ELEVATE YOUR PERFORMANCE: MASTERING ALTITUDE TRAINING FOR ELITE ATHLETES

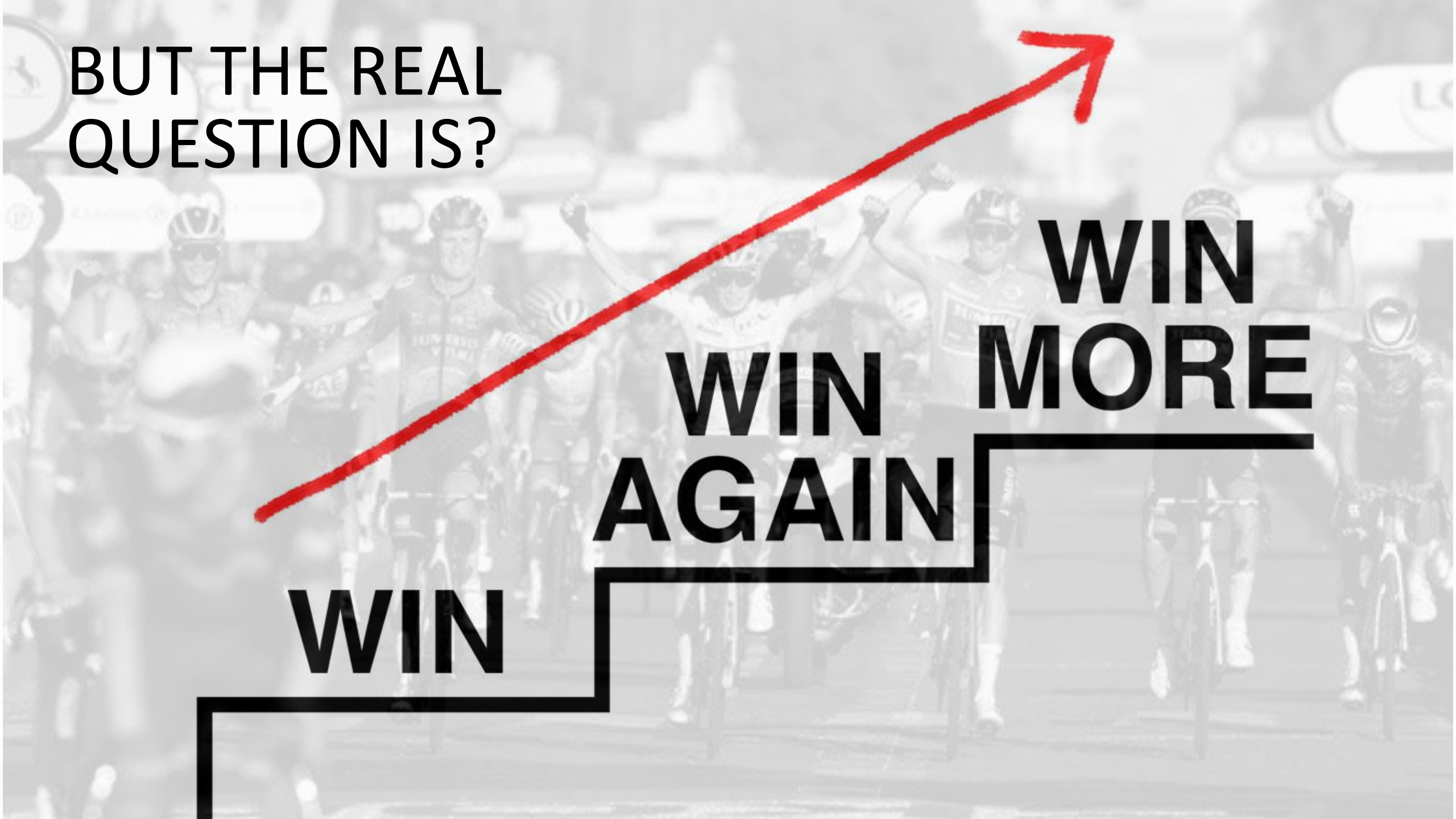
Irina Zelenkova, MD, PhD

- Expert in altitude training with more than 20 years of experience in elite sports
- Altitude training advisor of UAE EMIRATES and Alpecin-Deceuninck pro cycling teams
- IOC Diploma in Sport Medicine

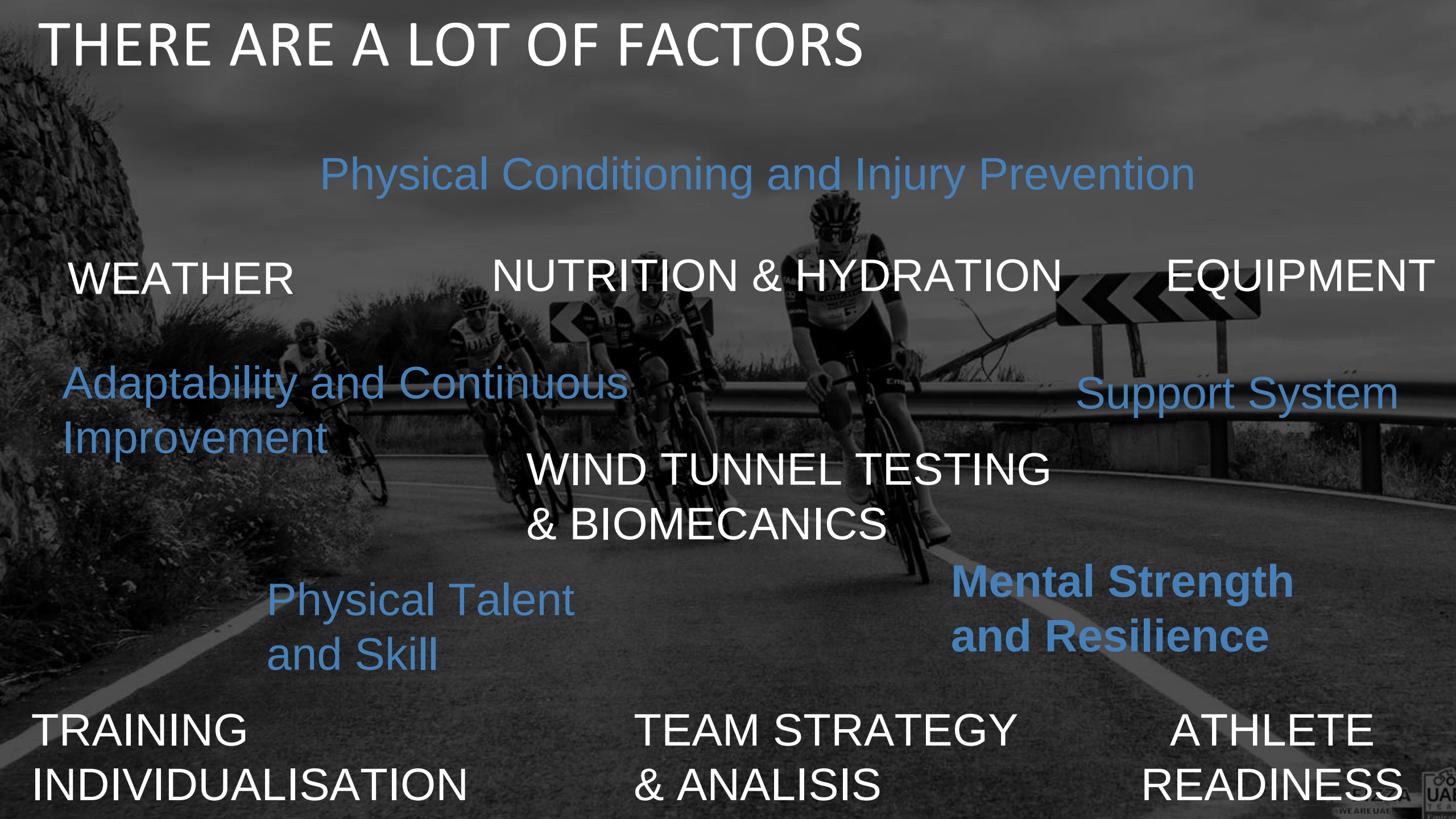
OVER 15 YEARS WORKING IN THE FIELD OF PROFESSIONAL SPORT

WILL IT HELP ME TO WIN?

BUT THE REAL QUESTION IS?



THERE ARE A LOT OF FACTORS



Physical Conditioning and Injury Prevention

WEATHER

NUTRITION & HYDRATION

EQUIPMENT

Adaptability and Continuous Improvement

Support System

WIND TUNNEL TESTING & BIOMECANICS

Physical Talent and Skill

Mental Strength and Resilience

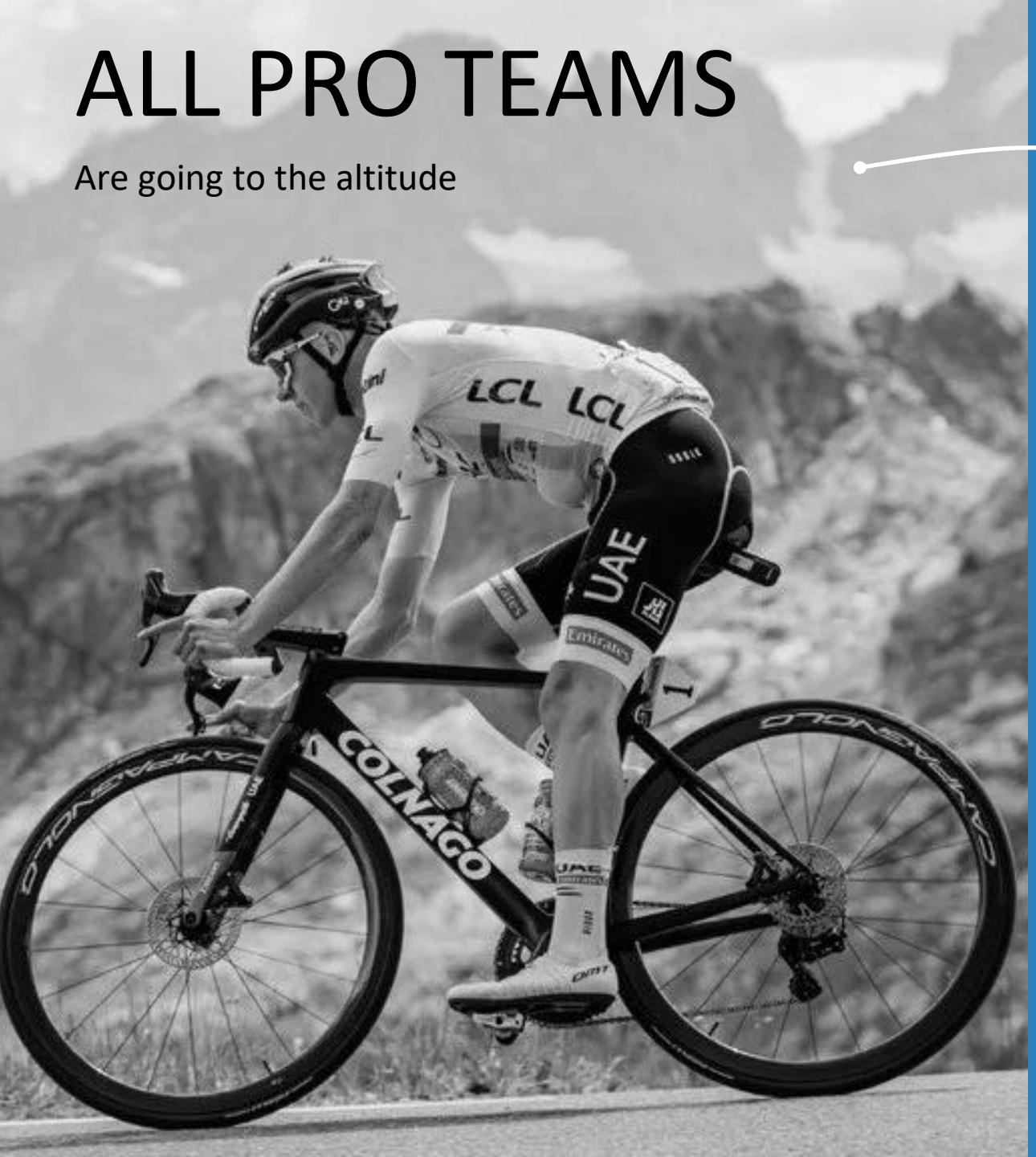
TRAINING INDIVIDUALISATION

TEAM STRATEGY & ANALISIS

ATHLETE READINESS

ALL PRO TEAMS

Are going to the altitude



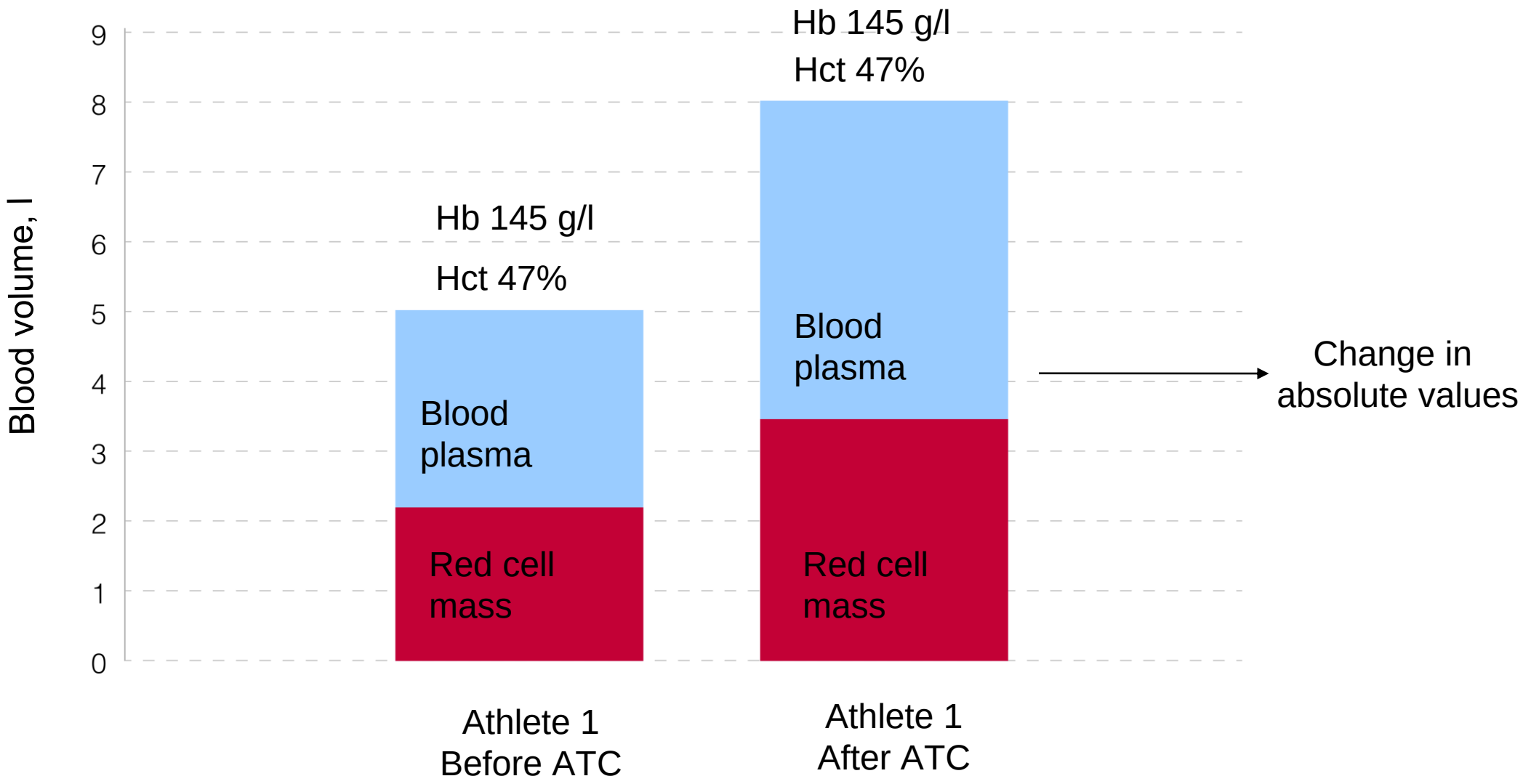
HOW YOU CAN GAIN THE COMPETITIVE EDGE?

COMPETITIVE EDGE

-01

MAKE THE ALTITUDE TRAINING TRANSPARENT

HB AND HCT LEVELS ARE NOT INFORMATIVE



ALTITUDE TRAINING FOR PEAK PERFORMANCE

Oxygene
↓P_{O_2} ↓ P_{O_2}

- Autonomic Tone
- Ventilation
- BloodTissue
- Flow pH

Non-haematological mechanisms:

- Improved economy
- Muscle buffering

HIF-1a

EPO

Oxidative stress
Wound Healing
Sleep Regulation

- CNS
- Kidney
- Heart
- Lung
- Testis
- Skeletal Muscle
- Smooth Muscle
- Pancreas

HBmass

ERYTHROPOIESIS

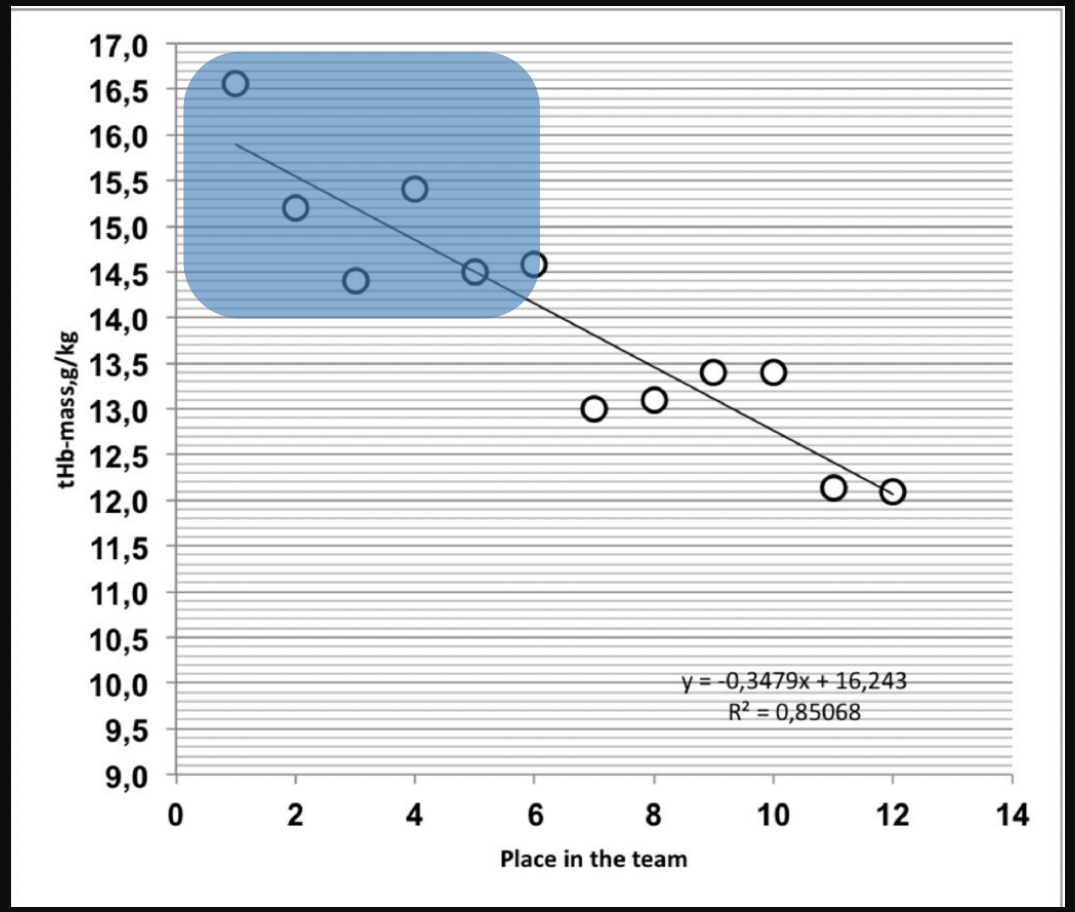
- Glycolytic enzymes
- Angiogenic factors
- Oxidative stress defence
- PH Regulation

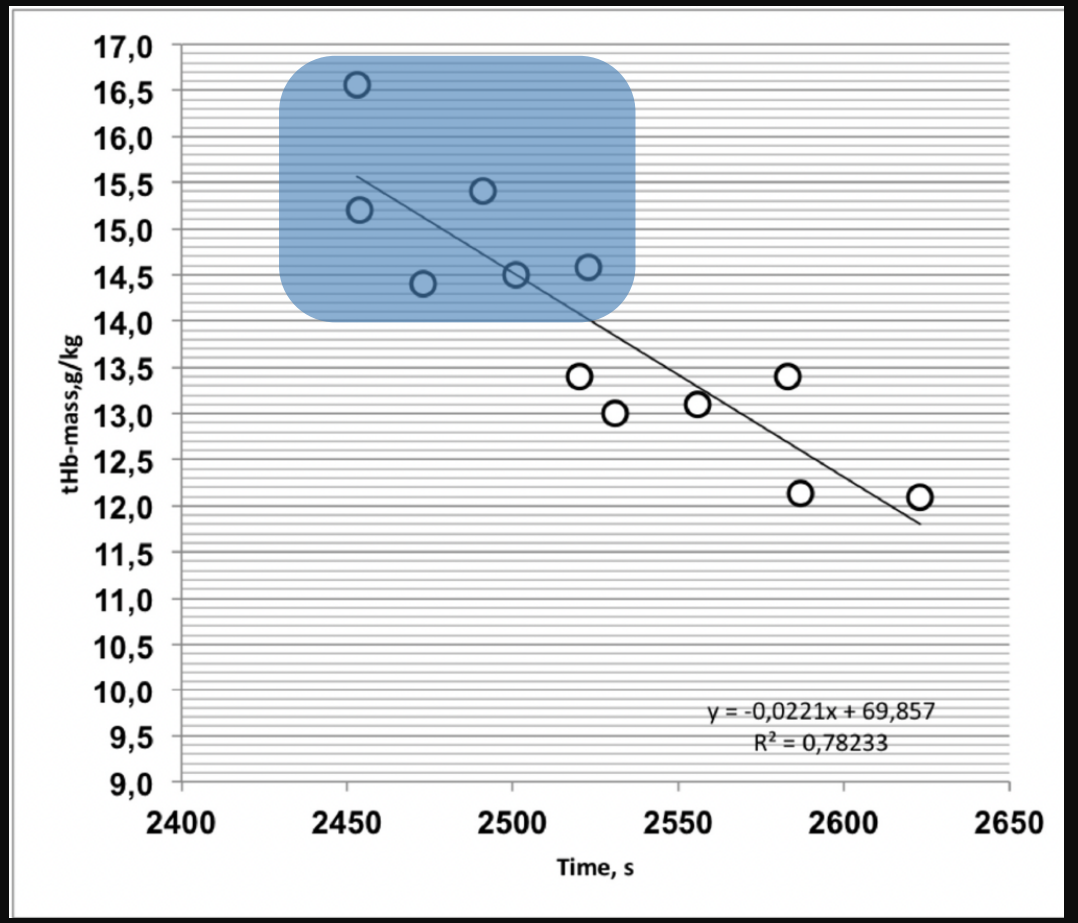
VO2max

PERFORMANCE

Garvican L, PhD thesis

RELATIONSHIP BETWEEN tHB-MASS AND PERFORMANCE





Zelenkova et al., 2018

CASE. TEAM ALTITUDE TRAINING CAMP

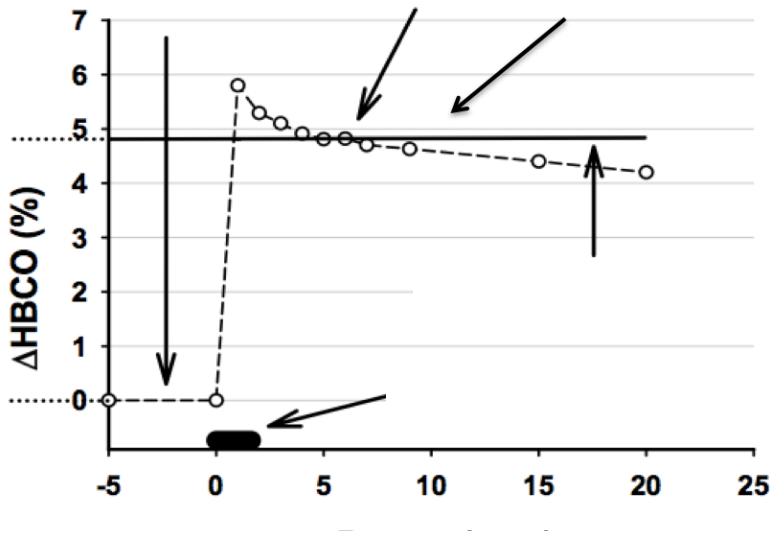
You have a team of 7 athletes at the training camp at altitude

After the training camp some athletes decreased HBC and HCT, some didn’t change and some improved

How to understand the individual response to altitude exposure?

ABSOLUTE VALUES OF tHB-MASS BEFORE TRAINING CAMP

	Before TC1
Subject 1	1204
Subject 2	1140
Subject 3	1103
Subject 4	1024
Subject 5	1005
Subject 6	-
Subject 7	-



Vinogradov M & Zelenkova I, 2020

UNIQUE WAY TO DETERMINE INDIVIDUAL REACTION

	Before TC1	After TC1
Subject 1	1204	1241
Subject 2	1140	1176
Subject 3	1103	1138
Subject 4	1024	1019
Subject 5	1005	993
Subject 6	-	-
Subject 7	-	564

Vinogradov M & Zelenkova I, 2020

ABSOLUTE VALUES OF tHB-MASS (g)

	Before TC1	After TC1	Before TC2	After TC2
Subject 1	1204	1241	1210	1256
Subject 2	1140	1176	1153	1192
Subject 3	1103	1138	1140	-
Subject 4	1024	1019	1021	1069
Subject 5	1005	993	1009	1033
Subject 6	-	-	914	935
Subject 7	-	564	-	582

Vinogradov M & Zelenkova I, 2020

ABSOLUTE VALUES OF tHB-MASS (g)

	Before TC1	After TC1	Before TC2	After TC2
Subject 1	1204	1241	1210	1256
Subject 2	1140	1176	1153	1192
Subject 3	1103	1138	1140	-
Subject 4	1024	1019	1021	1069
Subject 5	1005	993	1009	1033
Subject 6	-	-	914	935
Subject 7	-	564	-	582

AFTER 1138±104 g*

Vinogradov M & Zelenkova I, 2020


If you can’t measure it, you can’t improve it
Peter Ferdinand Drucker

COMPETITIVE EDGE

-02

GOOD PREPARATION

WHAT CAN GO WRONG?

Health & Prevention

Nutrition & Supplements

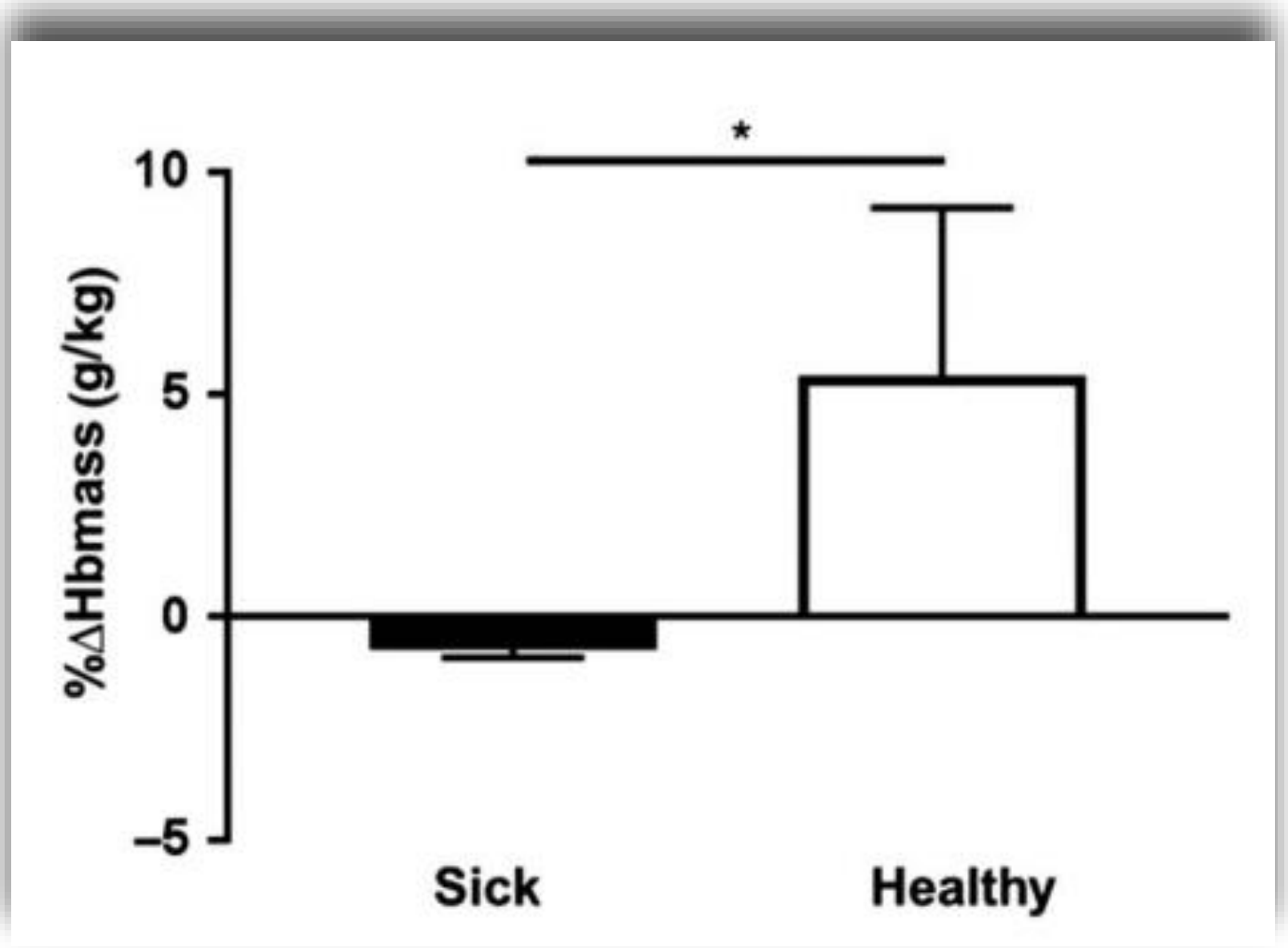
Iron levels

Climate

Accommodation

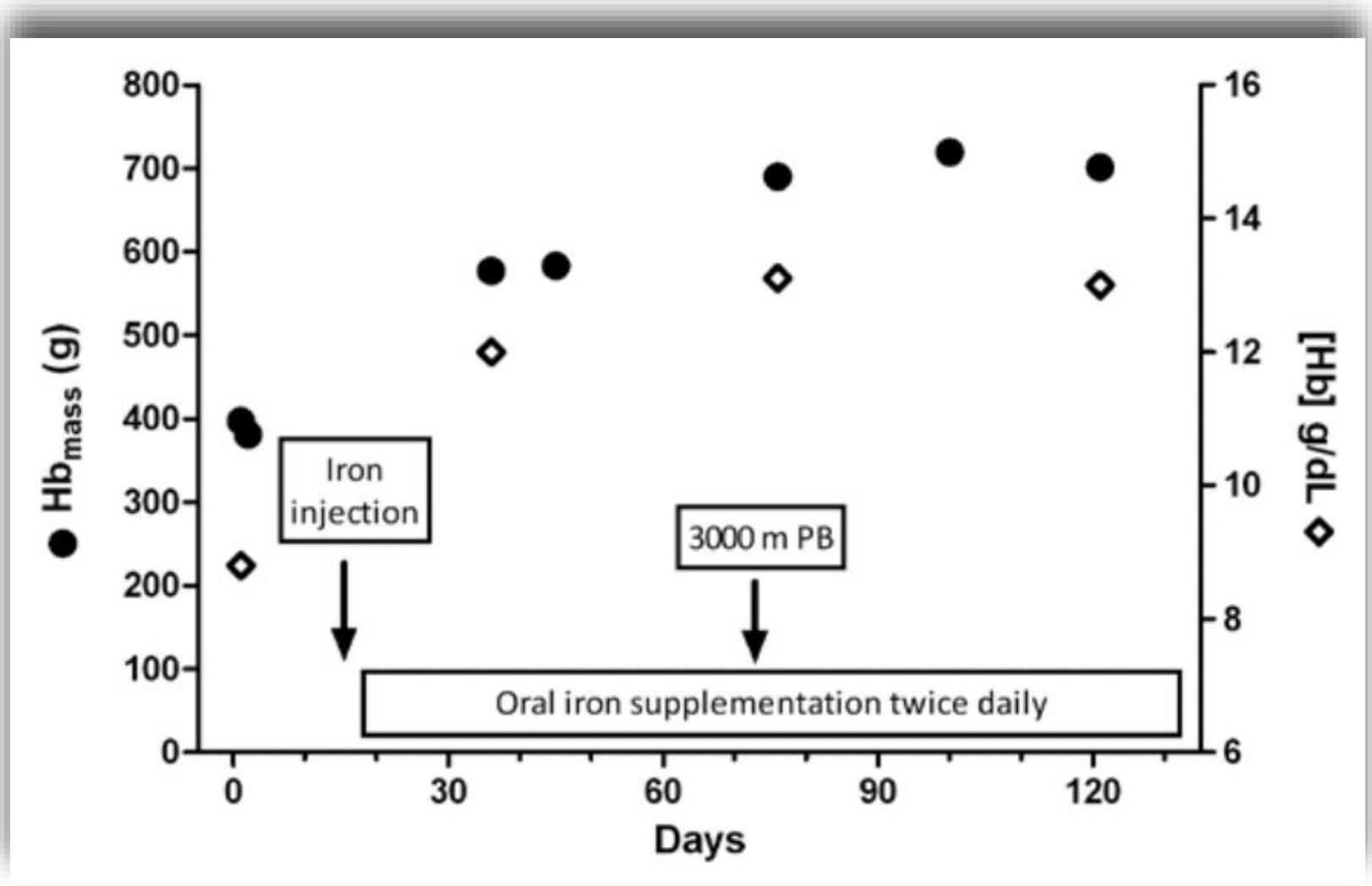
Equipment

Change in Hb-mass in healthy athletes com



Garvican L, 2011

Hb-mass and Hb after iron supplementation



Garvican L, 2011

PREPARATION CHECK - LIST

- **HEALTHY ATHLETE:** NO inflammation, colds, injuries, etc.

IRON LEVEL: Ferritin not less than <35 ng/ml

HEALTH PROTECTION: Start taking probiotics 4 weeks before and vitamin D, C and others if necessary

BRIEFING: Athlete informed of altitude, its effects, time and etc.

PRE ALTITUDE SCREENING: General and biochemical blood tests, tHb-mass test, CRP, health check, genetics (MTHFR Mutation Test and others)


Successful altitude training camp starts
one month before the date

COMPETITIVE EDGE

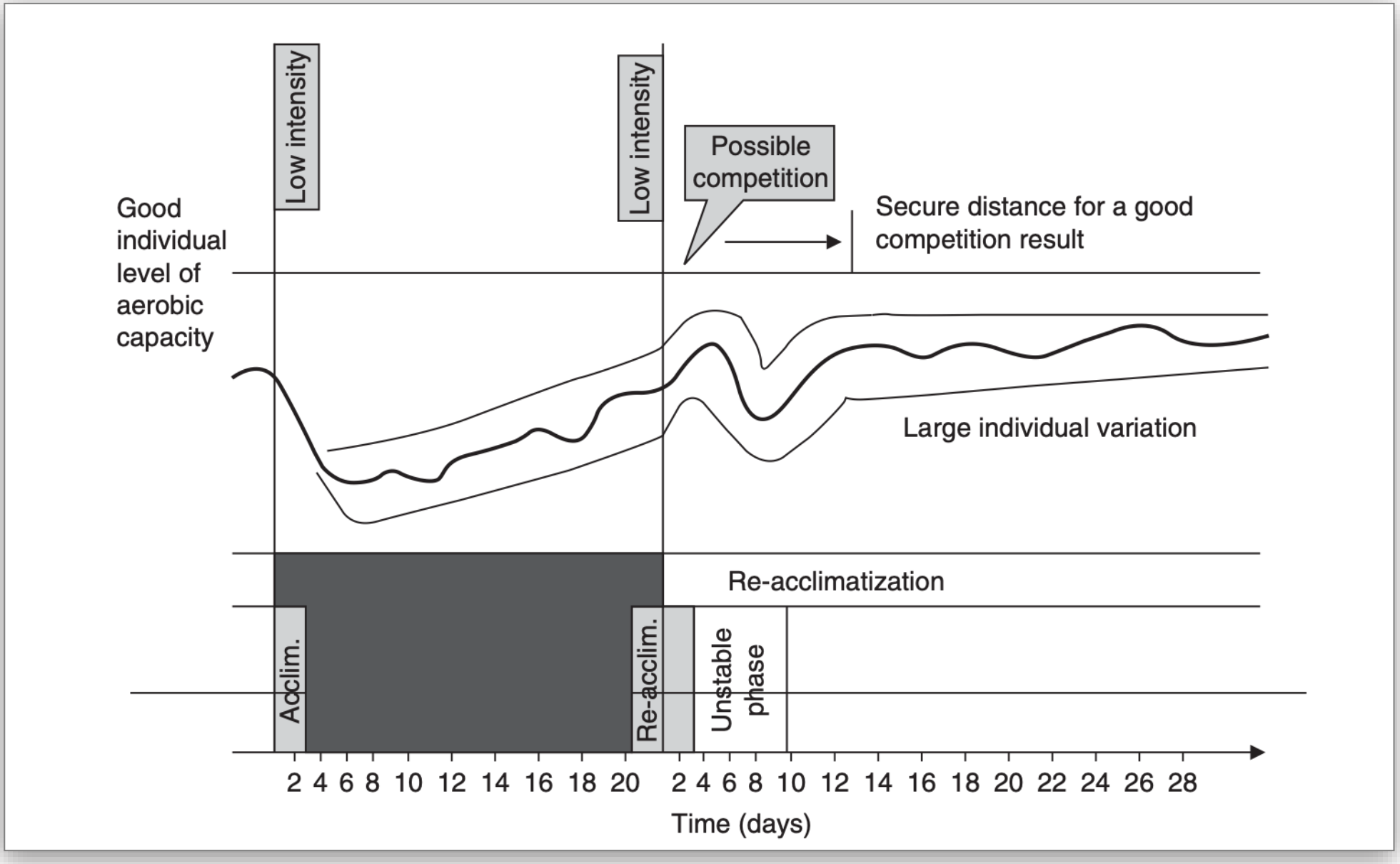
-03

MONITORING

Negative effects of altitude training

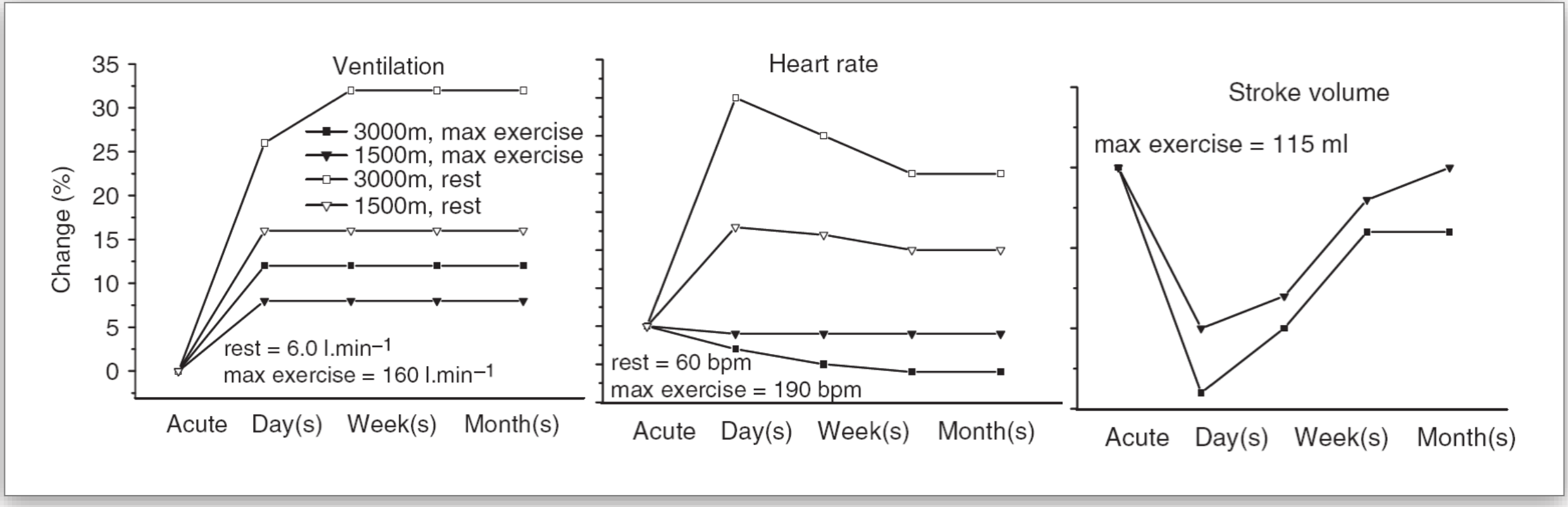
- Difficulty in following the training plan
- Altitude sickness in the first days
- Increased risk of disease and overtraining
- Recovery diminution & fatigue accumulation
- Decrease in exercise intensity
- Decrease of muscle mass

ADAPTATION FASES AND PERFORMANCE CHANGE



Millet G et al, 2010

ADAPTATION TO HYPOXIA



Increased ventilation

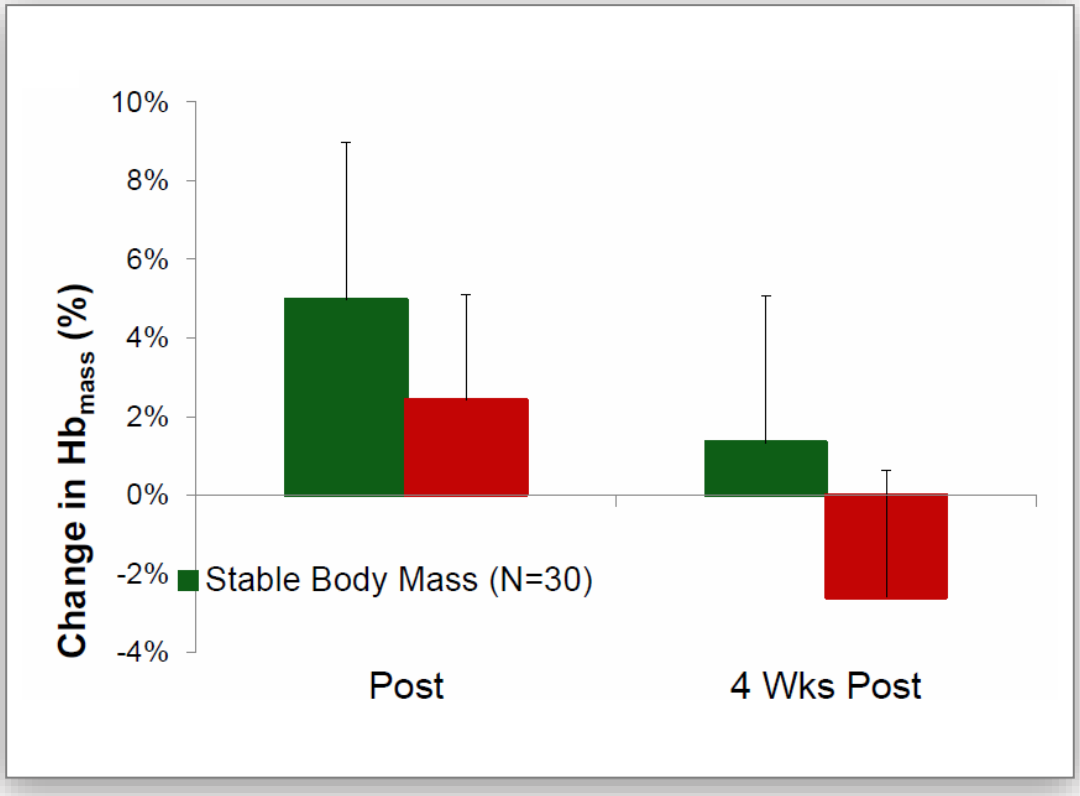
Increased rest heart rate

Maximal heart rate reduced

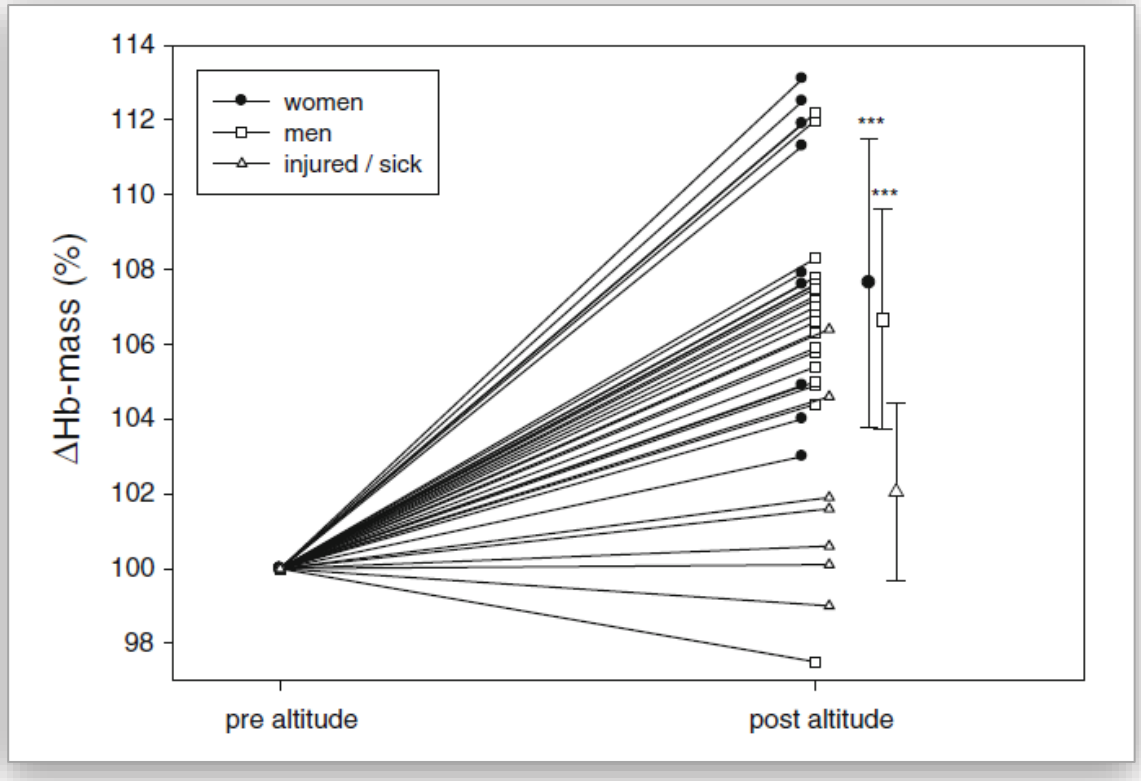
Decreased stroke volume

Bärtsch P et al, Scand J Sci Med Sports, 2008

COMPOUND FACTORS



Negative Energy Balance



Illness/ Injury

McLean et al. BJSM 2013,

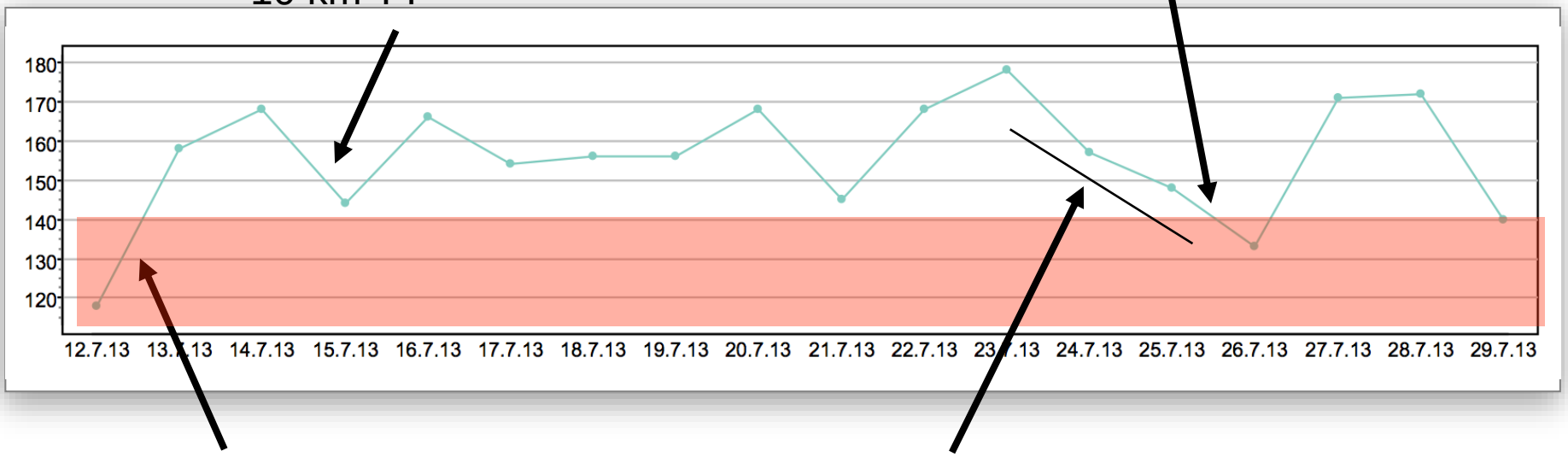
Wachsmuth N et al. Eur J Appl Physiol 2013

CONTINOUS MONITORING

AVOIDING NEGATIVE ASPECTS OF ALTITUDE TRAINING

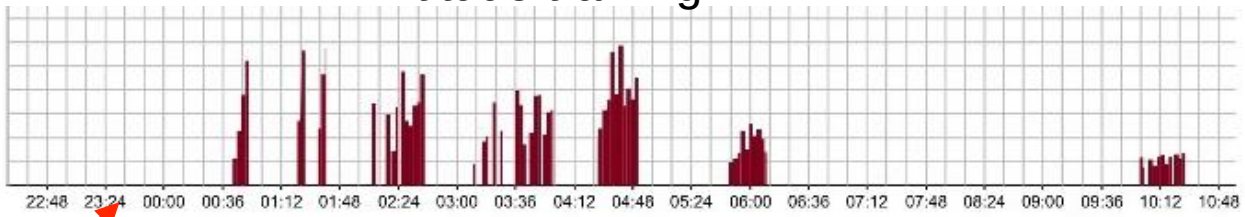
Volume training
(132 km, 3600 m)

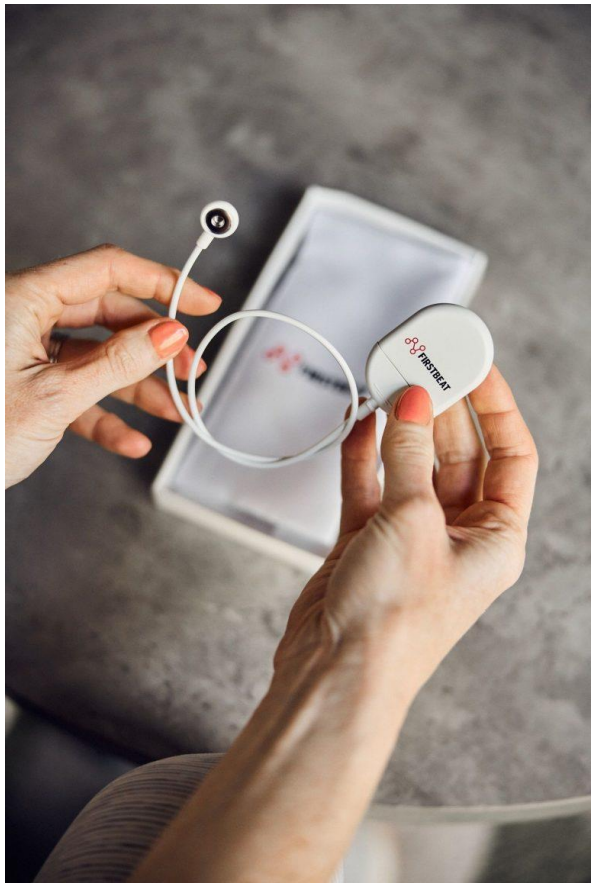
10 km TT



Day 5 at 1800 m

Altitude training





Recovery Index: 197

TRAINING CAMP CHECK - LIST

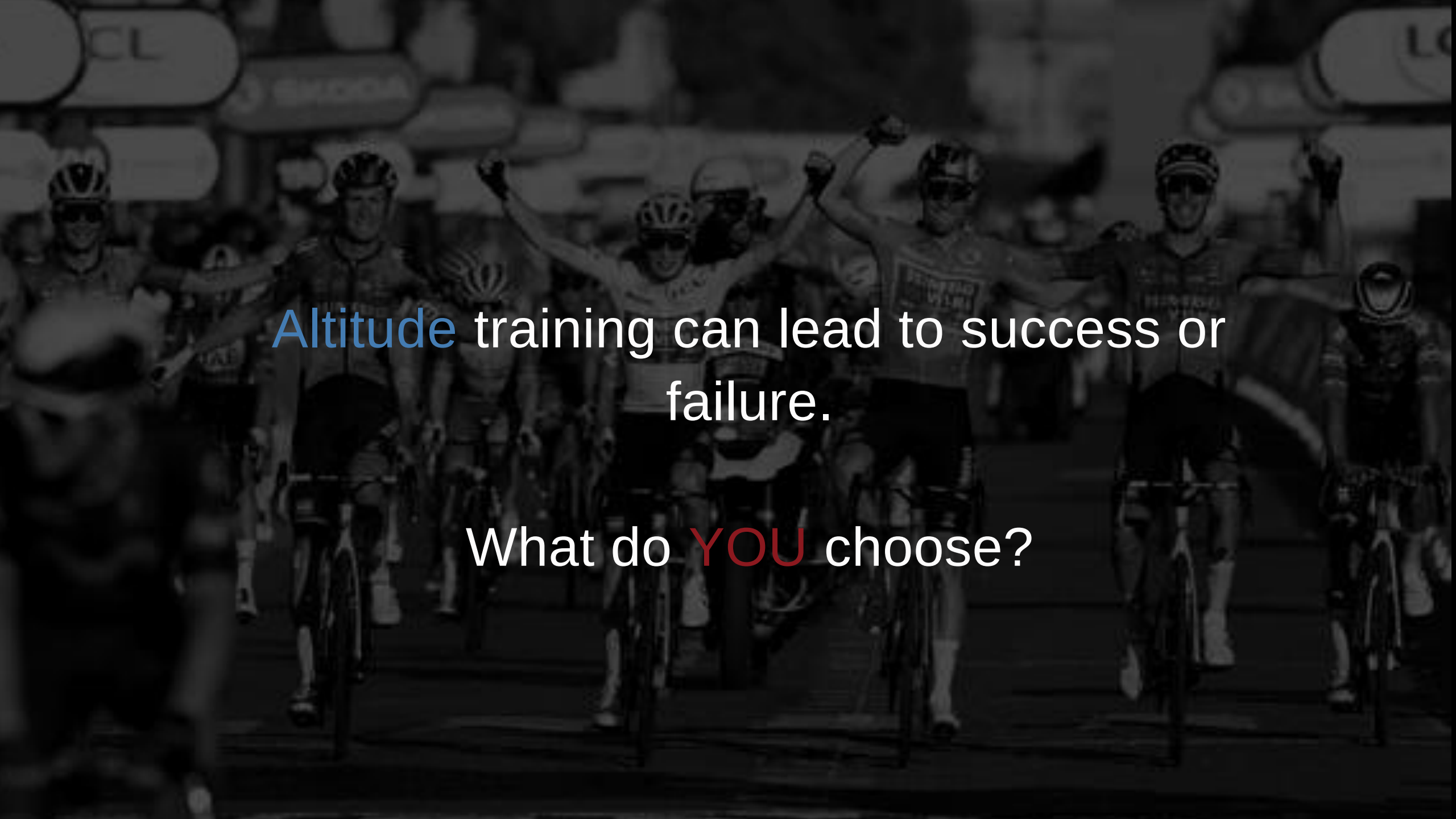
TRAINING: Decrease volume and intensity until complete adaptation

MONITORING ADAPTATION AND FATIGUE: SpO2, HR, HRV, POMS, blood tests

POWER/STRENGTH: Monitor power/strength and include necessary workouts in the training program

NUTRITION AND HYDRATION: CH 8-12 g/kg/day. For 60-120 g. 2 h before exercise should drink 400-600 ml of fluid, for 400-800, after V fluid = (weight before exercise + weight of fluid drunk - weight after exercise) * 1.2

SUPPLEMENTATION: Iron 200 mg/d and probiotics Lactobacillus casei and Latobacillus fermentum 1.3x10^11 and 1.0x10^9 each


Altitude training can lead to success or failure.
What do YOU choose?

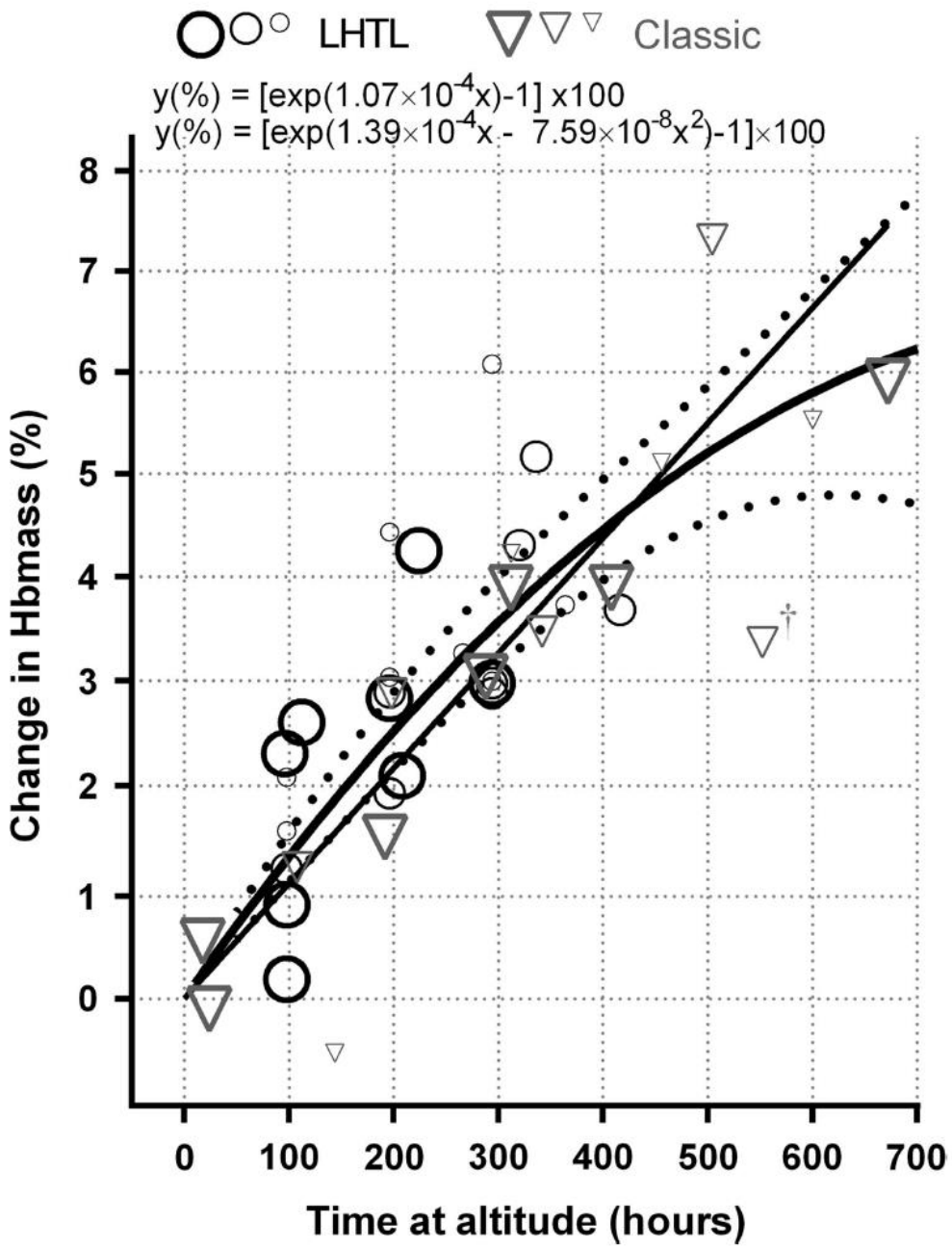
COMPETITIVE EDGE

-04

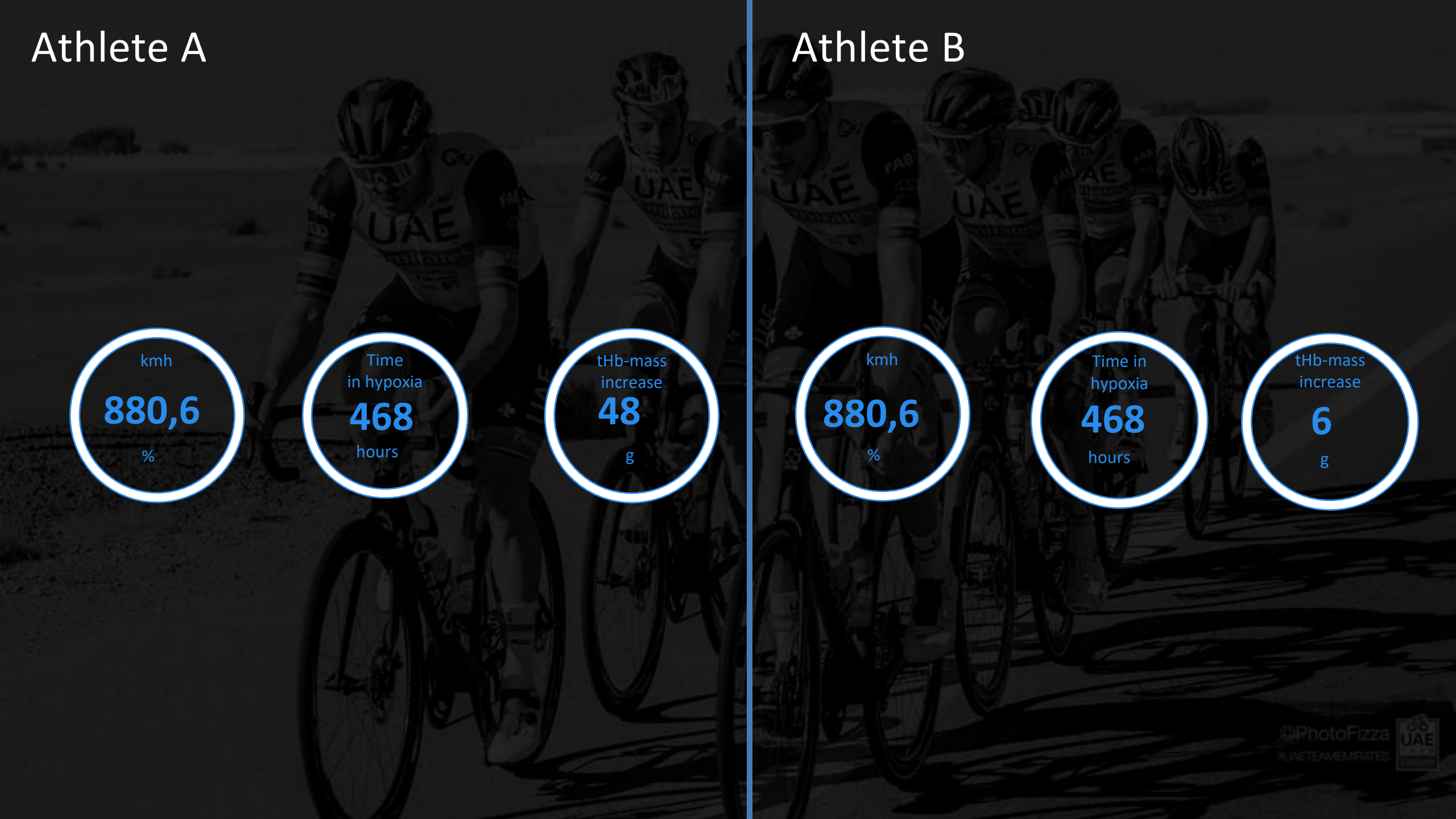
INDIVIDUALISE THE HYPOXIC DOSE

Estimates of the change in haemoglobin mass (Hbmass)during live high train low (LHTL, n=24) and classic (n=16) altitude exposure.

During-altitude Hbmass was estimated to increase by ~1.1%/100 h for LHTL and classic altitude.

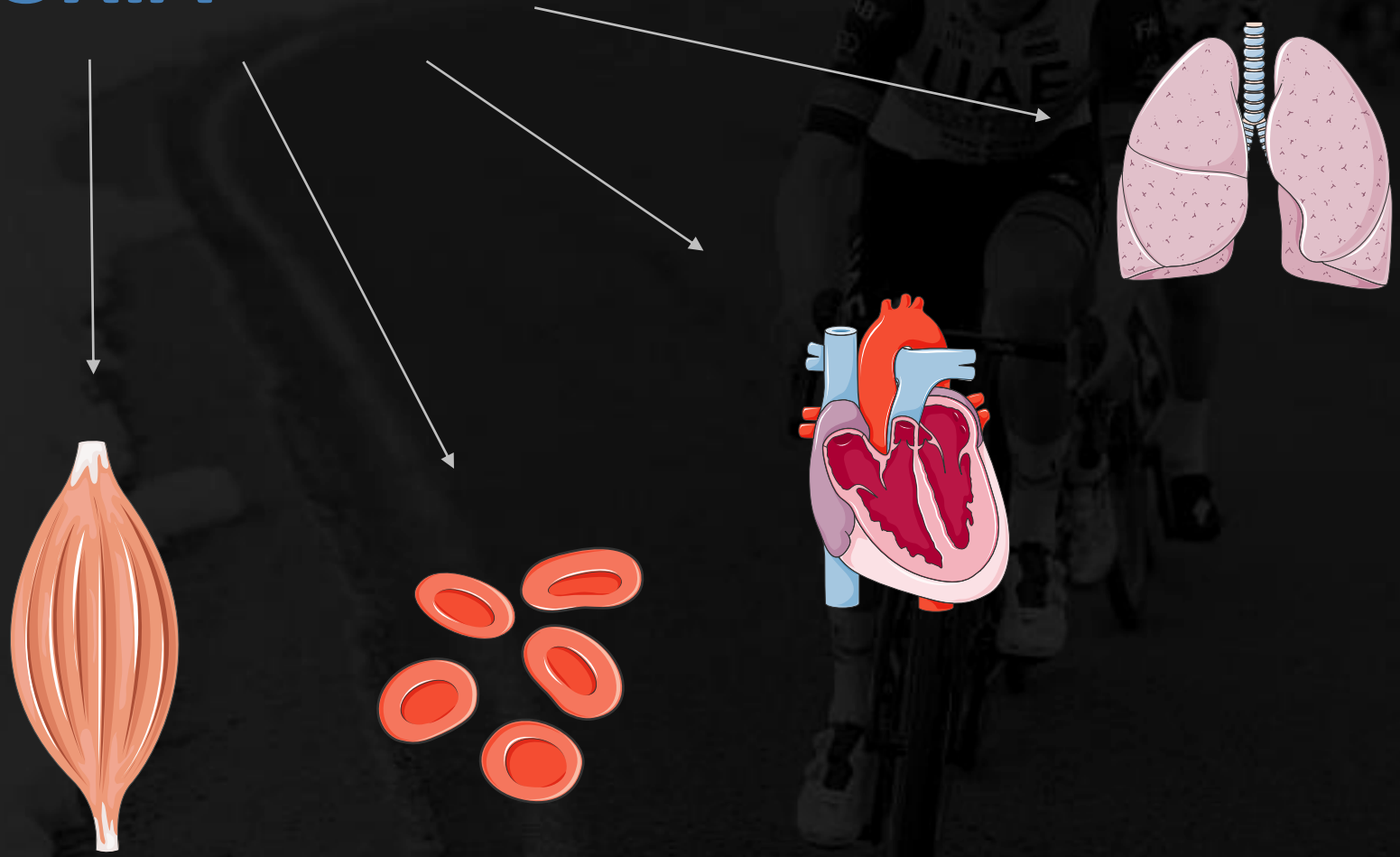


Gore CJ et al. *Br J Sports Med*. 2013;47 Suppl 1(Suppl 1):i31-i39.

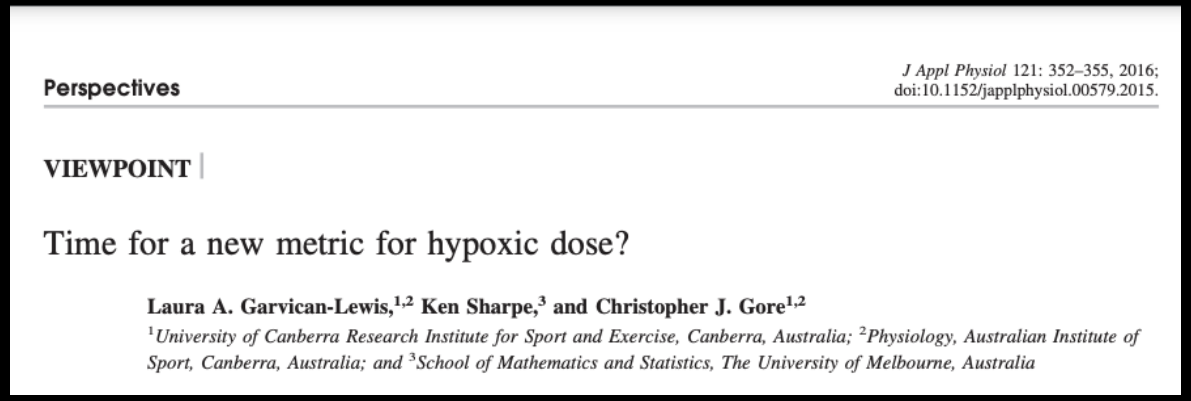

Athlete A
kmh
880,6
%
Time
in hypoxia
468
hours
tHb-mass
increase
48
g
Athlete B
kmh
880,6
%
Time in
hypoxia
468
hours
tHb-mass
increase
6
g
©PhotoFizza
#UAETEAMEMIRATES

WHAT IS MORE IMPORTANT ALTITUDE OR OXYGEN SATURATION?

SATURATION TRIGGERS PHYSIOLOGYCAL ADAPTATION TO HYPOXIA



INDIVIDUALISATION OF TRAINING AT ALTITUDE



Perspectives

J Appl Physiol 121: 352–355, 2016;
doi:10.1152/japplphysiol.00579.2015.

VIEWPOINT

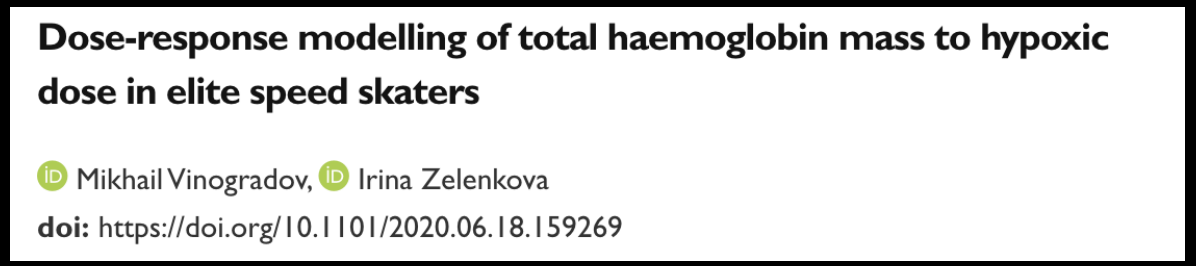
Time for a new metric for hypoxic dose?

Laura A. Garvican-Lewis,[1,2] Ken Sharpe,[3] and Christopher J. Gore[1,2]

[1]University of Canberra Research Institute for Sport and Exercise, Canberra, Australia; [2]Physiology, Australian Institute of Sport, Canberra, Australia; and [3]School of Mathematics and Statistics, The University of Melbourne, Australia

Saturation hours: %·h = (98/s – 1) × t × 100%

Where s is the saturation value (in %) and h is the time (in hours) sustained at this level of saturation.



Dose-response modelling of total haemoglobin mass to hypoxic dose in elite speed skaters

Mikhail Vinogradov, Irina Zelenkova

doi: https://doi.org/10.1101/2020.06.18.159269

Saturation hours: %·h = (95/s – 1) × t × 100%

Where s is the saturation value (in %) and h the time (in hours) sustained at th s level of the saturation.

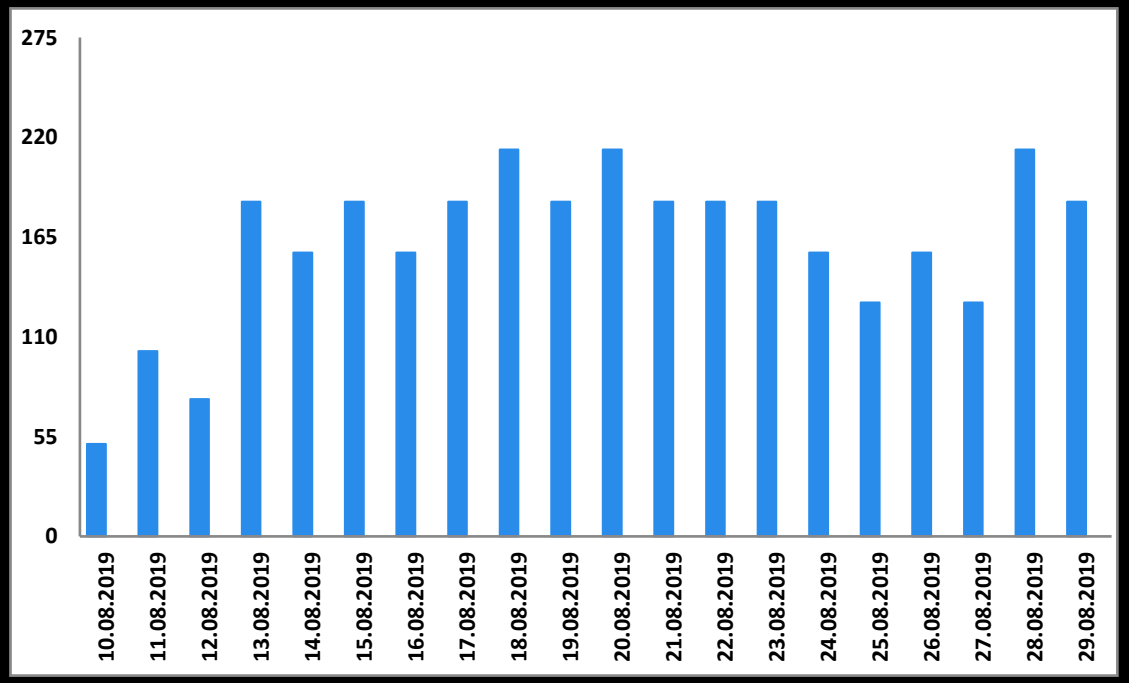
Athlete A

kmh
880,6
%

%h
3230
%

Time in hypoxia
468
hours

tHb-mass increase
48
g



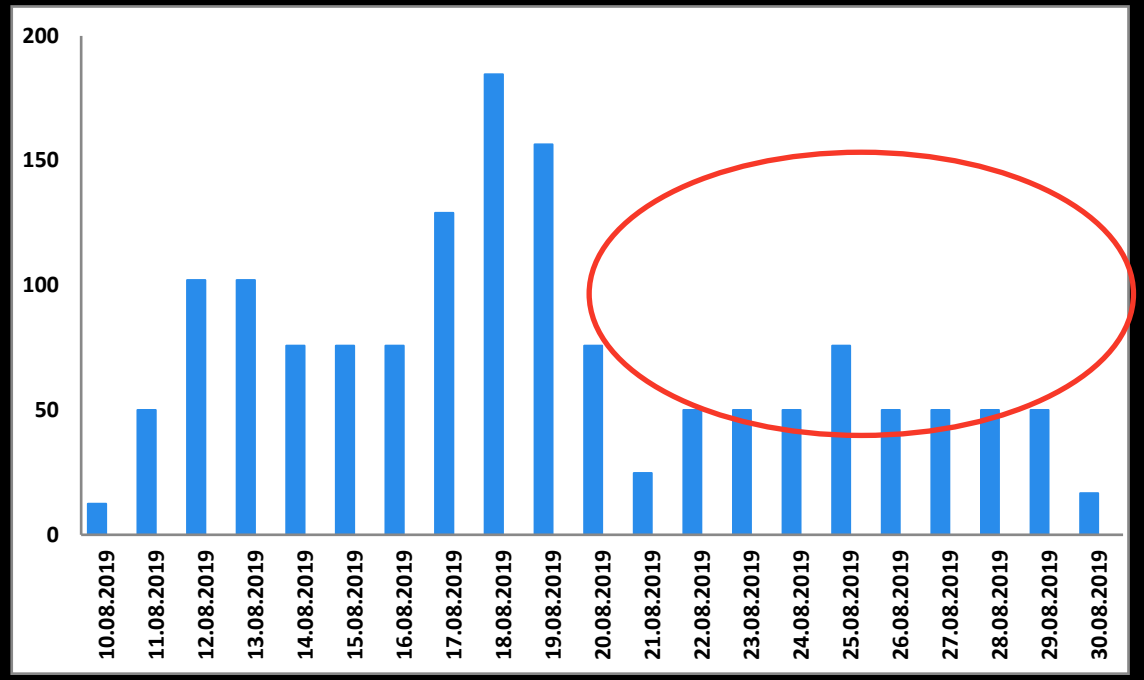
Athlete B

kmh
880,6
%

%h
1507
%

Time in hypoxia
468
hours

tHb-mass increase
6
g



Vinogradov M & Zelenkova I, 2020

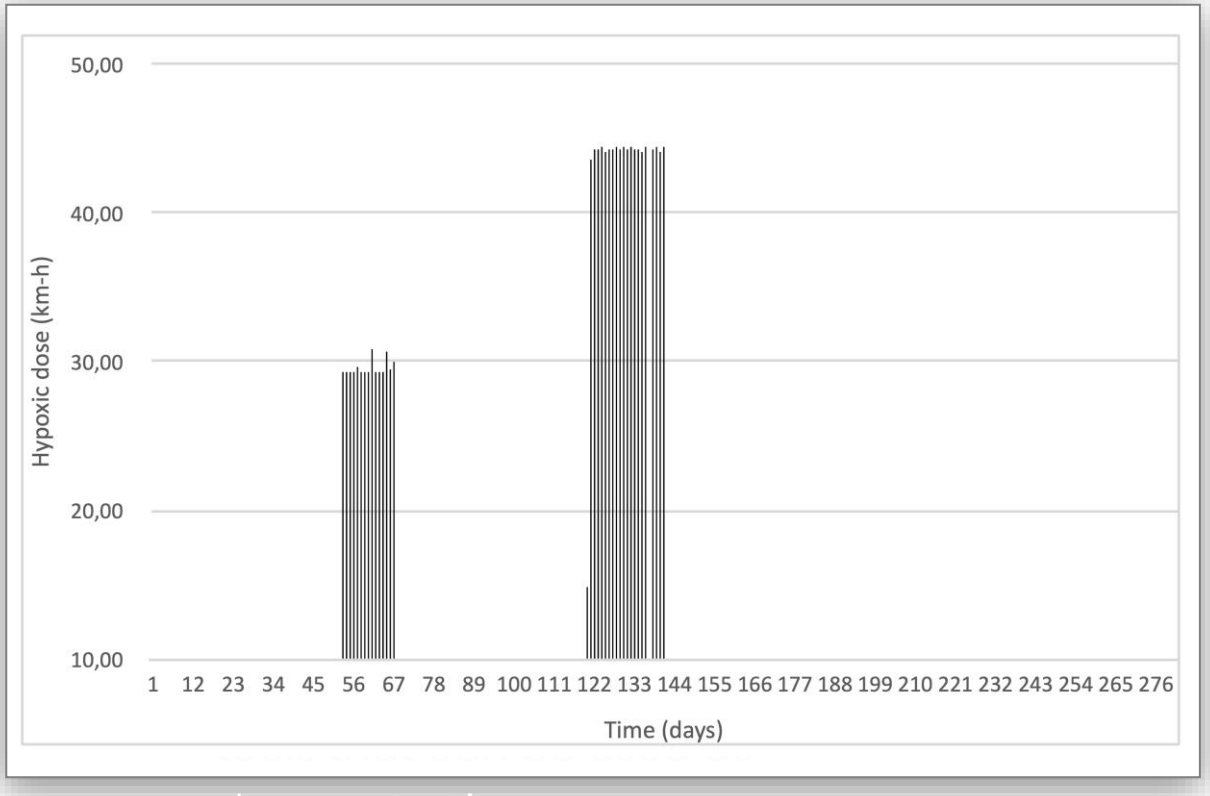
CASE. TEAM ALTITUDE TRAINING CAMP

You have a team of 7 athletes at the training camp at altitude

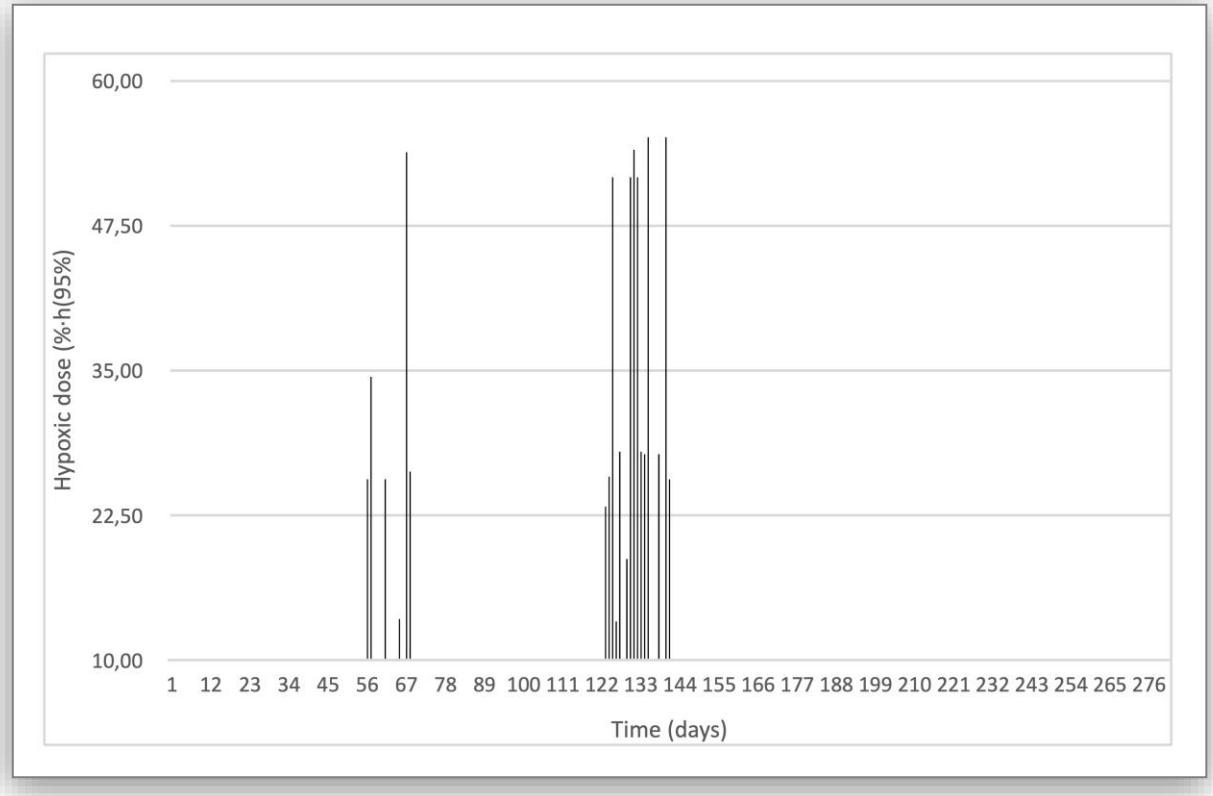
They are all staying at altitude 2000 m asl. Some athletes have SpO2 96%, some 92%

Who will benefit more from altitude training?

ATHLETES WITH HIGHER SATURATION HOURS DOSE



Kilometer hours: km·h = (m/1,000) × h



Saturation hours: %·h = (95/s - 1) × t × 100%

Vinogradov M & Zelenkova I, 2020


No hypoxic dose, no response

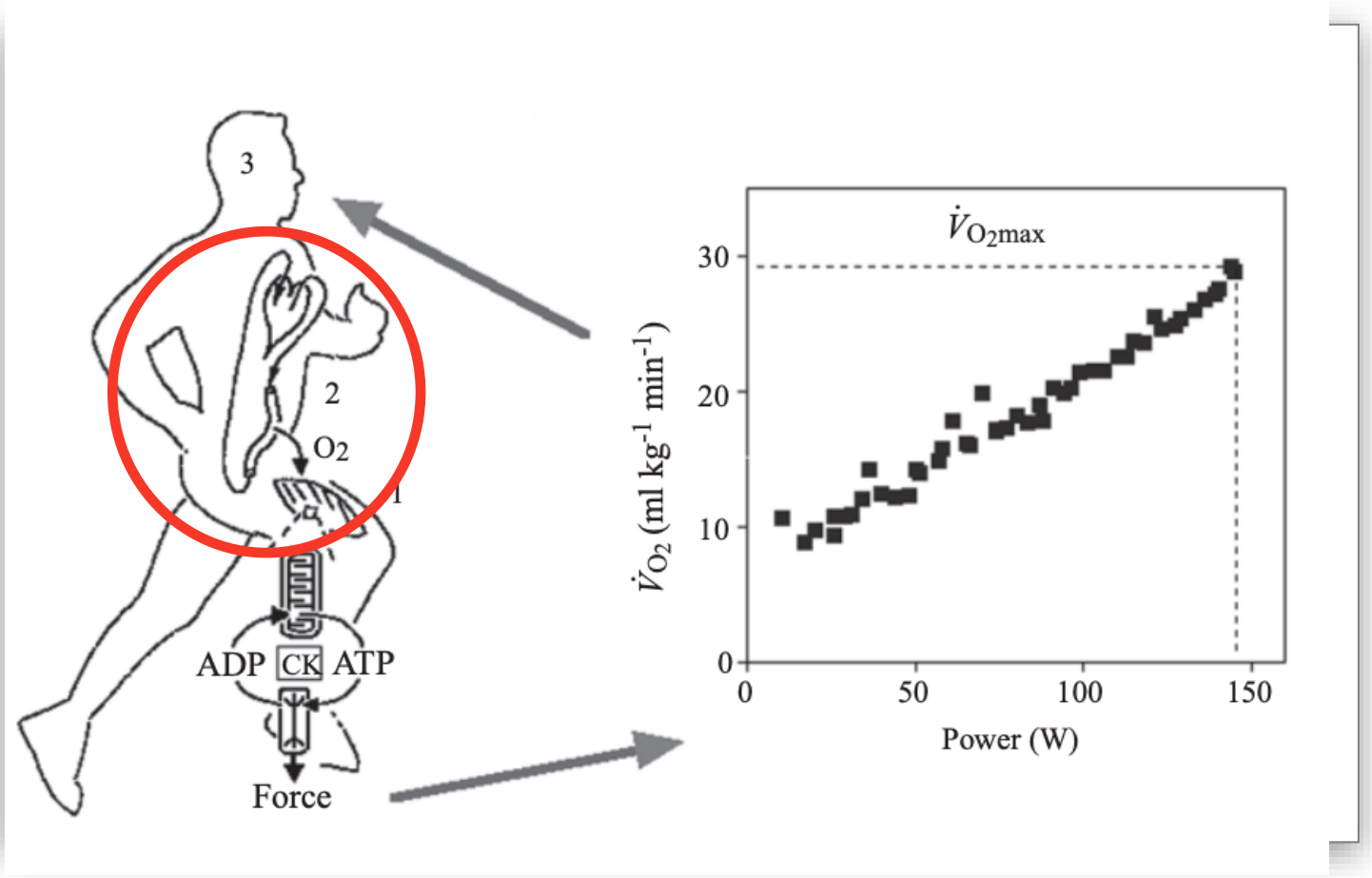
COMPETITIVE EDGE

-05

TRIGGER DIFFERENT SYSTEMS

FACTORS LIMITING AEROBIC PERFORMANCE

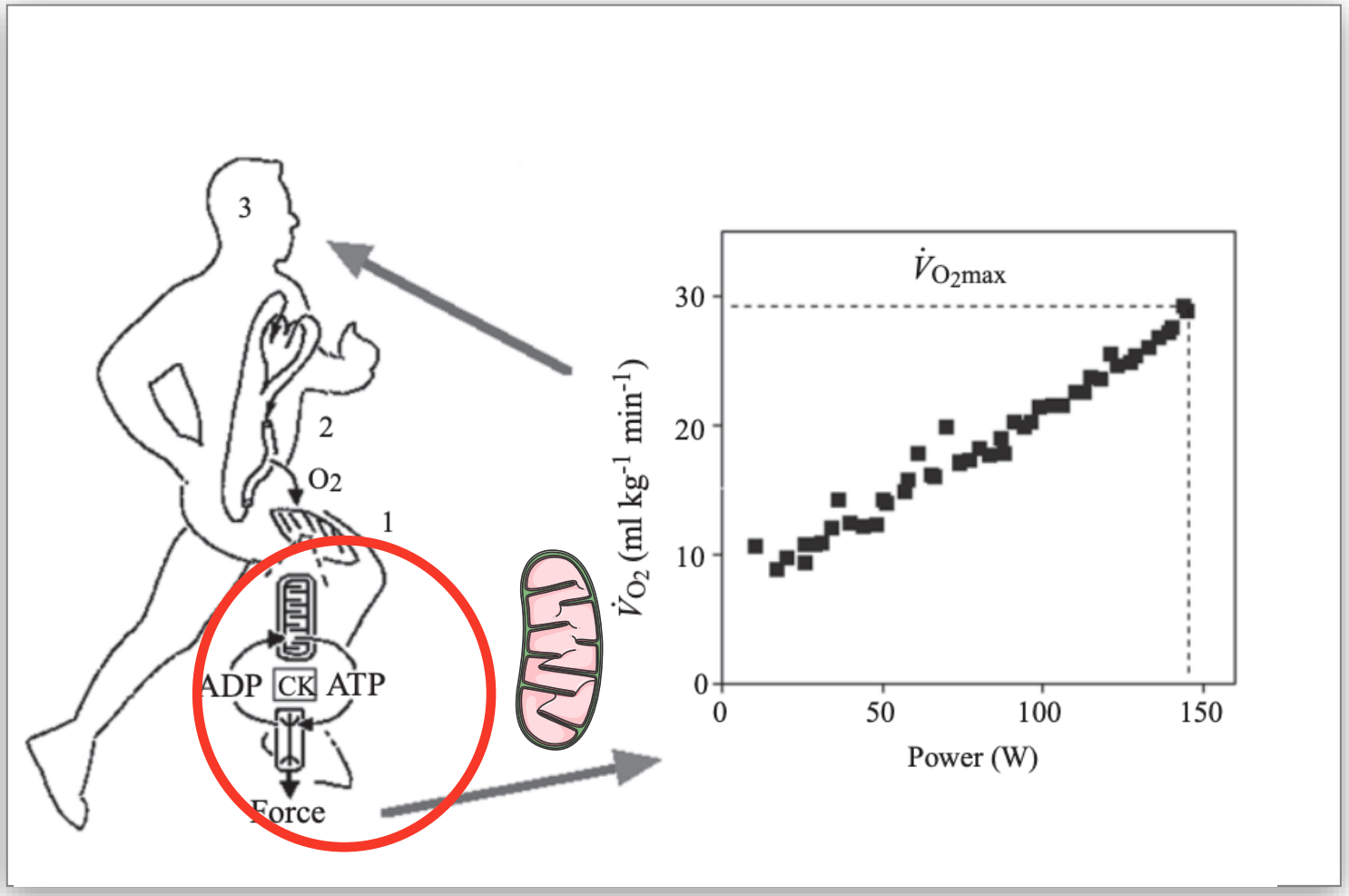
- VO2max
- Cardiac output
- O2 delivery
  [tHb-mass]
  PO2
- O2 extraction
- Mitochondria



Lindstedt SL, Conley KE. Human aerobic performance: too much ado about limits to V(O(2)). J Exp Biol. 2001 Sep;204(Pt 18):3195-9. Review

FACTORS LIMITING AEROBIC PERFORMANCE

- VO2max
- Cardiac output
- O2 delivery
  [tHb-mass]
  PO2
- O2 extraction
- Mitochondria



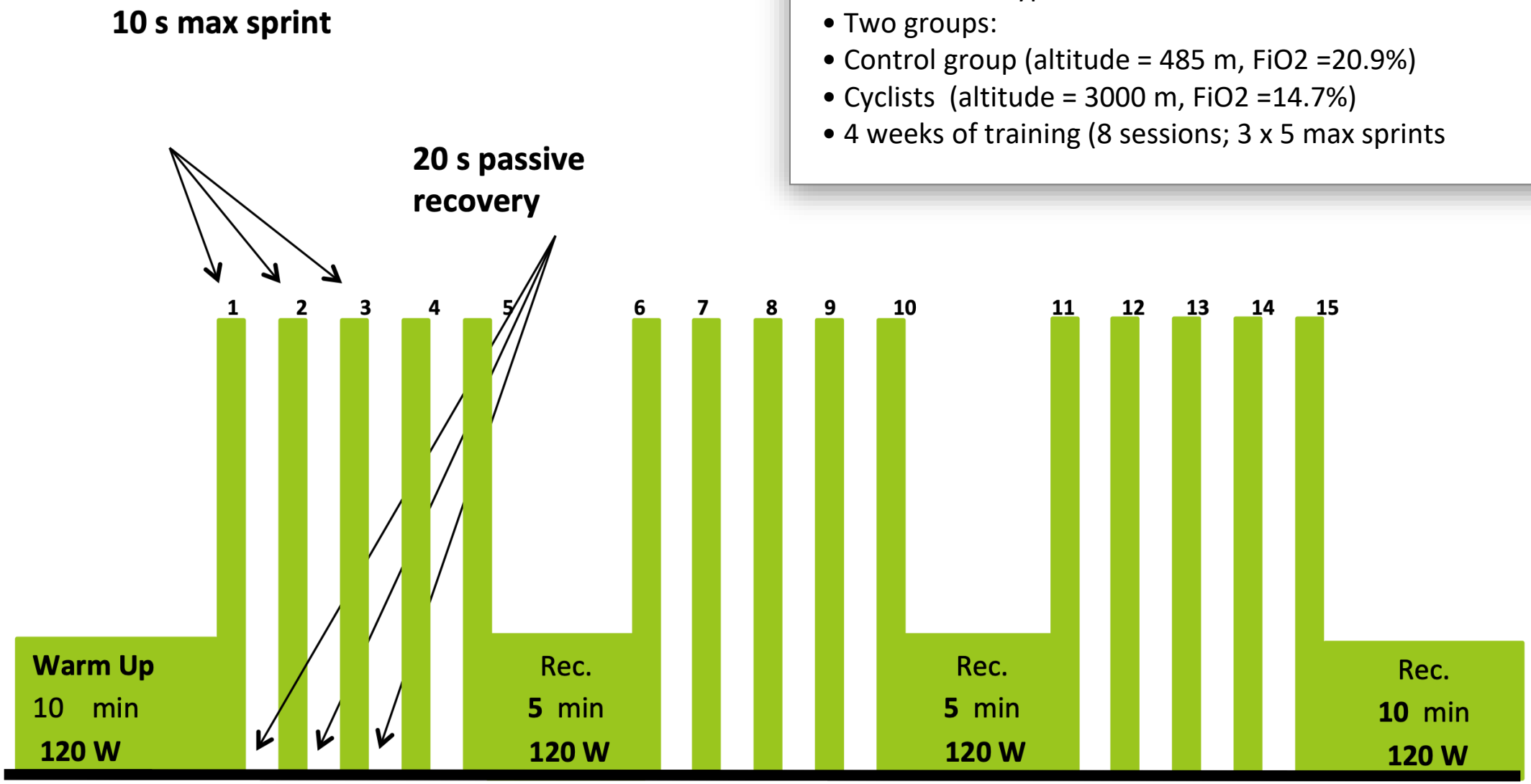
Lindstedt SL, Conley KE. Human aerobic performance: too much ado about limits to V(O(2)). J Exp Biol. 2001 Sep;204(Pt 18):3195-9. Review

WHAT CAN BE IMPROVED?

- Activate fast twitch fibers
- Increased muscle perfusion
- Improved anaerobic glycolysis
- Improved oxygen extraction
- Faster recovery between efforts
- Improved mitochondrial function

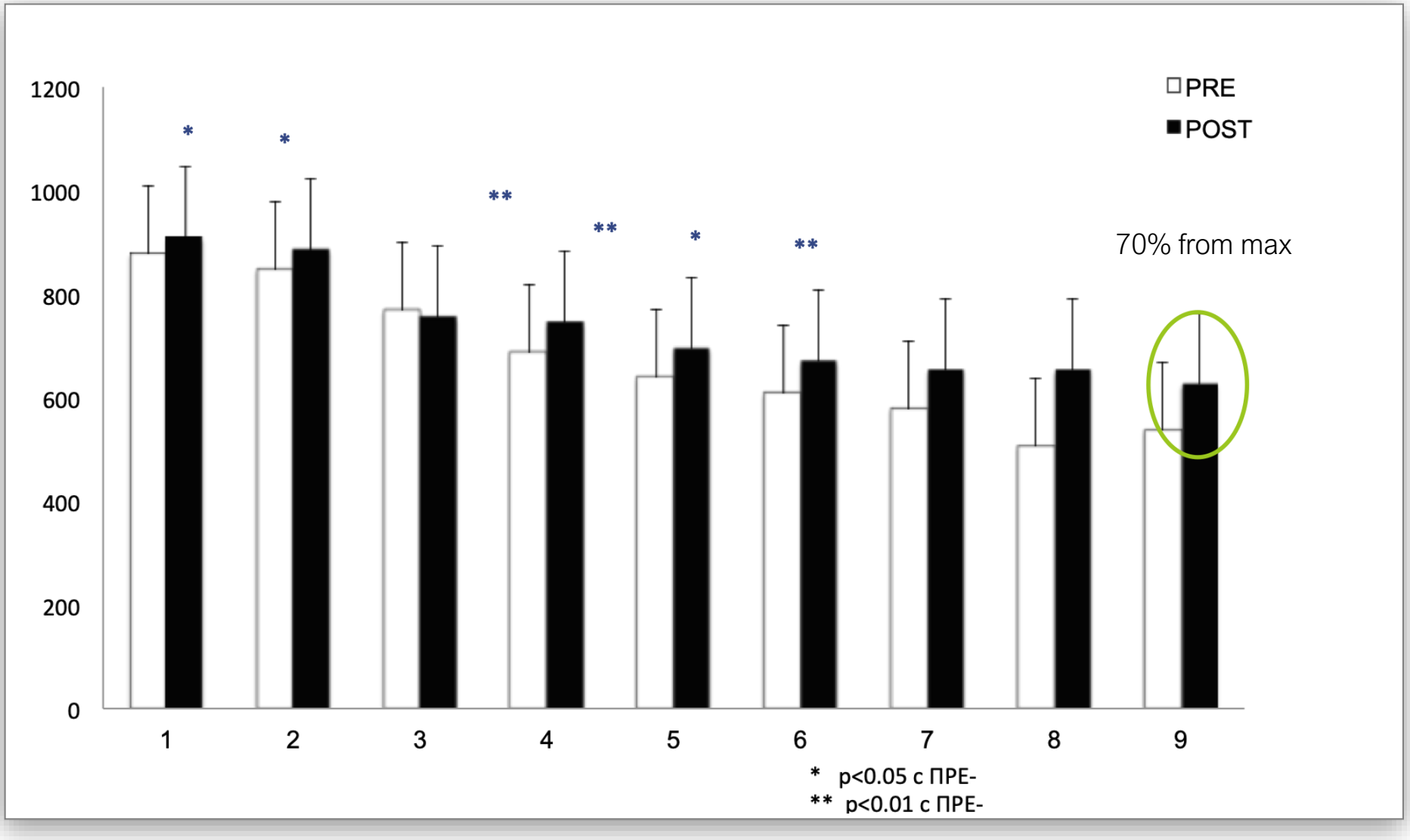
REPEATED SPRINTS IN HYPOXIA (RSH)

- Normobaric hypoxia, blind
- Two groups:
- Control group (altitude = 485 m, FiO2 =20.9%)
- Cyclists (altitude = 3000 m, FiO2 =14.7%)
- 4 weeks of training (8 sessions; 3 x 5 max sprints



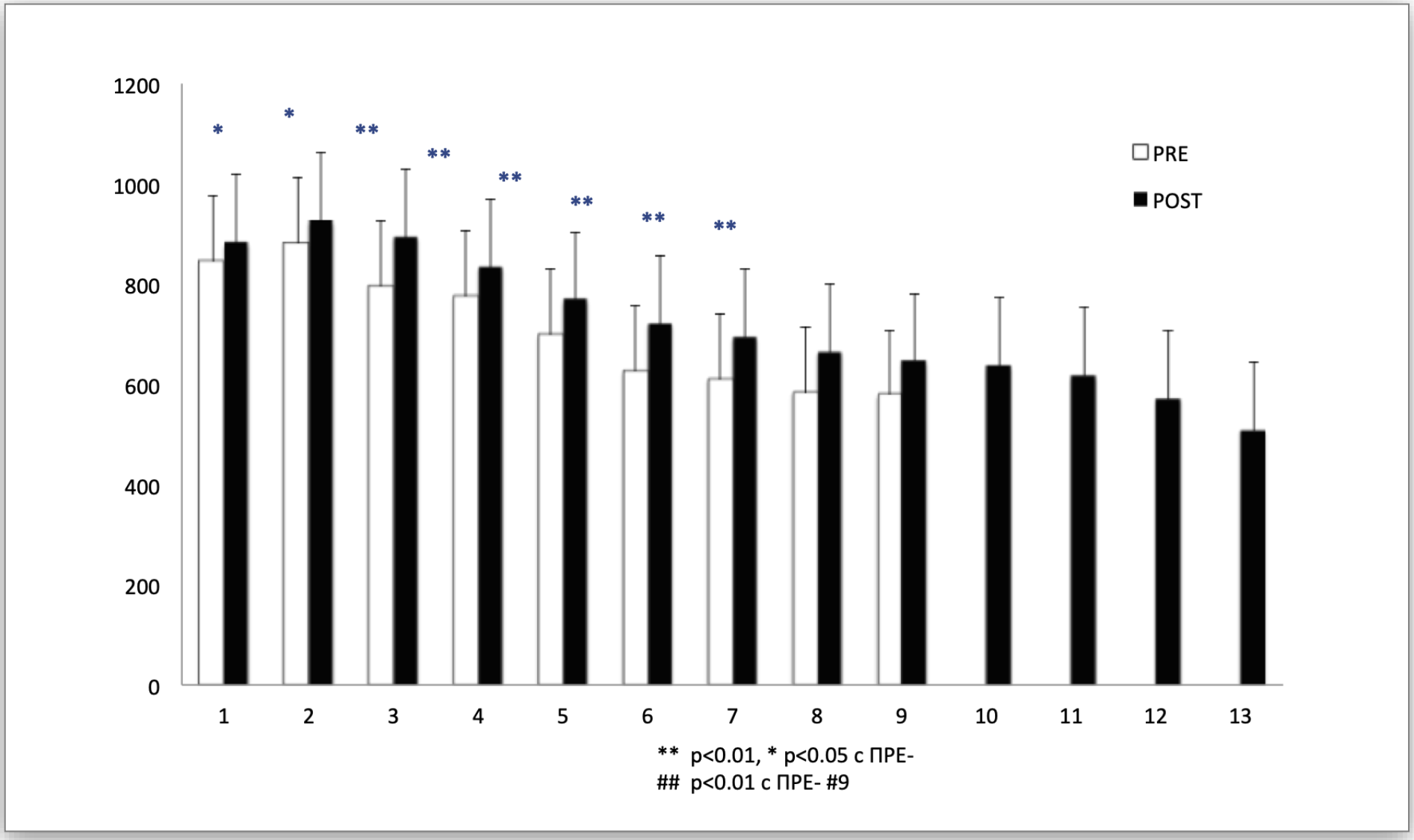
Faiss et al 2013

REPEATED SPRINTS IN NORMOXIA



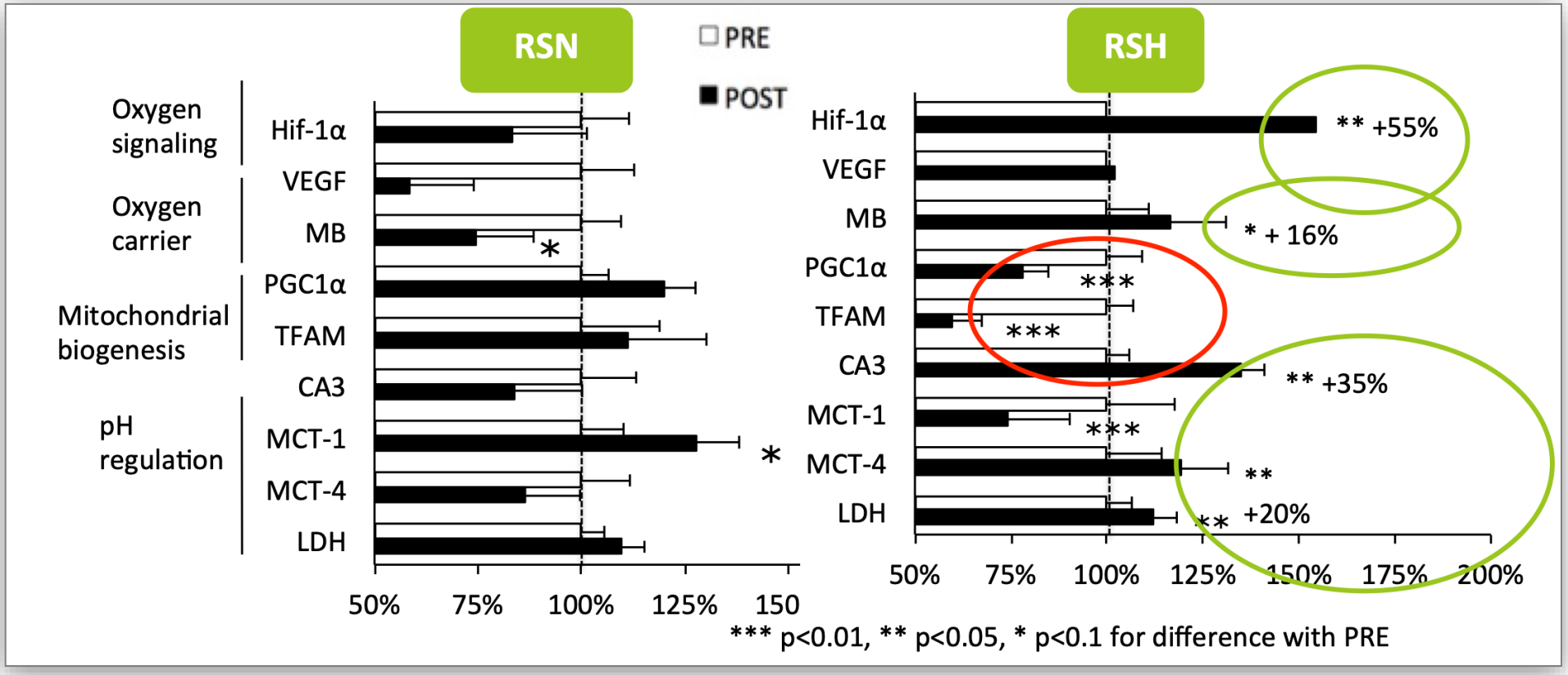
Faiss et al (2013) Significant molecular and systemic adaptations after repeated sprint training in hypoxia. PLoS ONE

REPEATED SPRINTS IN HYPOXIA



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

MOLECULAR ADAPTATIONS



oxygen signaling

oxygen carrying

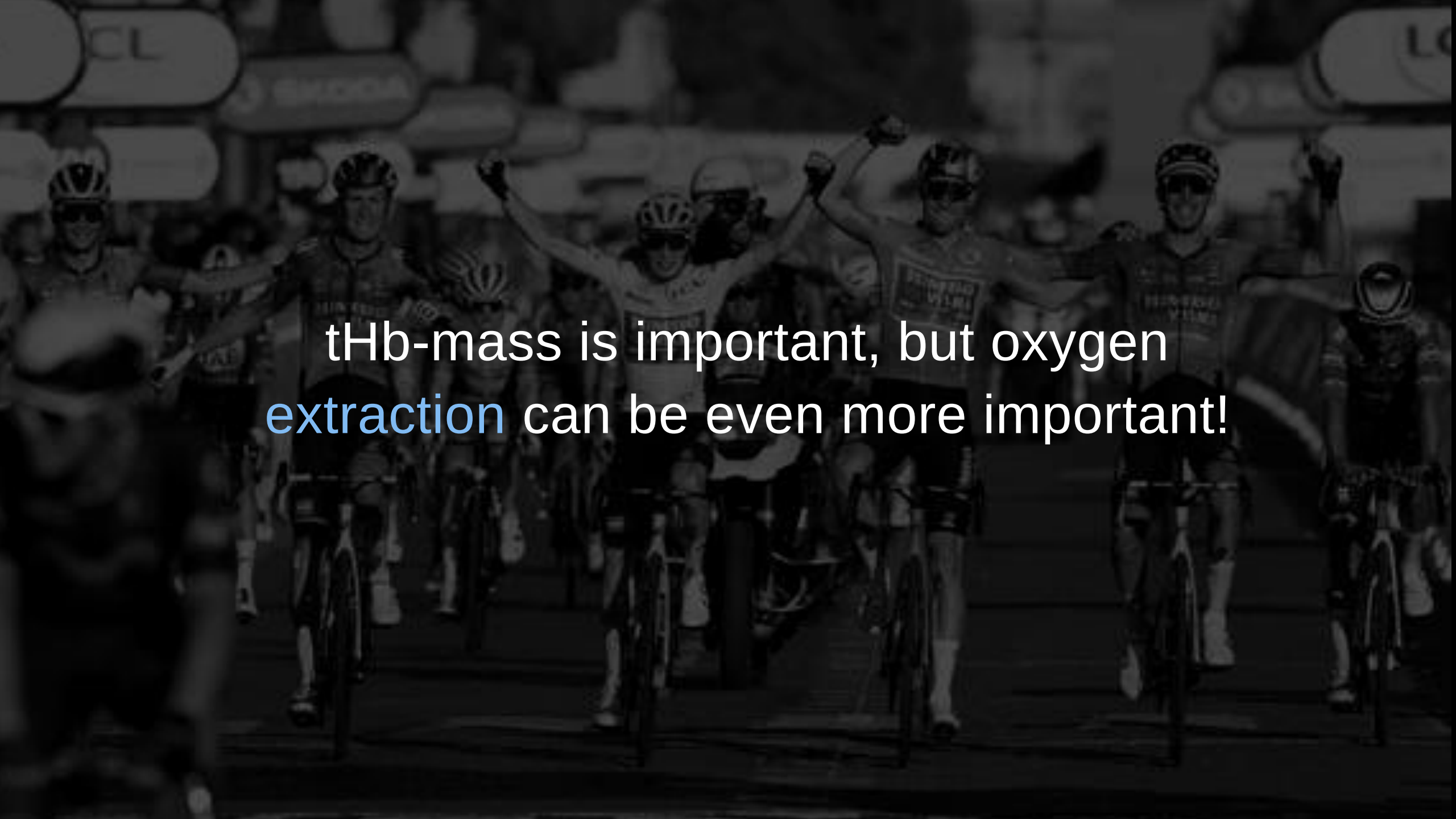
shift to anaerobic glycolytic activity

pH regulation

- Fast-twitch fibers are better utilized
- Increase blood flow perfusion
- Improvement of anaerobic glycolytic activity

Faiss et al 2013

CAN BE INDIVIDUALISED (CLIMBERS,SPRINTERS)


tHb-mass is important, but oxygen
extraction can be even more important!

COMPETITIVE EDGE

-06

COMBINE METHODS

ALTITUDE TRAINING METHODS

Hypobaric hypoxia

- Live high – train low
- Live high – train high
- Live high – train low and high

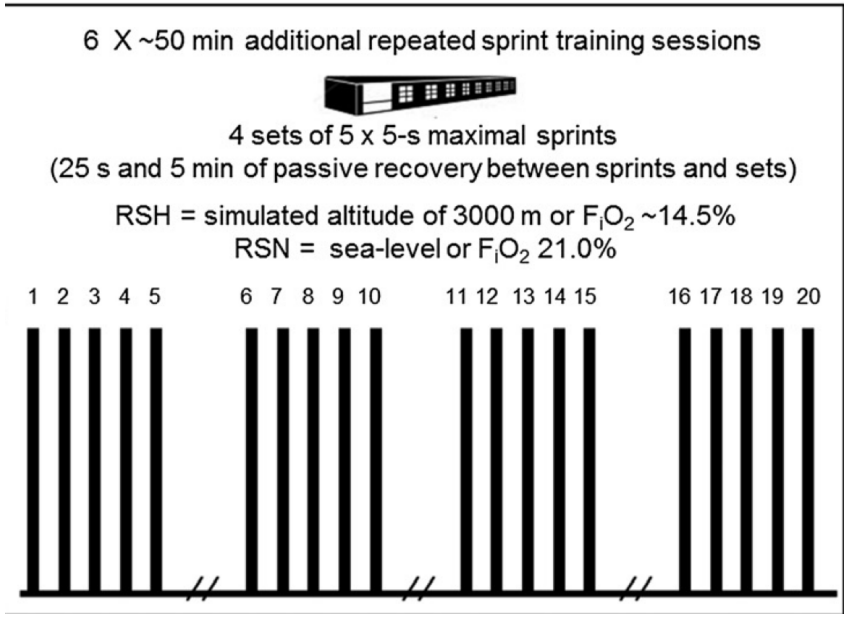
Normobaric hypoxia

- Live high – train low
- Live high – train high
- Live high – train low and high

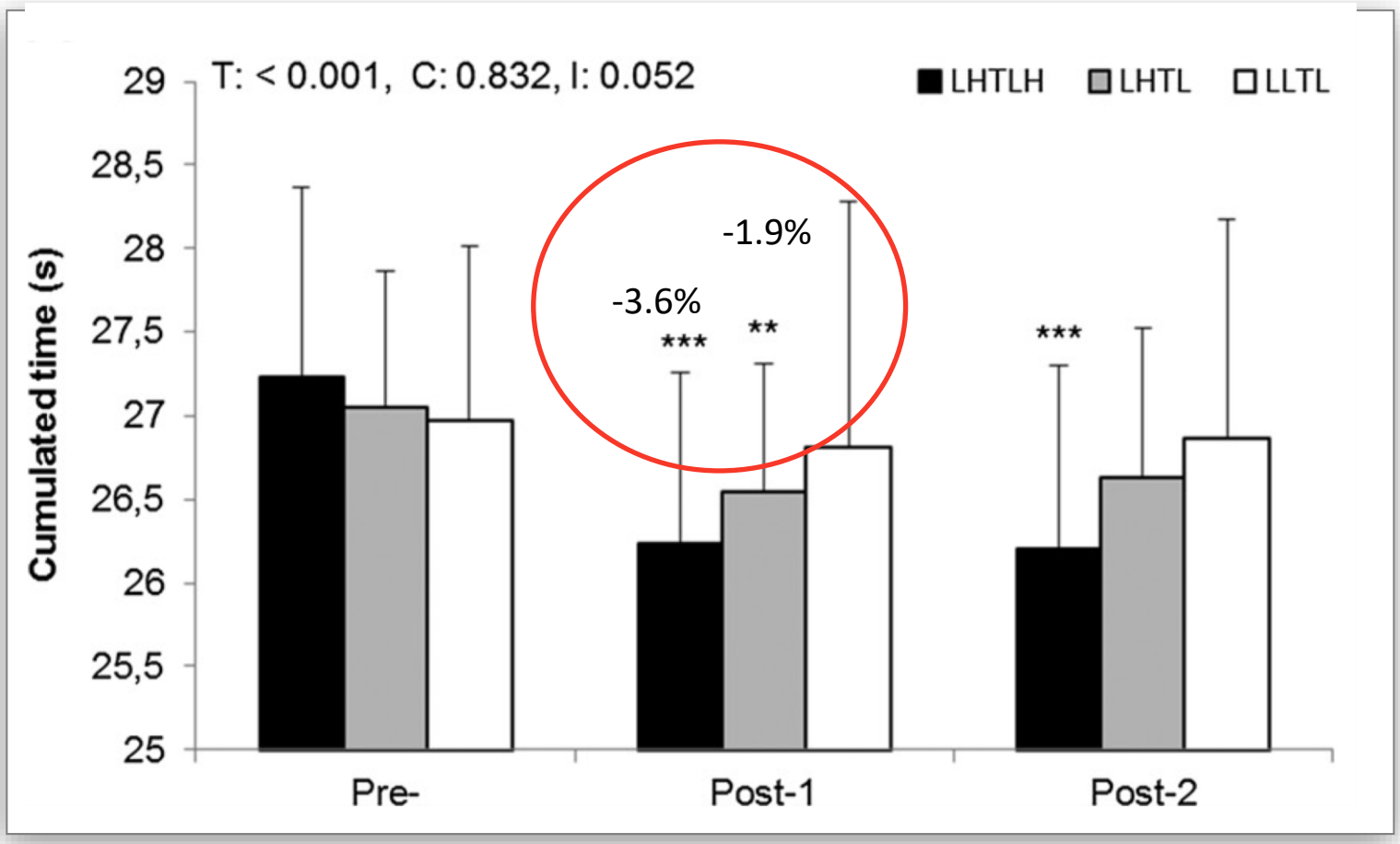
Systemic and local hypoxia

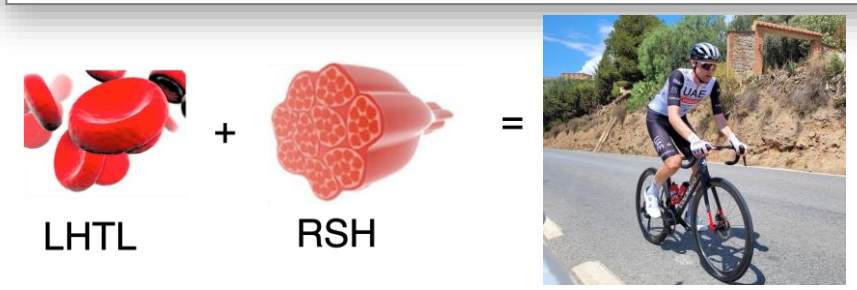
- Blood flow restriction
- Repeated sprints in hypoxia
- Continuous or interval training in hypoxia

COMBINATION OF REPEATED SPRINTS AND LHTL



- Control group, LLTL n=9
- Group LHTL + RSN n=12
- Group LHTL + RSH n=12
- ≥ 14 days, altitude 2500 – 3000 m (FiO_2 = 15,1-14,5





Brocherie et al 2015

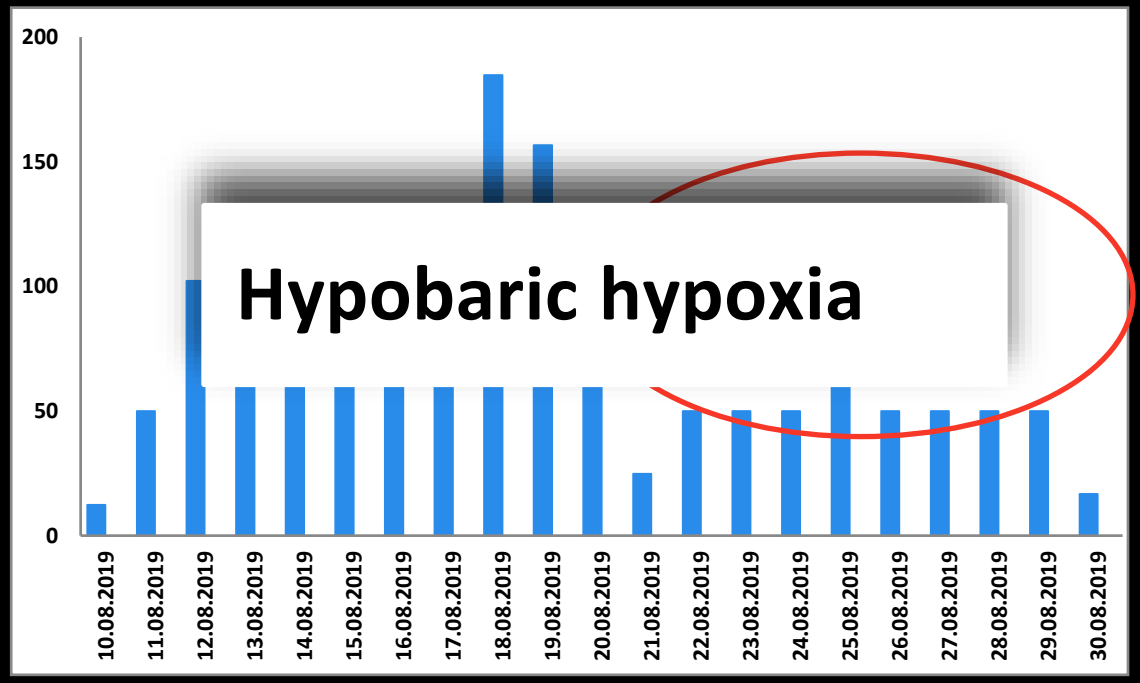
INCREASING HYPOXIC DOSE

kmh
880,6
%

%h
1507
%

Time in hypoxia
468
hours

tHb-mass increase
6
g



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A combination of training methods leads
to more performance improvement

COMPETITIVE EDGE

COMPARISON OF MODELLED AND REAL ABSOLUTE DATA OF tHb-mass

	Modeled (BL)	Difference ,%	Modeled BTC1	Difference, %	Modeled ATC1	Difference, %	Modeled BTC2	Difference, %	After TC2	Modeled ATC2	Difference,%
Subject 1	1152	2.0	1184	-1.7	1219	-1.8	1208	-0.2	1256	1280	1.9
Subject 2	1154	-0.5	1163	2.0	1172	-0.3	1169	1.4	1192	1194	0.2
Subject 3	1109	2.0	1122	1.7	1122	-1.4	1118	-1.9			
Subject 4	1000	1.5	1021	-0.3	1033	1.4	1027	0.6	1069	1079	0.9
Subject 5	986	1.1	1000	-0.5	1001	0.8	997	-1.2	1033	1018	-1.5
Subject 6	901	0.4					908	-0.7	935	930	-0.5
Subject 7	559	-1.9			560	-0.6			582	575	-1.2

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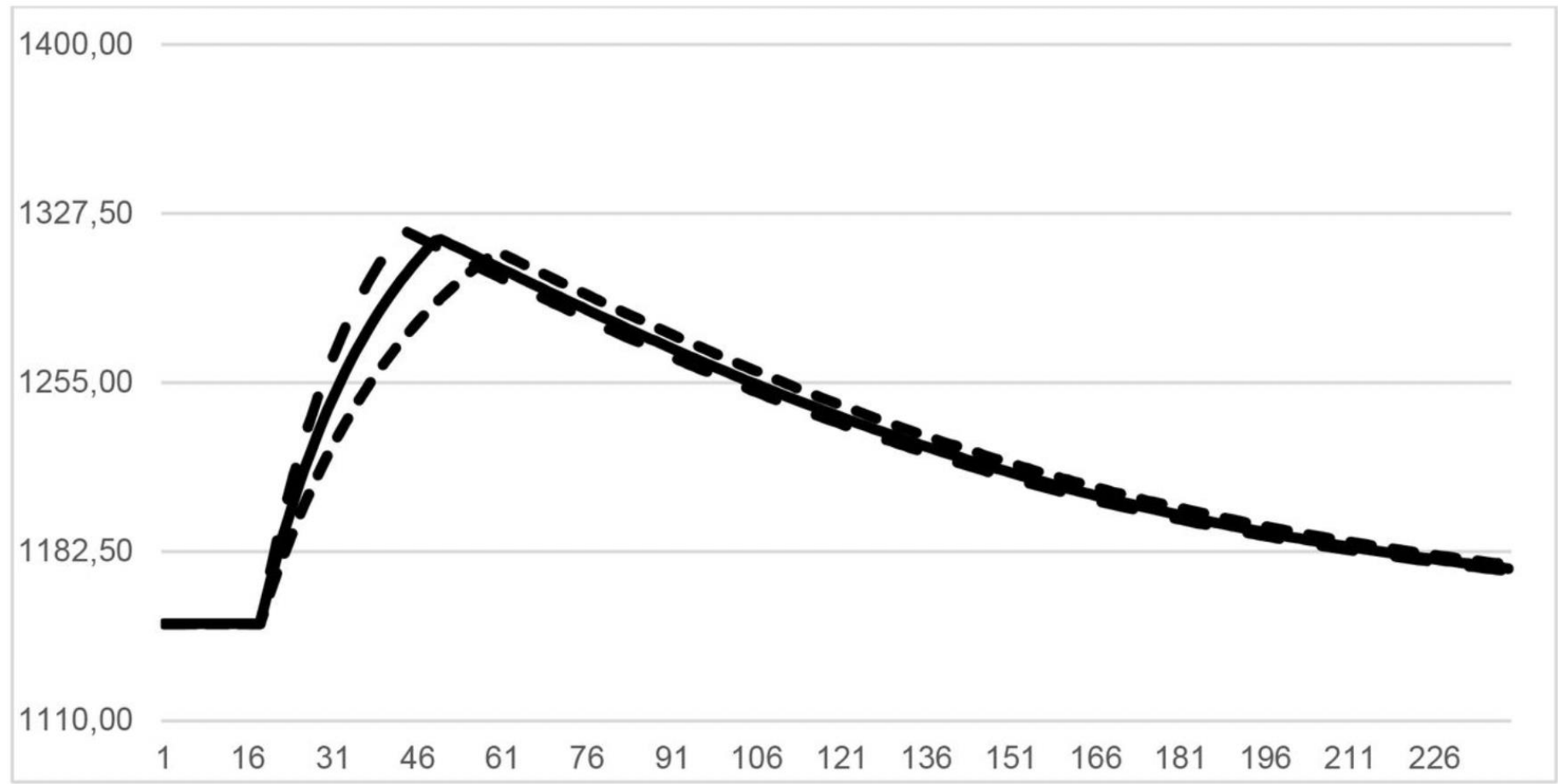
SIMULATION OF HAEMATOLOGICAL RESPONSE



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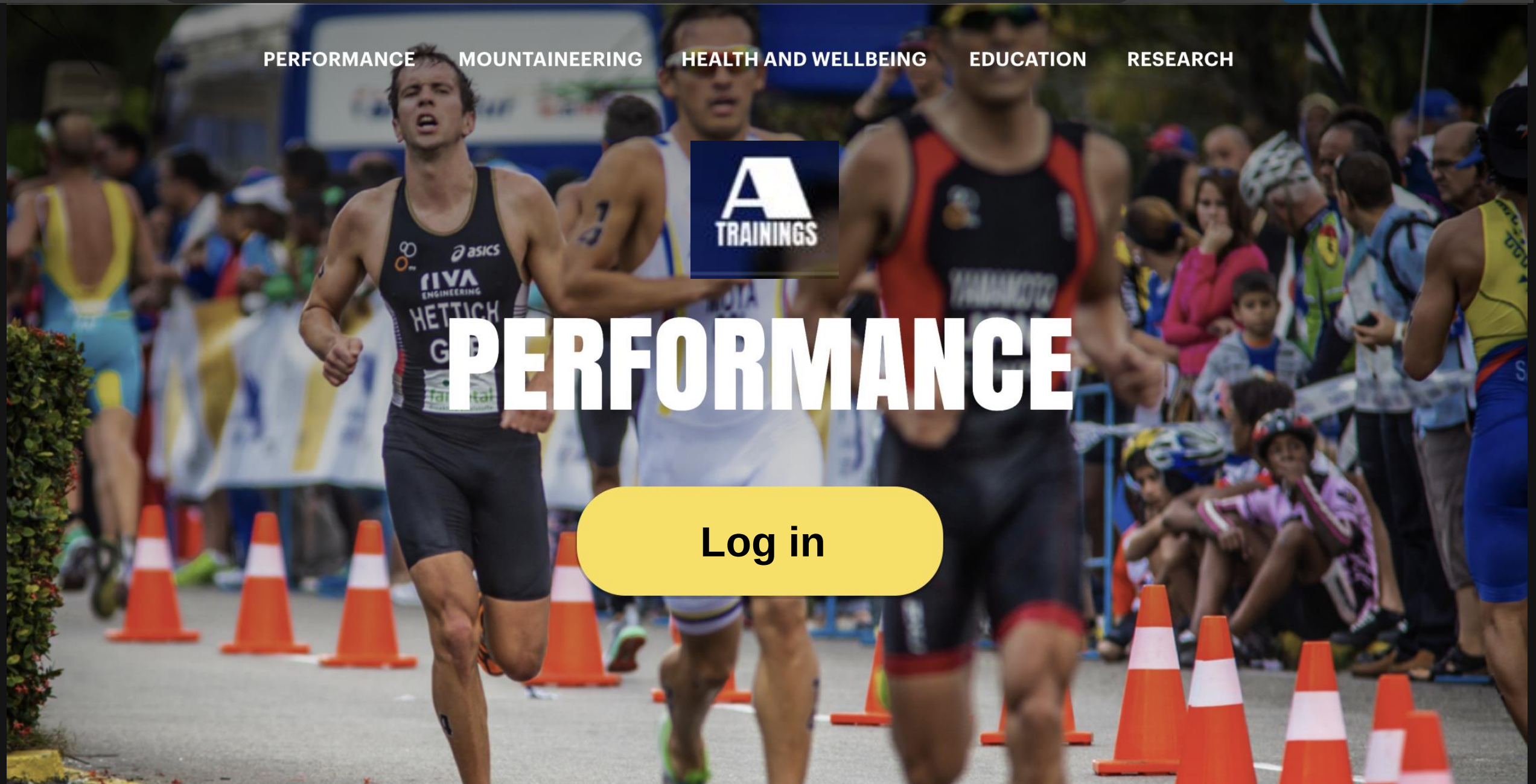
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Do not hesitate to contact me

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