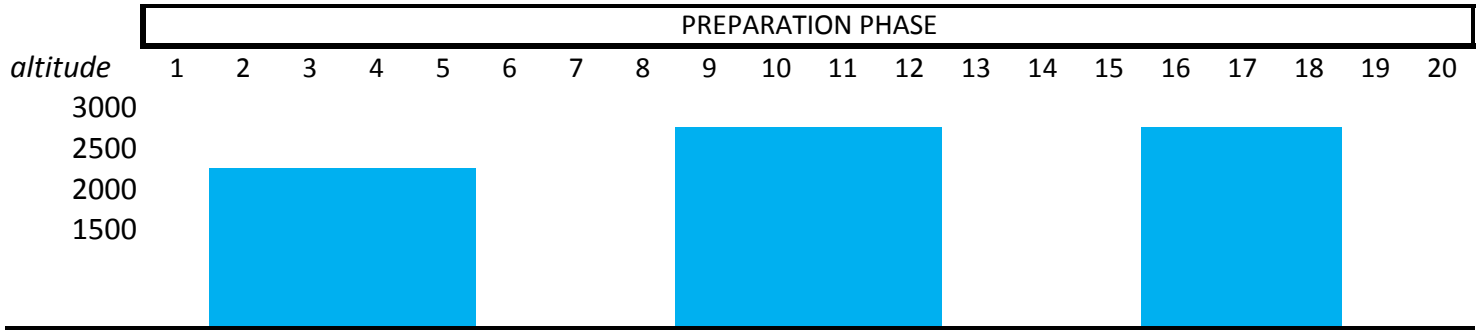

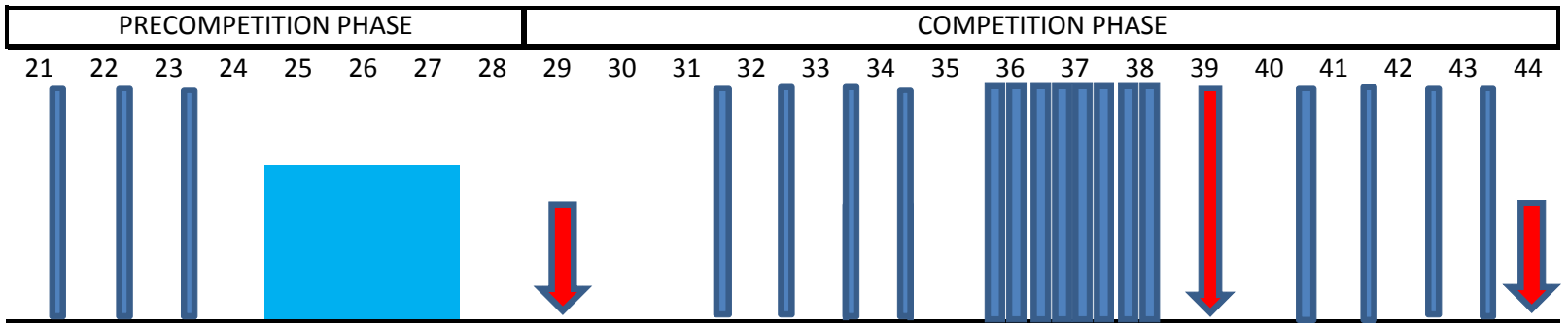

(Millet et al. 2009)

“Lactic” Sports

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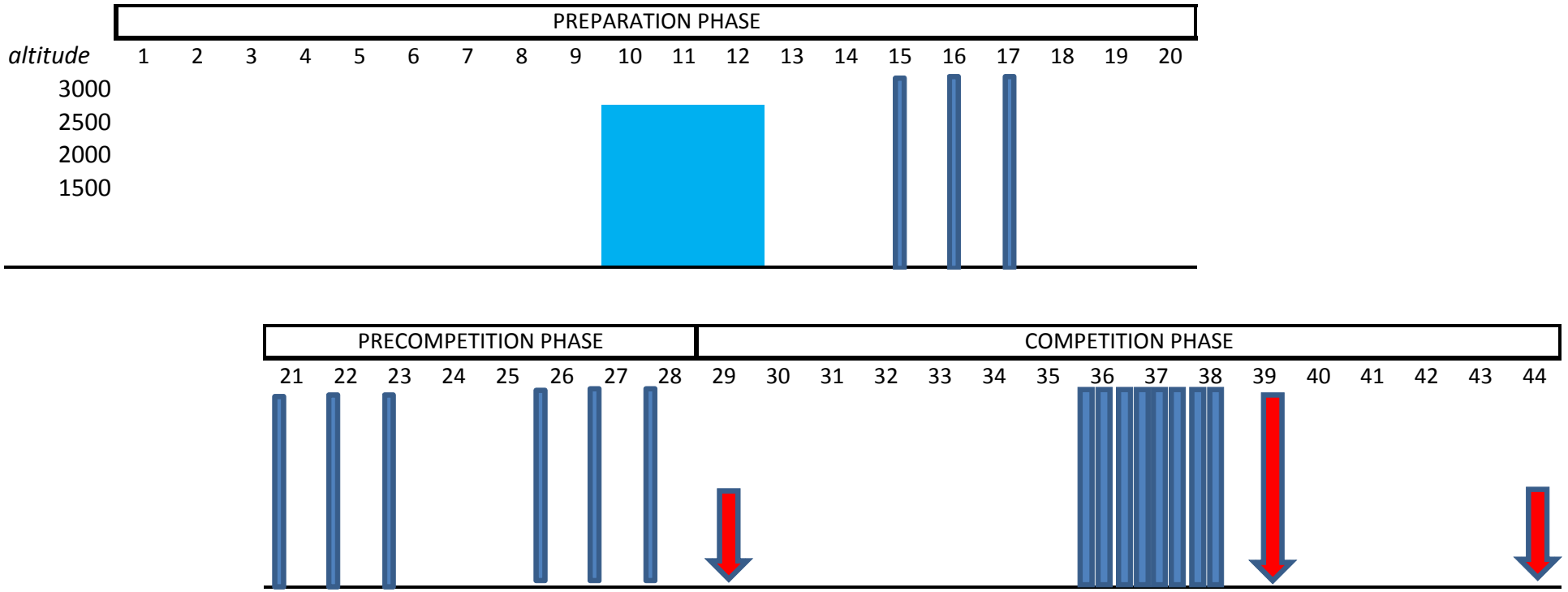

(Millet et al. 2009)

Intermittent Sports

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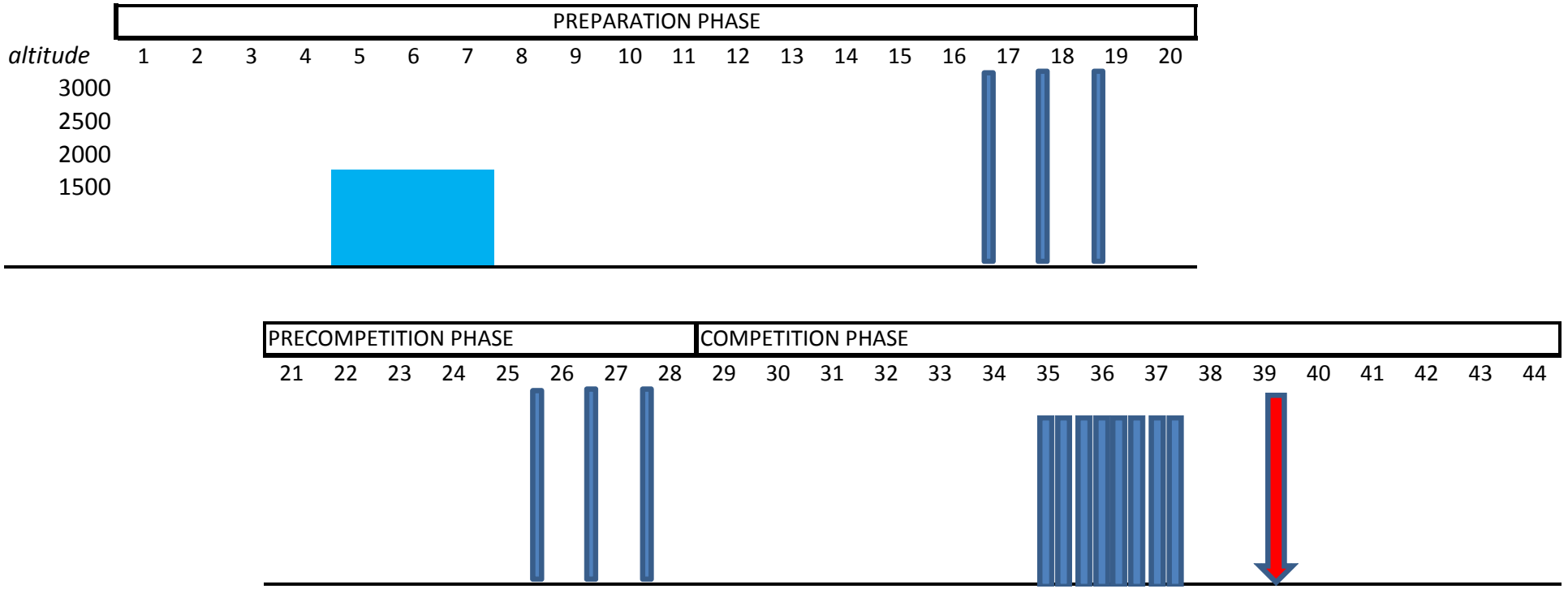

(Millet et al. 2009)

If interested ...

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REVIEW ARTICLE
Sports Med 2009; 39 (12): 1-25
0112-1642/09/0012-0001/$49.95/0

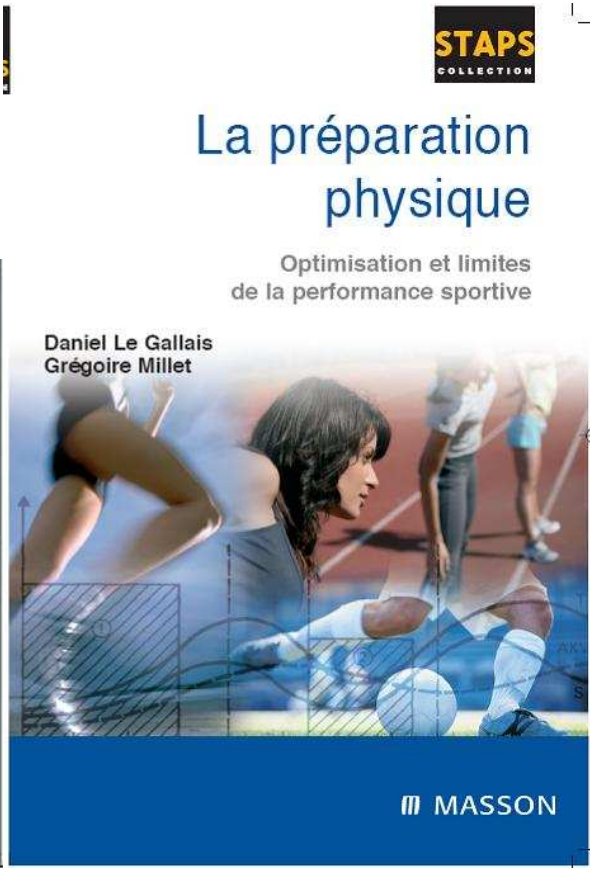
Combining Hypoxic Methods for Peak Performance

Gregoire P. Millet,[1] B. Roels,[2] L. Schmitt,[3] X. Woorons[4] and J.P. Richalet[4]

La préparation physique.
D. Legallais & G. Millet, 2007, *Masson*

L'endurance.
Millet G., 2006
Edition EPS

Coming in 2010
Entrainement en altitude
G. Millet & L. Schmitt
2010, deBoeck Univ



Grazie

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Any Questions ?