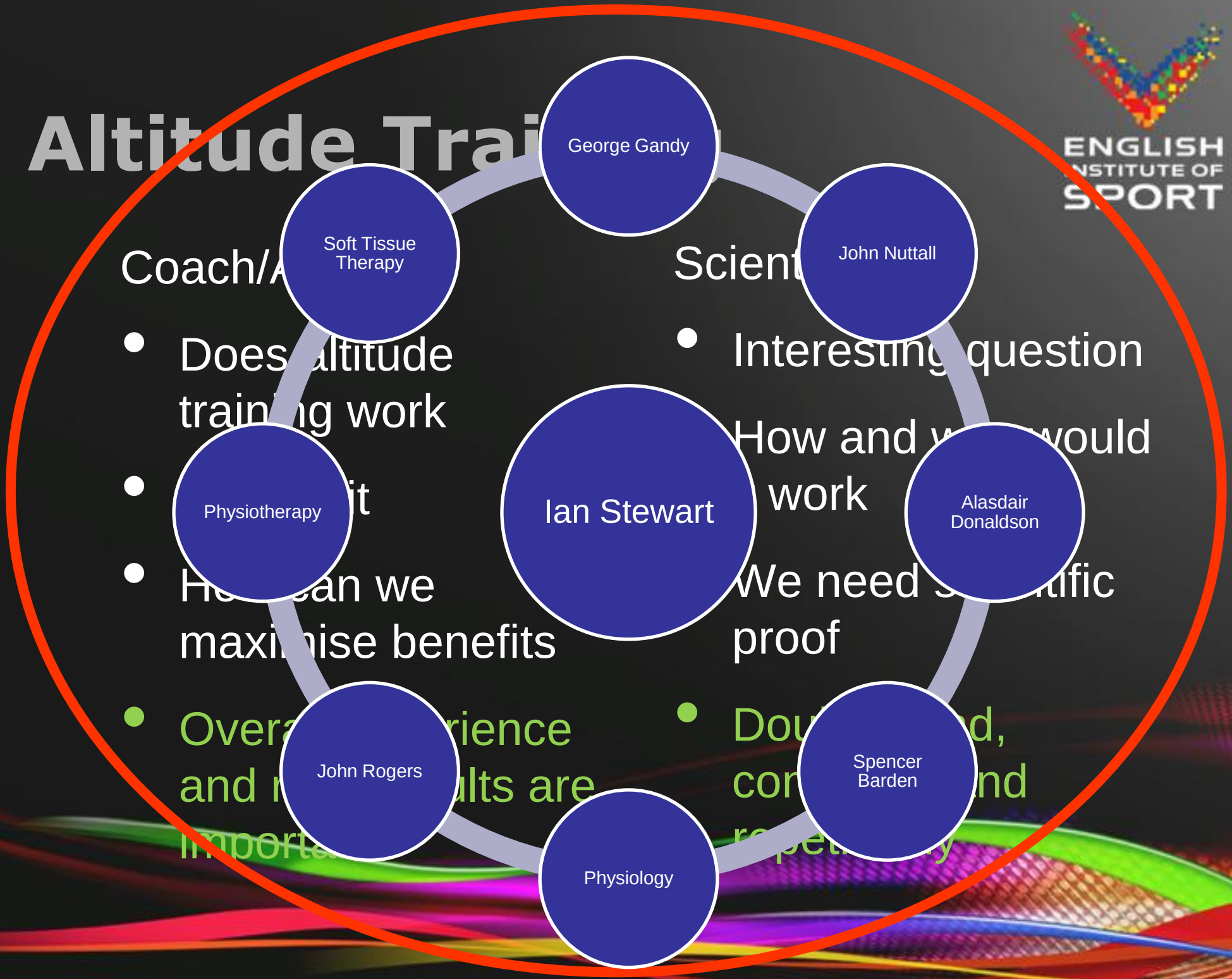
Altitude Physiology – Dr Barry Fudge

Talk to English Athletics - 20th April 2011 – Font Romeu

Altitude Trai



Coach/A

- Does altitude training work
- it
- How can we maximise benefits
- Overa rience and r lts are importa

Scient

- Interesting question
- How and w would work
- We need s tific proof
- Dou d, con nd repeti y

Overview

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- Introduction
- Physiology
- UKA – Strategy and results
- Questions & Discussions

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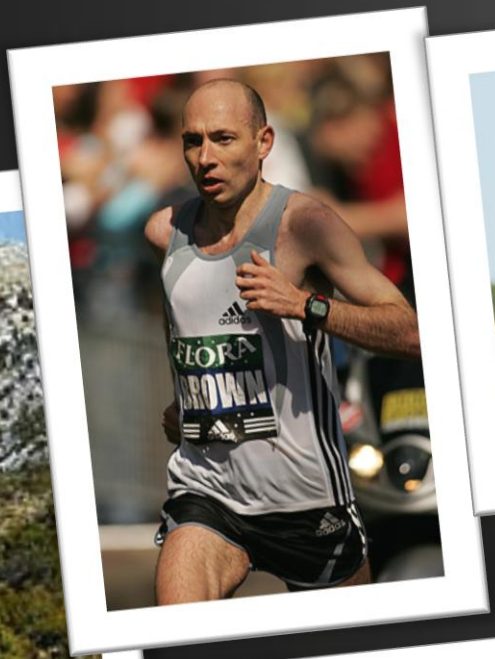
Introduction

Altitude Training

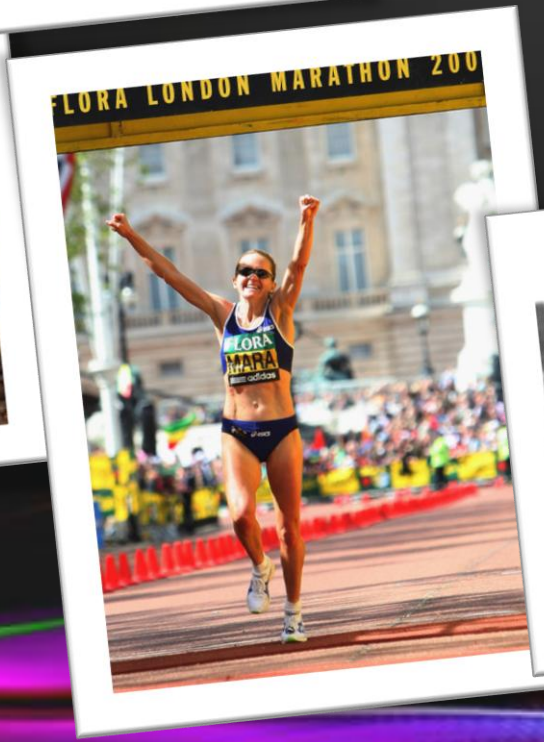
UKA Physiologist

- Based in Loughborough at the NPC
- 100% UKA
- Responsibility for all event groups but primarily endurance

Top Brits


FLORA
BROWN

SPAR
Clitheroe
PARIS 2011


FLORA LONDON MARATHON 200
FLORA
MARA

Top E. Africans

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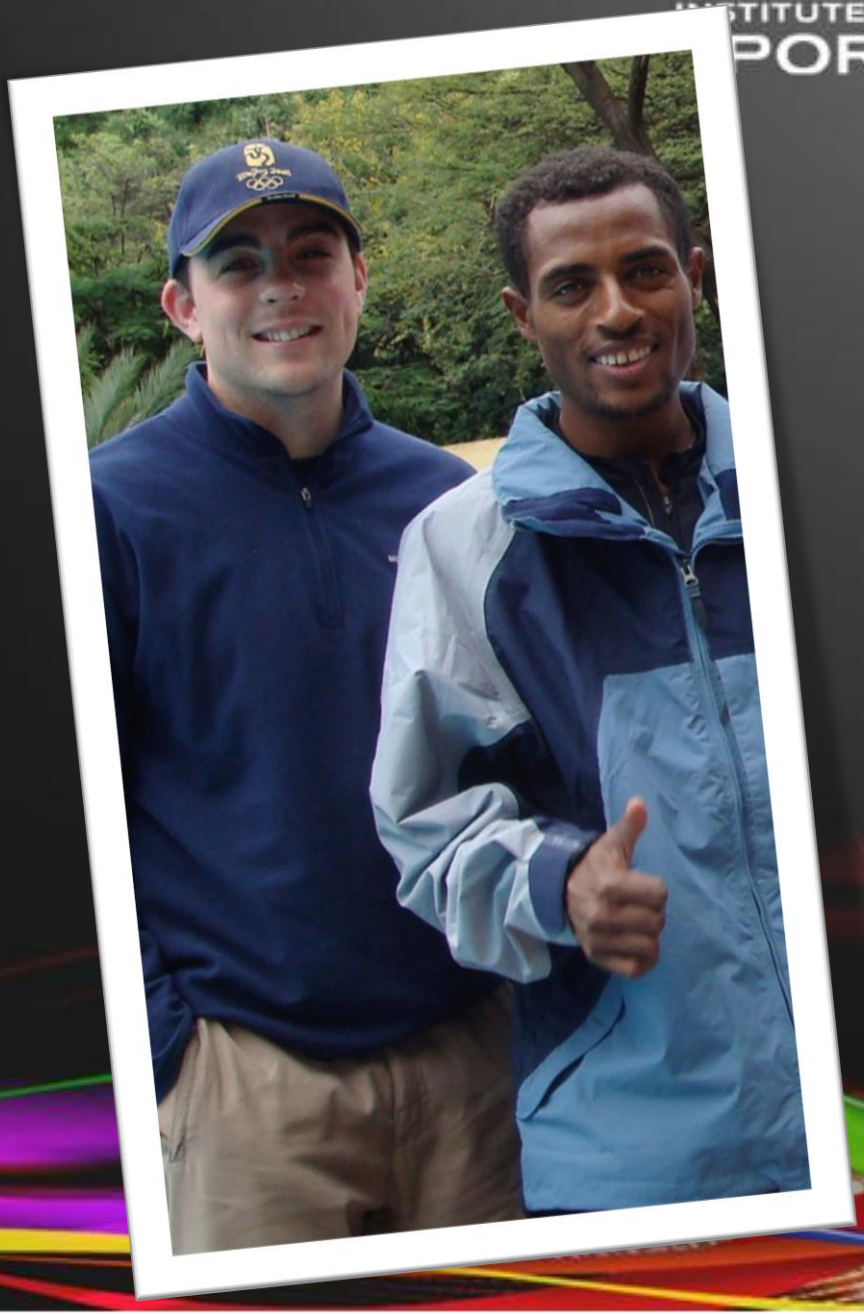
PhD – East African Running



Section main points

- East African athletes have a conducive environment for developing as an endurance runner:
  - Diet
  - Hydration
  - Rest/recovery
- The “correct genetics” for elite performance are fundamental
- The “correct genetics” are unlikely to be unique to only east Africa
- Without a conducive/optimum environment true genetic potential shall not be realised

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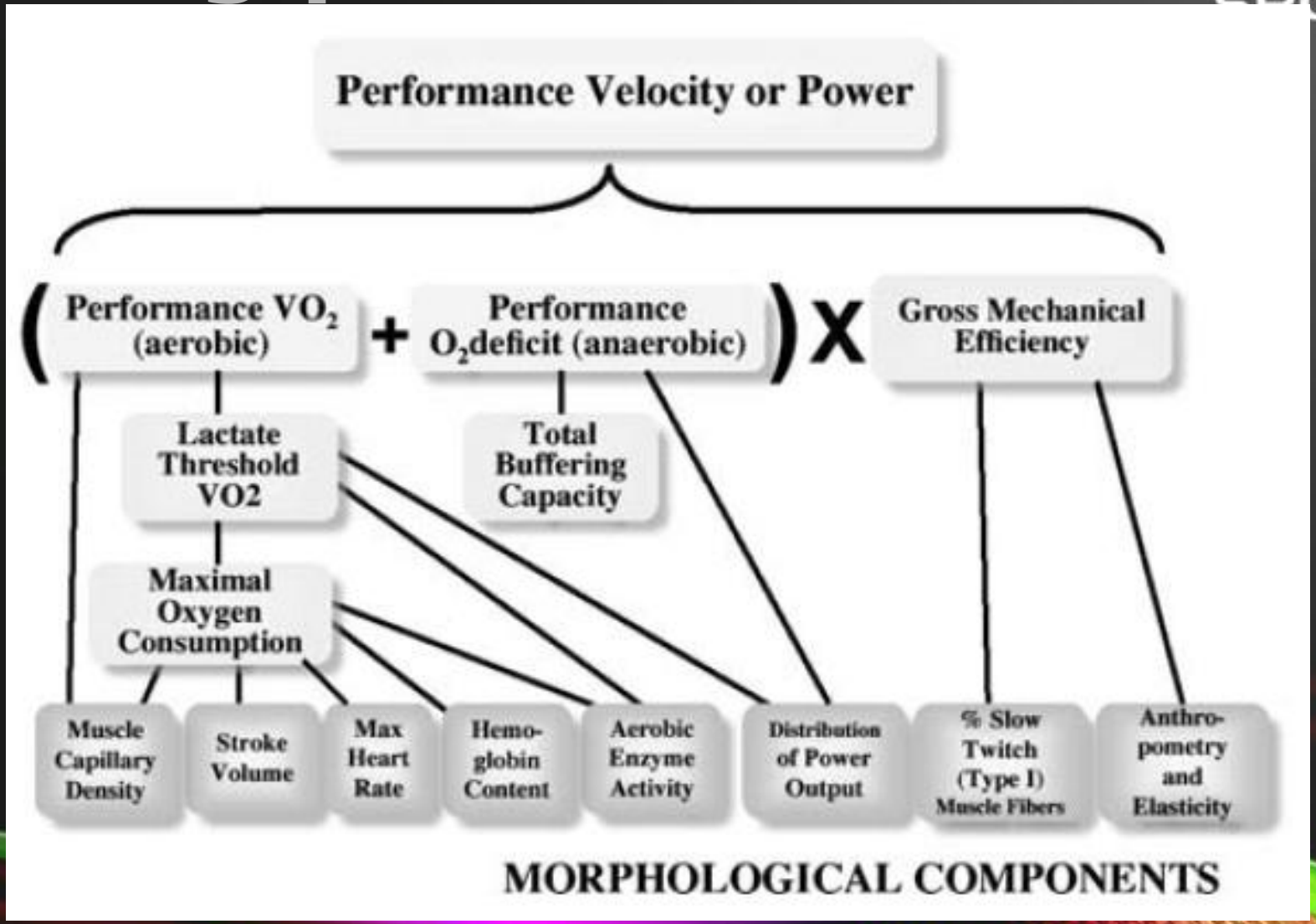
Physiology

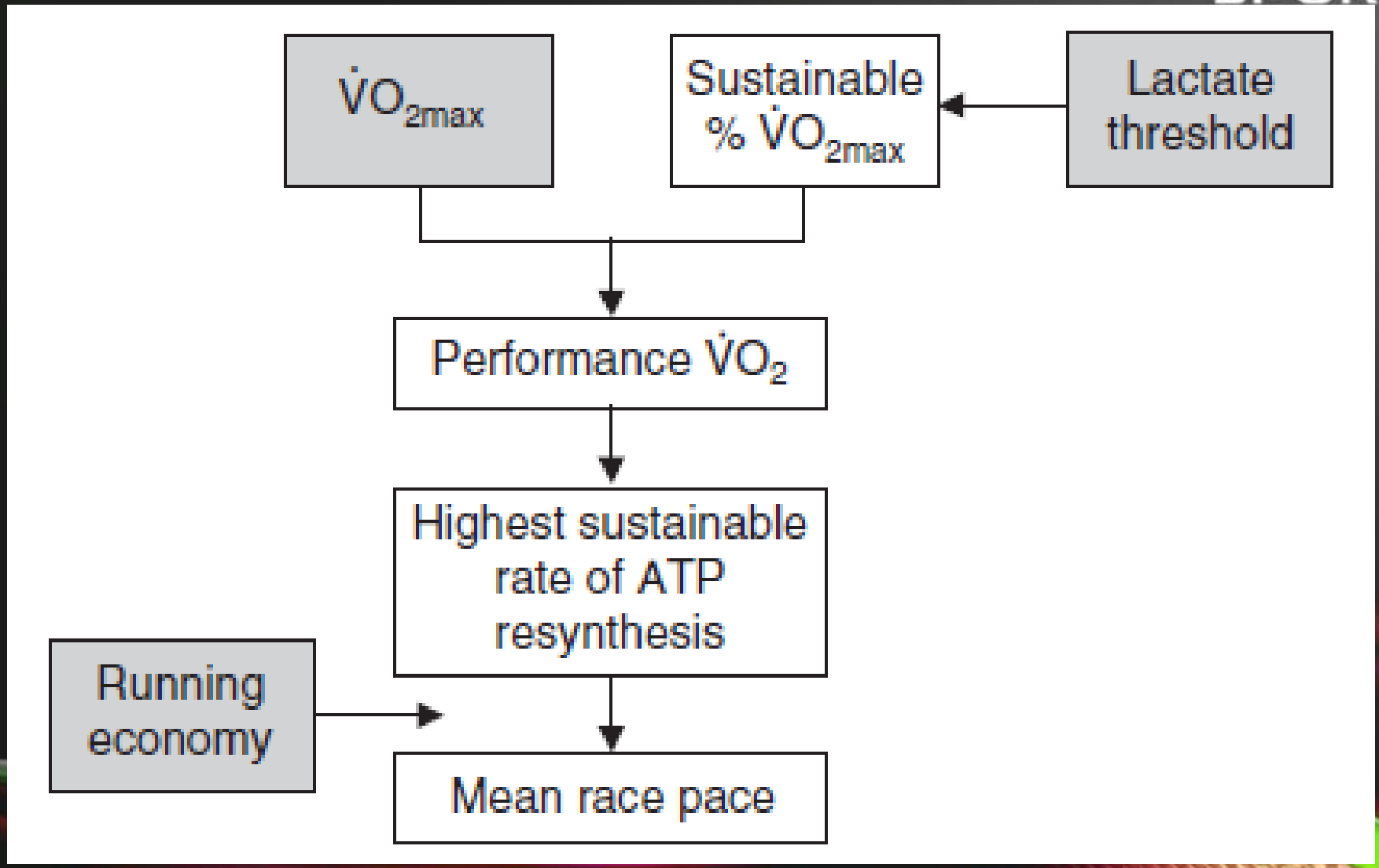
Altitude Training

Determinants of endurance running performance...



Joyner and Coyle, 2007

Determinants of endurance running performance...



Midgley et al, 2007

Prevailing paradigm

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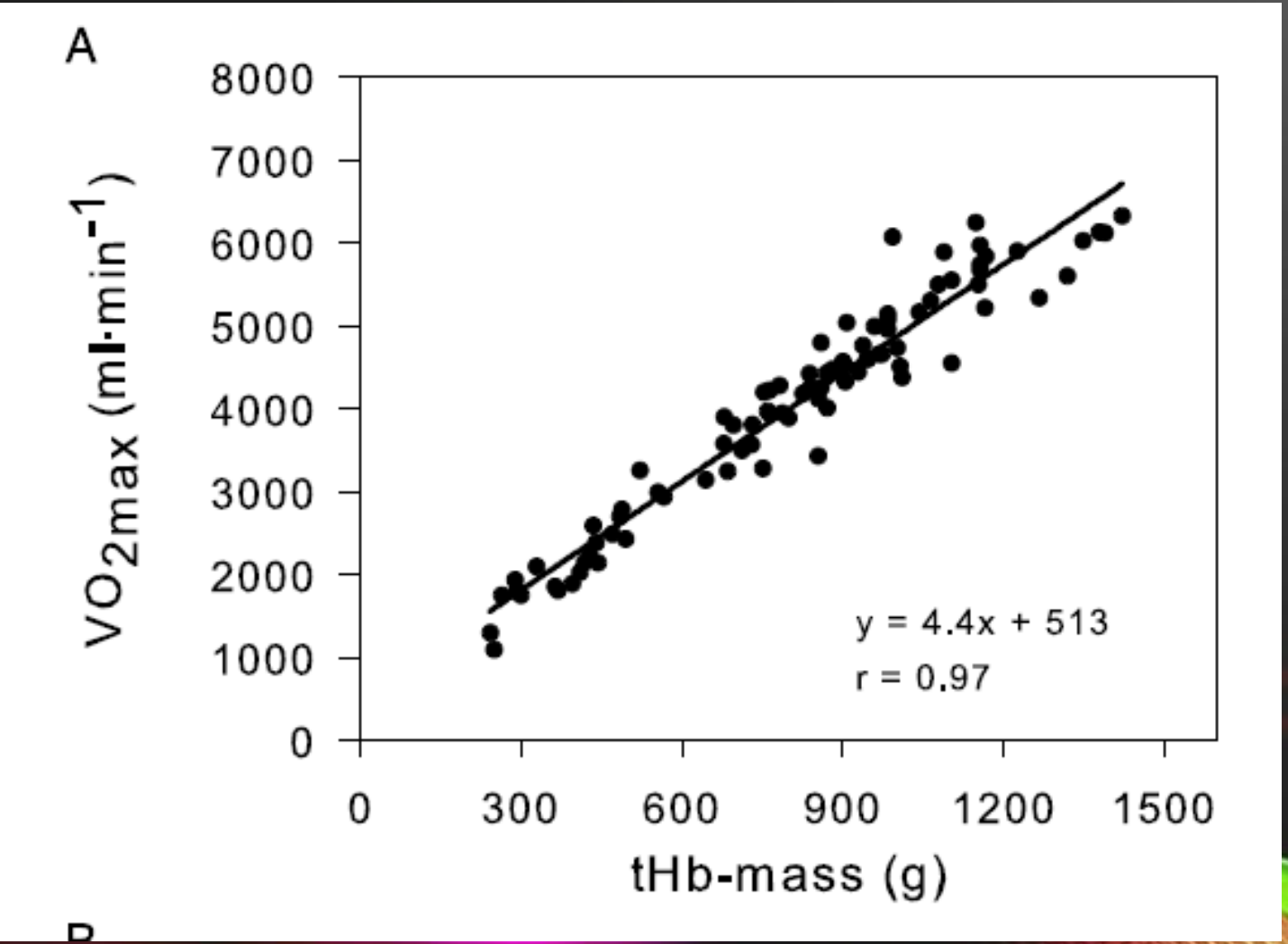
Increase red cell mass → Increase VO_2max → Increase Performance

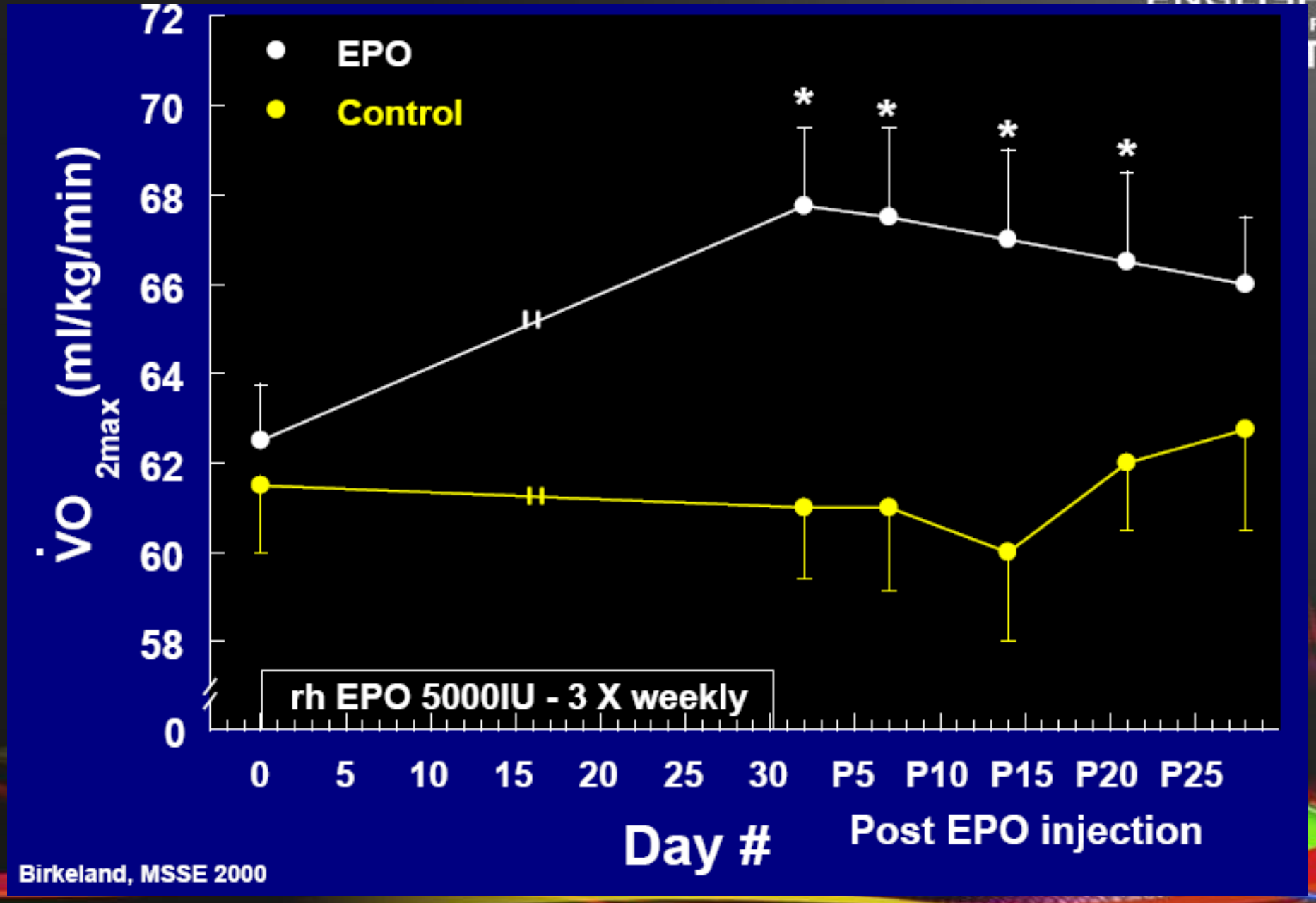
What's the scientific evidence?

Red cell mass...VO2max

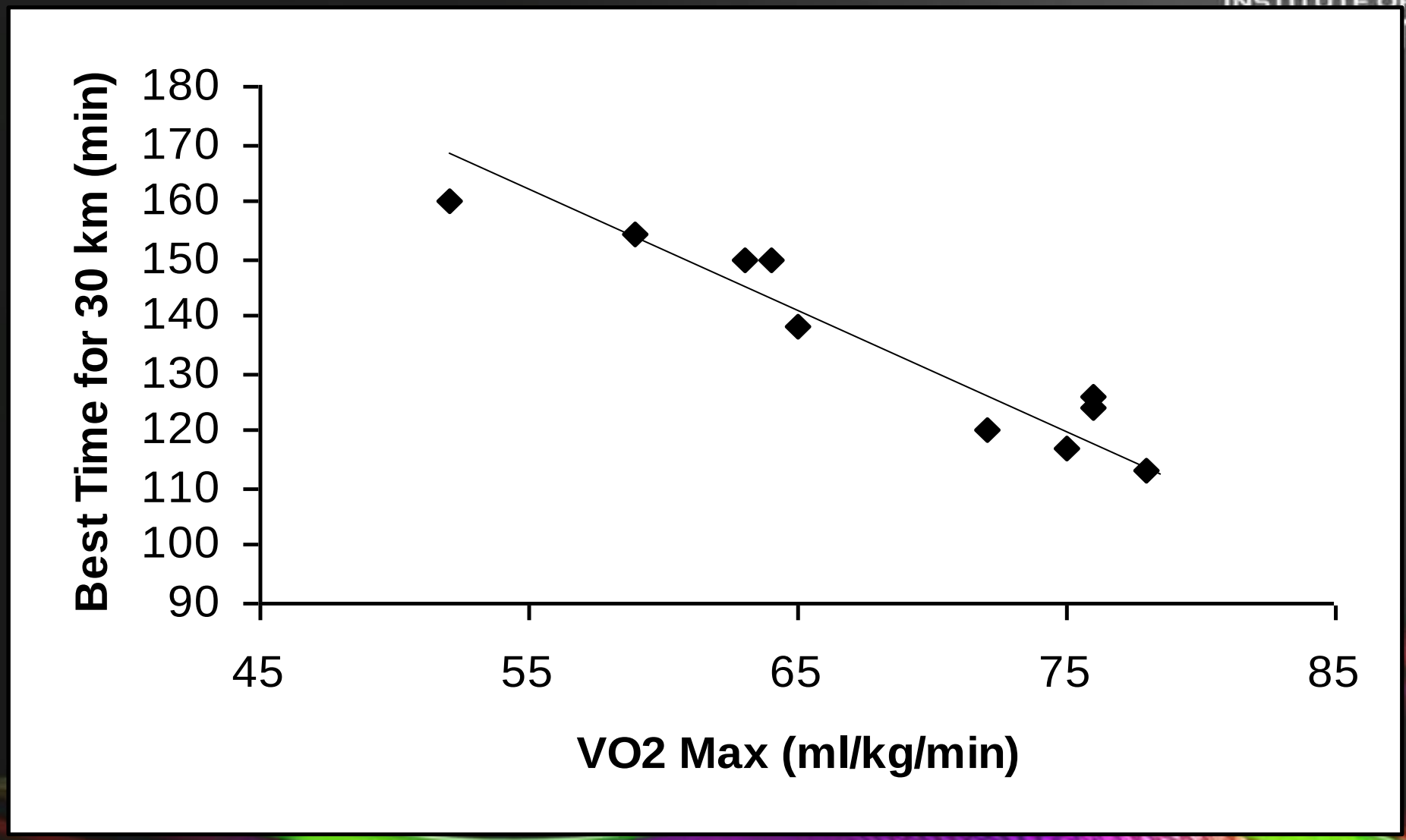


Schmidt & Prommer, 2010

Red cell mass...VO_2max



VO_2max...Performance



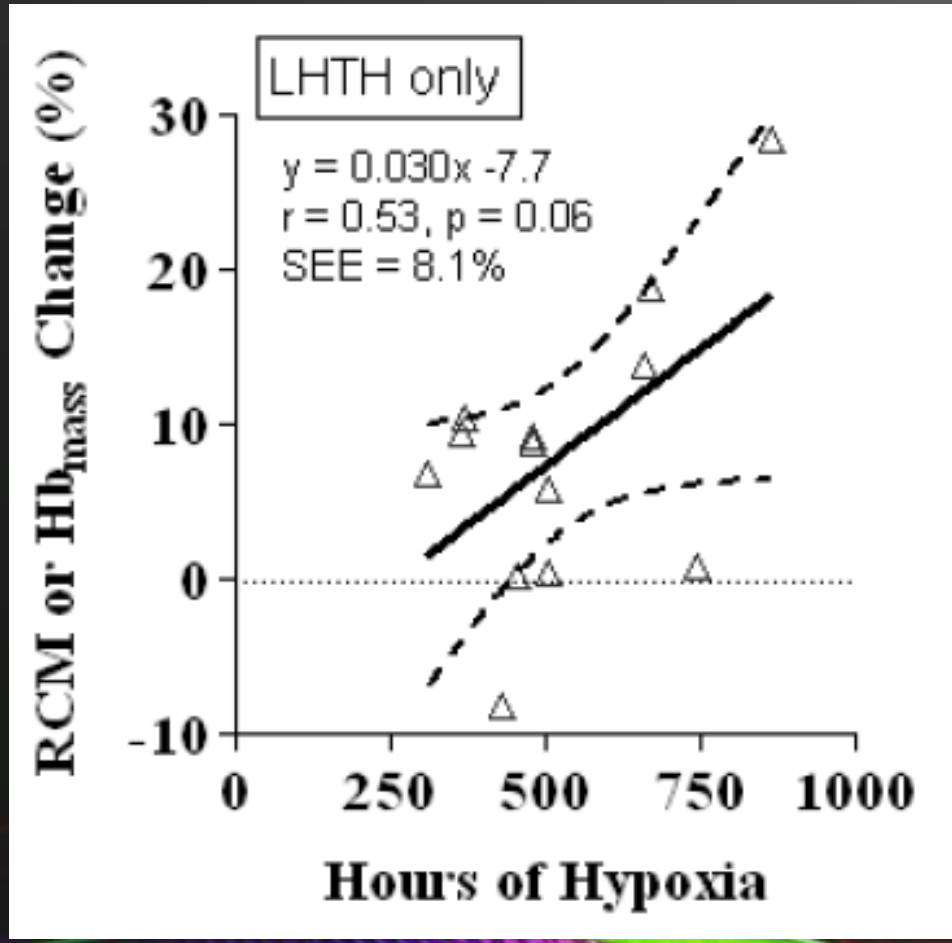
Karlsson & Saltin, 1971

Different types of altitude training?

LHTH – Red cell mass

- 504h (~3wks) = 7.4% increase (including non-athletes)
- 672h (~4 wks) = 12.5% increase (including non-athletes)
- Reduced “top end” work

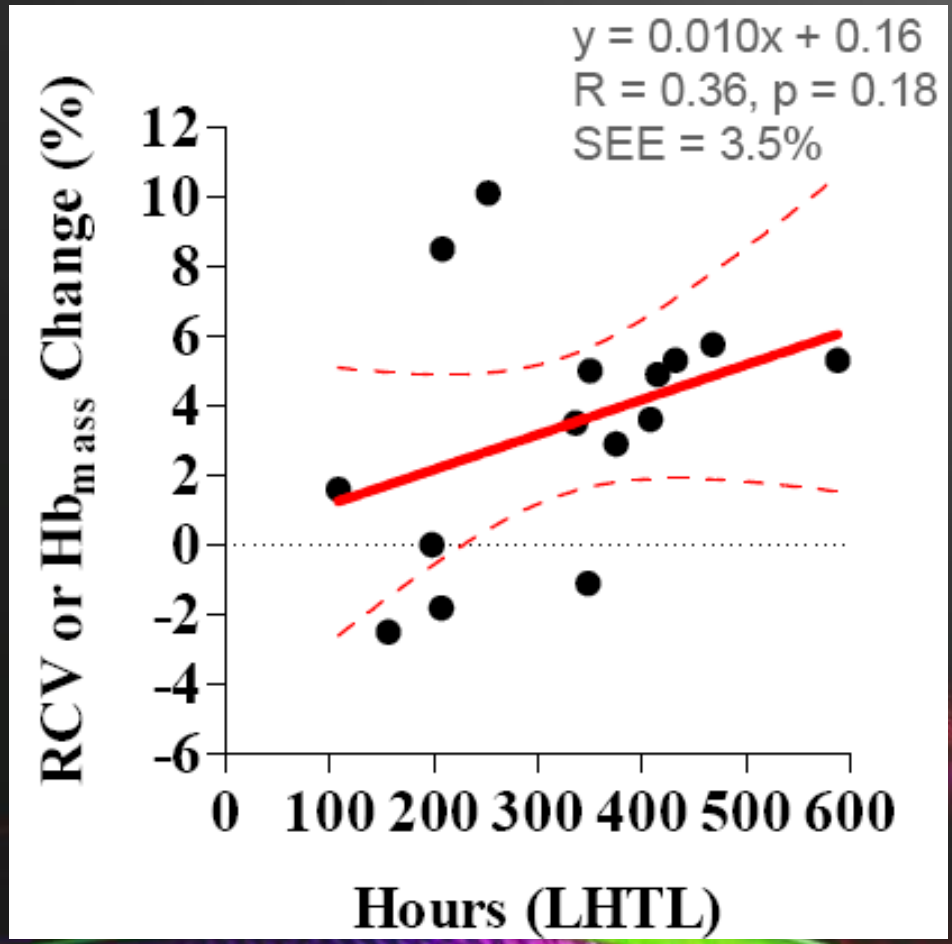
Saunders et al, 2009



LHTL – Red cell mass

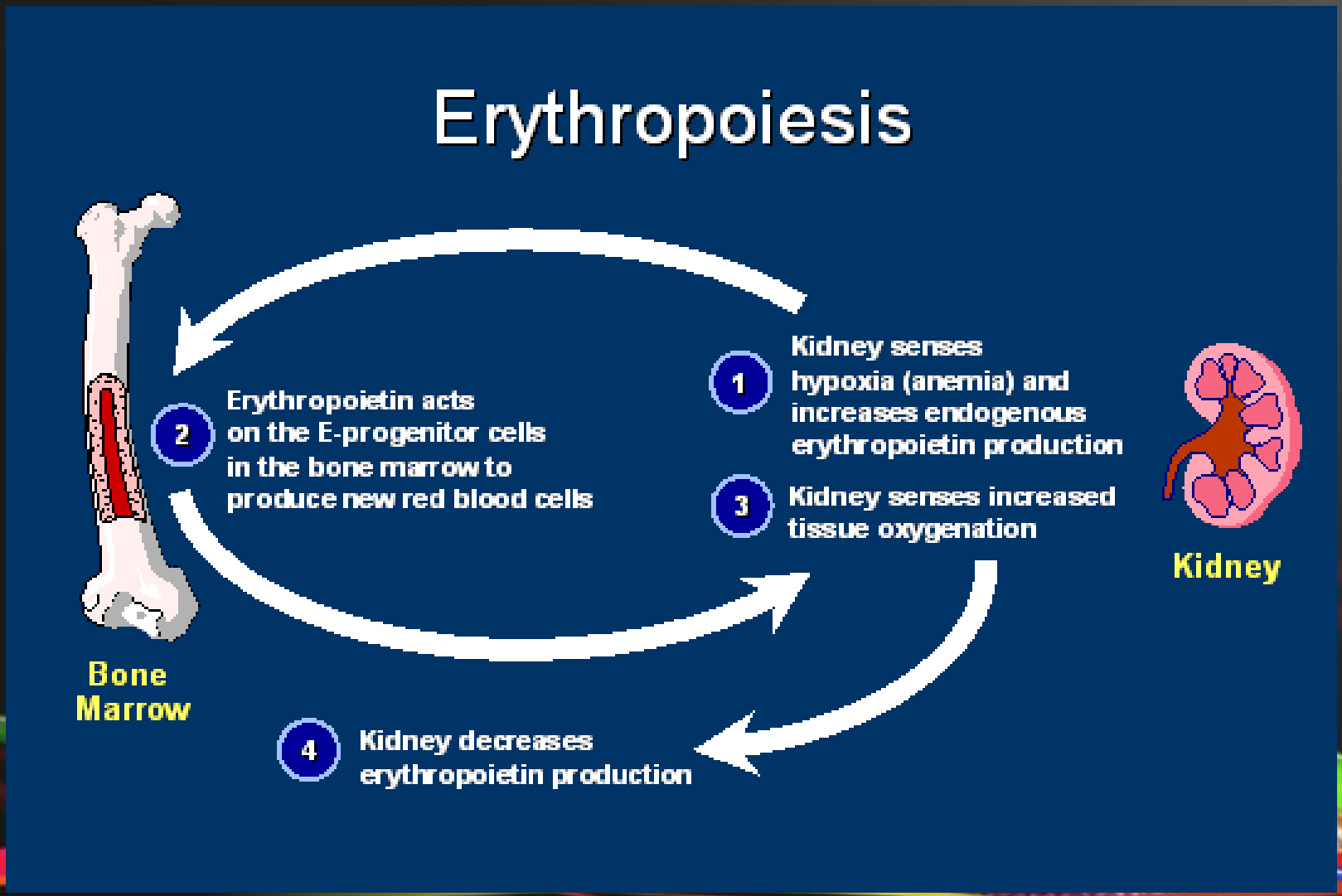
- 1% per 100 h, but need to be ~3% to be confident of change
- Can complete “quality” work

Clark et al, 2009



LLTH – Red cell mass

Exposure too short to stimulate erythropoiesis



Sub-section main points

- Altitude will increase red blood cells / total hemoglobin in most athletes (not sick, not injured) provided:
  - Iron status is adequate
  - Altitude is adequate (~1800-2500m)
  - Duration is sufficient (>12 h/day)
- Unclear if an athlete will always respond similarly each time they go to altitude

Performance

- Any improvement is worthwhile, but have to take into account within-athlete variation (within athlete CV)
- At the elite level, the smallest worthwhile change in performance is about half the typical variation in an athlete's performance from competition to competition, or ~0.5%

Hopkins, Sportscience, 2004

Performance – LHTH & LHTL

Bonetti & Hopkins, Meta-analysis of sea level performance following adaptation to hypoxia. Sports Medicine 39: 107-27, 2009

	Natural-Altitude Protocols		Live High 8-18 h.d^{-1}
	Live High, Train High	Live High, Train Low	Continuous, Train Low
Effect of Mean Protocol[a] (%); ±90%CL[b]			
Elite	1.6; ±2.7	4.0; ±3.7	0.6; ±2.0
Subelite	0.9; ±3.4	4.2; ±2.9	1.4; ±2.0
Effect of Enhanced Protocol[c] (%); ±90%CL			
Elite	5.2; ±4.1	4.3; ±4.1	4.0; ±5.5
Subelite	4.5; ±4.1	4.6; ±3.3	4.8; ±5.3
Study characteristics changed by +1 SD or -1 SD for enhanced protocol	+altitude –days exposure +test day	–altitude –test day	+altitude +hours hypoxia –days exposure

Performance – LHTH & LHTL

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- LHTH: enhancement of performance at very short times (~2.5 d) followed by impairment (~5 d), enhancement (~17 d) and impairment (~33 d)

- LHTH: VO2max appears to peak around 14 d after exposure

- LHTL: trivial improvements in VO2max can be improved by increasing the hours of exposure

Altitude Adaptation…Bekele

Run	Altitude (m)	Distance (km)	Average HR (bpm)	Average speed (km/h)	Average Speed (min:mile)
Rift Valley Plains	1400-1600	15	139	14.9	06:32
Forest	3000-3200	18	141	14.7	06:27

LLTH – Loughborough

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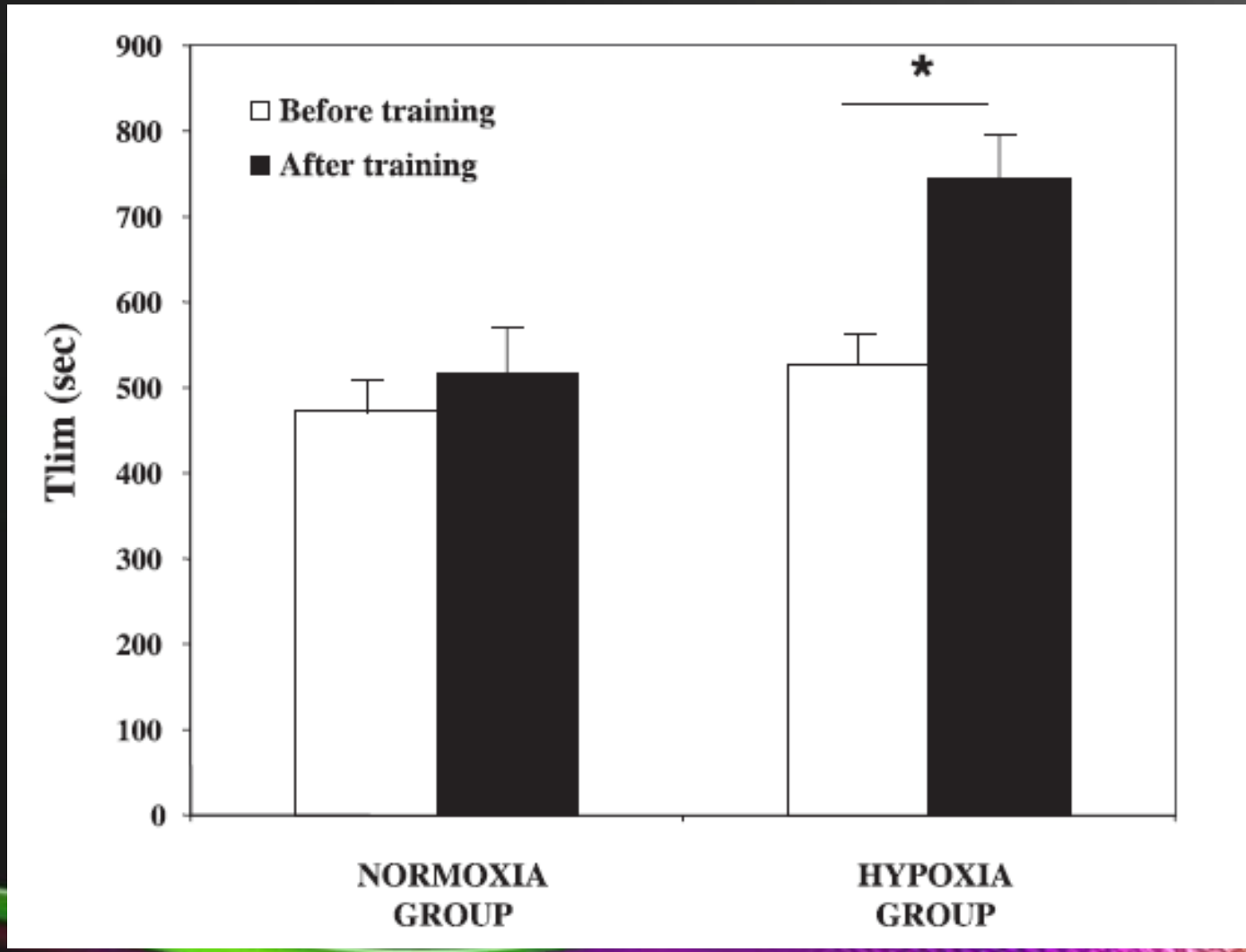
- Altitude chamber
- Performance
- Rehab

LLTH - performance



Ponsot et al, 2006

LLTH – gene expression

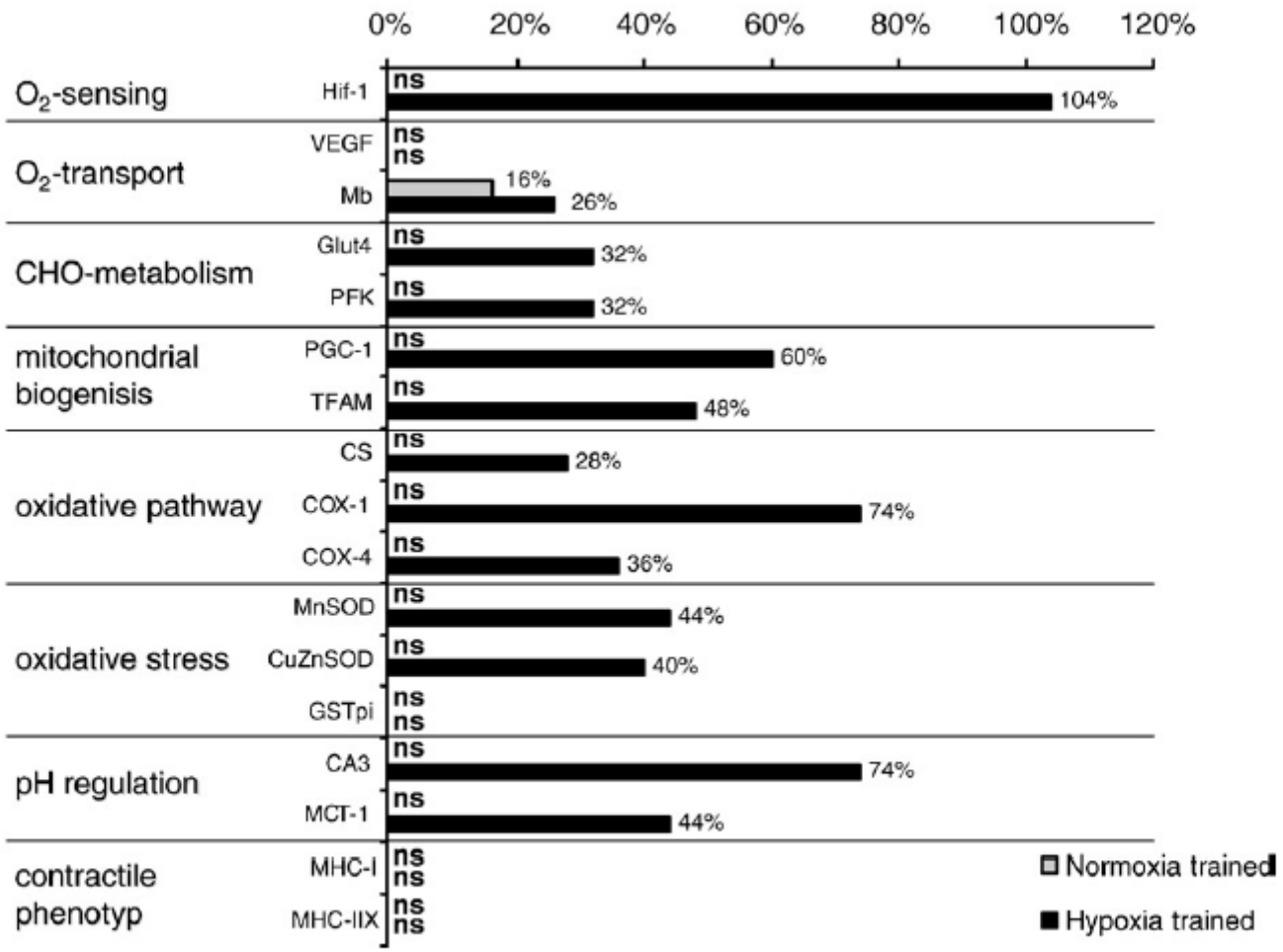


Fig 2. Change of the concentration of different mRNAs measured in musculus vastus lateralis of trained runners subjected to a 6-week training period with addition of either high-intensity hypoxic or normoxic training. ns indicates no significant difference between pretraining and posttraining measurements (data from Zoll et al (2006)[37]).

Vogt & Hoppeler, 2010

LLTH - Training

Table 1
The "live low–train high" training protocols

	Intermittent intensity protocol	Intermittent hypoxia protocol	Threshold training I protocol	Threshold training II protocol	Low-intensity hypoxia training protocol
Method	Change between high and low intensity in hypoxia	Change between 5-min periods of training in hypoxia and 5-min rest periods in normoxia	Constant load at "respiratory compensation point" threshold	Constant load at "respiratory compensation point" threshold hypoxia training	Low to moderate intensity–high-volume hypoxia training
Duration	3-6 wk	3-6 wk	3-6 wk	3-6 wk	1-2 wk
No. of sessions	2-3/wk	2-3/wk	2/wk	3-5/wk	6-7/wk
Duration per session	30-40 min	60 min	Increasing weekly exposure duration wk 1, 2: 2 × 10 min, 5 min wk 3, 4: 2 × 15 min, 5 min wk 5, 6: 2 × 20 min, 5 min	30 min	90-120 min
Intensity	2 min, 90%-95% HR_{max}; 3 min, 75%-80% HR_{max} (in the change over the entire session)	90%-95% HR_{max}	85%-90% HR_{max}	85%-90% HR_{max}	75%-80% HR_{max}
Altitude	2500-3000 m, natural or artificial hypoxia	3000-5000 m, artificial hypoxia	2500-3000 m, natural or hypoxia	3000-3500 m, natural or artificial hypoxia	2000-3000 m, natural or artificial hypoxia
Supplementary training	Low intensity–high volume (70%-75% HR_{max}) endurance training in normoxia	Low intensity–high volume (70%-75% HR_{max}) endurance training in normoxia	Low intensity–high volume (70%-75% HR_{max}) endurance training in normoxia	None	None (for endurance training)
Target group	Athletes	Athletes	Athletes	Untrained subjects	Athletes

Individual variation in response to altitude training

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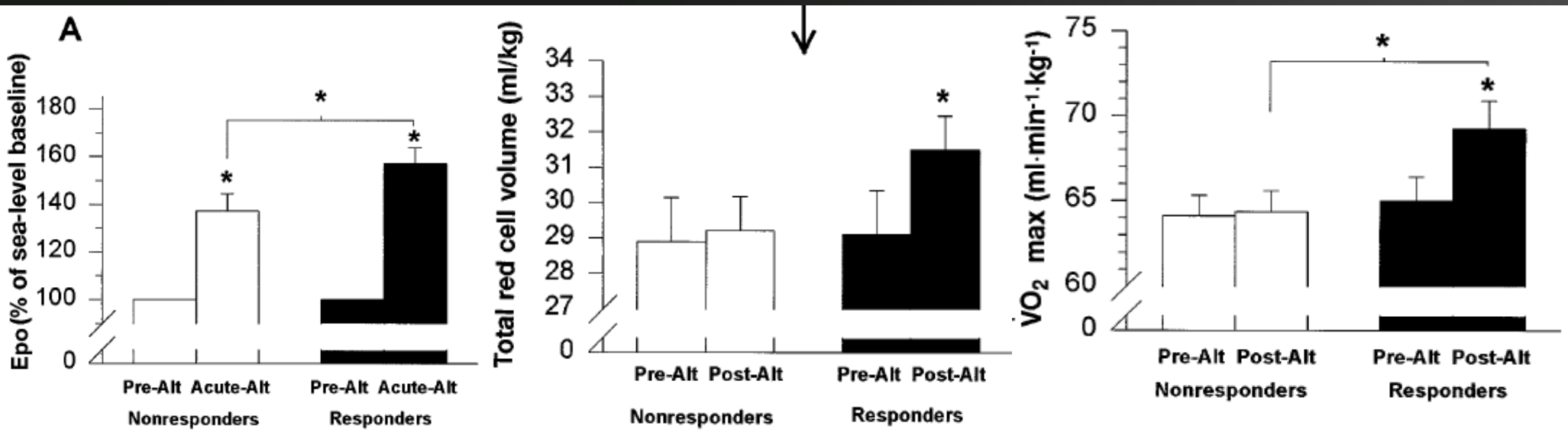
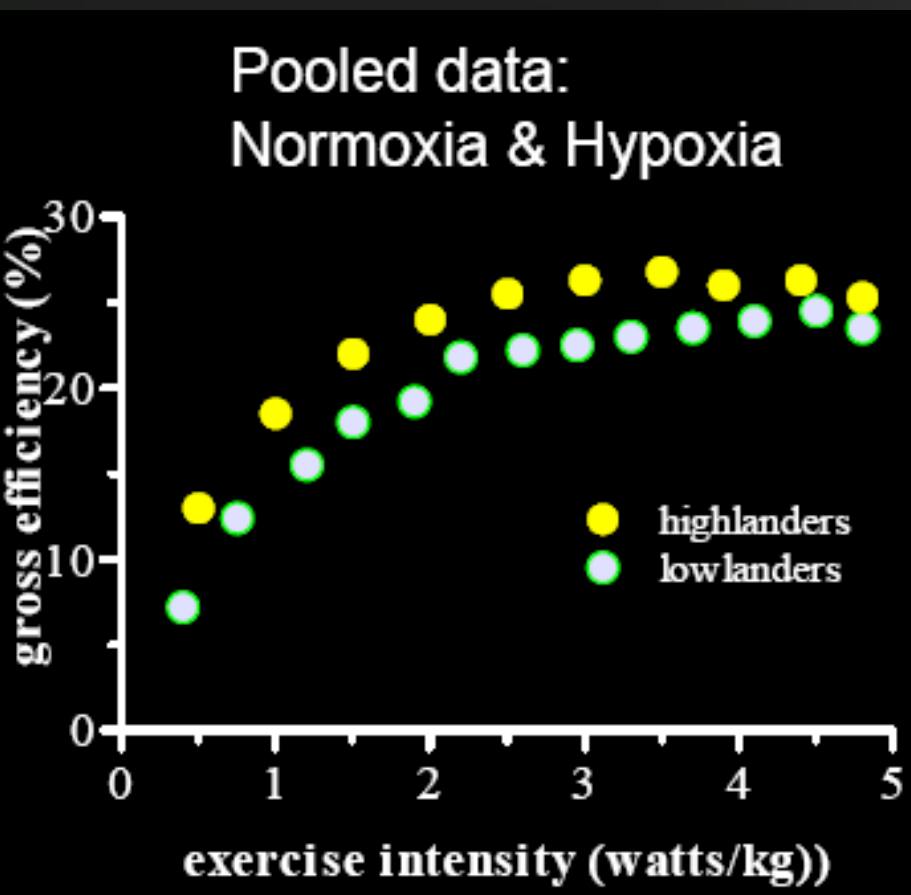
Institute for Exercise and Environmental Medicine, Presbyterian Hospital of Dallas, Dallas 75231; and University of Texas Southwestern Medical Center, Dallas, Texas 75235



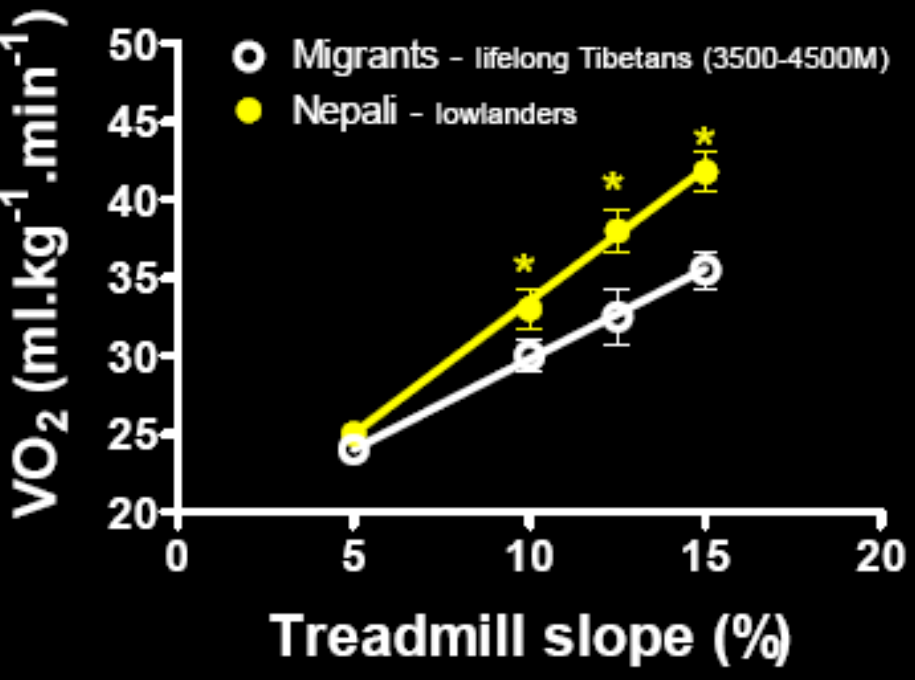
Sub-section main points

- There do appear to be tangible benefits in performance using all protocols
- There are individual responses to altitude that need to be taken in to consideration
- Particularly if care taken to enhance protocols...UKA strategy

Running economy - Chronic

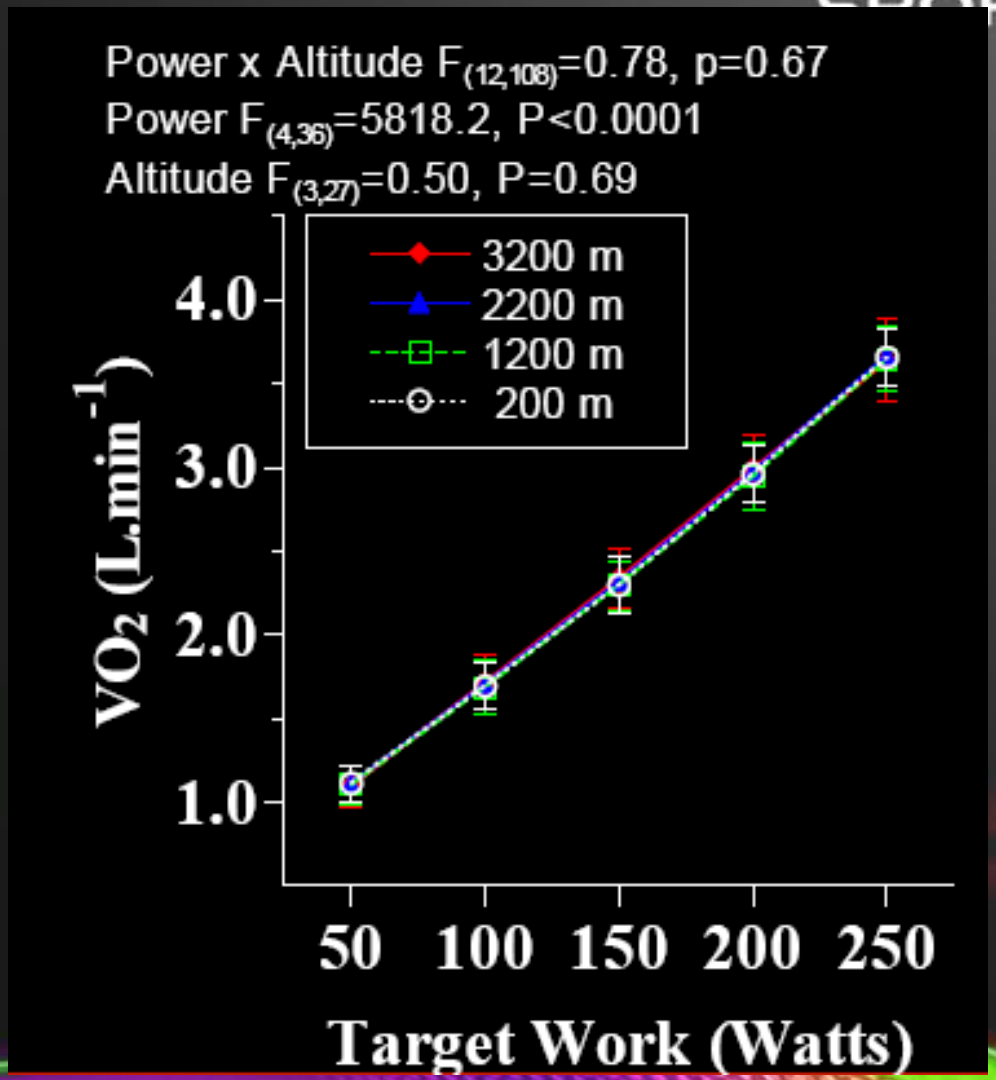


Hochachka et al.,
J Appl Physiol 70: 1720-30, 1991



Marconi et al.,
J Physiol. 569(Pt 2):667-75, 2005

Running economy - Acute



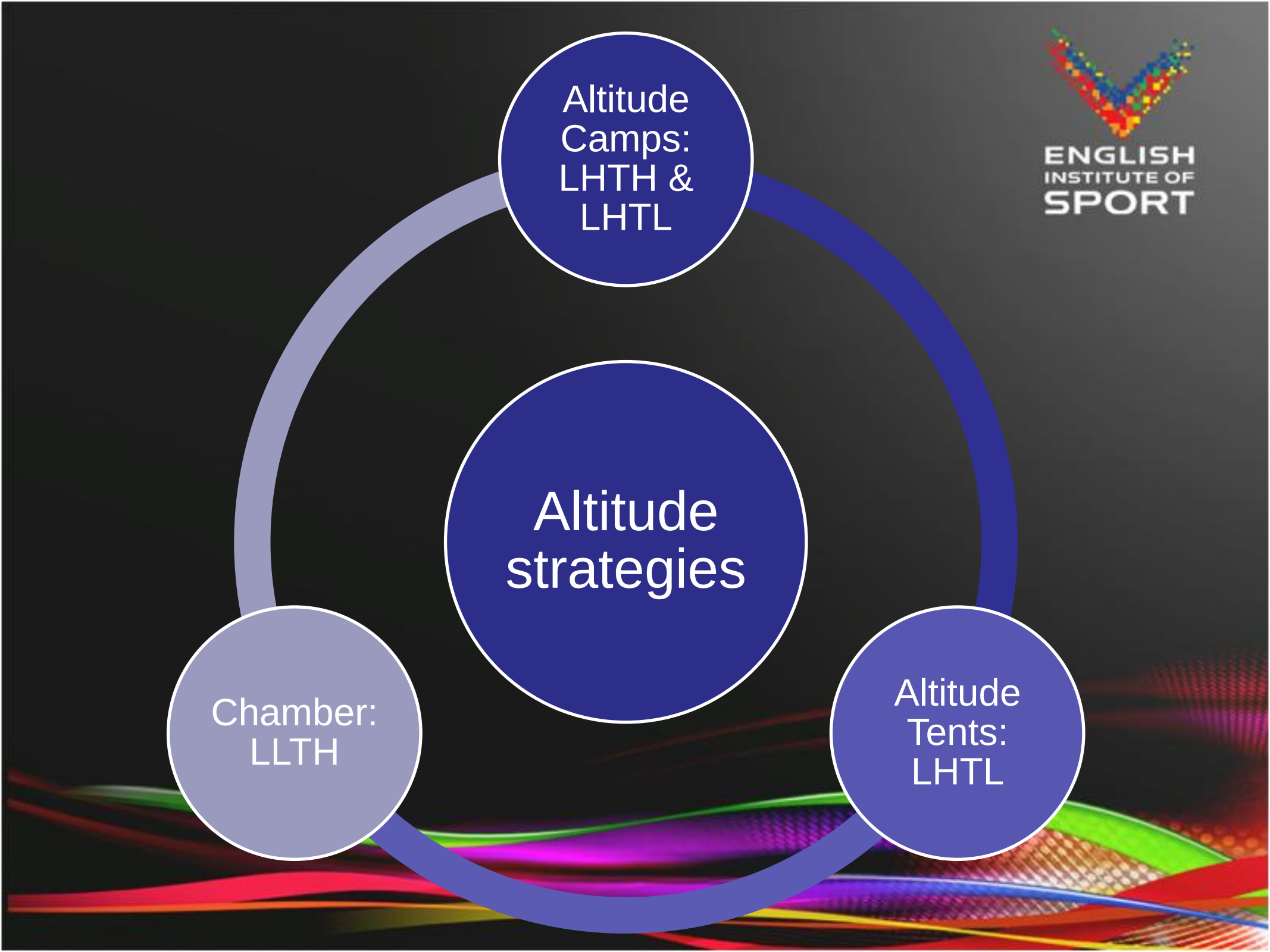
Clark et al, 2007

Section summary

- With some pre-requisites, altitude training appears to increase red blood cell mass, VO2max and performance
- There may be other benefits: running economy
- There are individual variations to the altitude response
- Altitude training may help athletes realise their true aerobic potential

UK Athletics

Endurance strategy for 2012 and beyond


Altitude Camps: LHTH & LHTL
Altitude strategies
Chamber: LLTH
Altitude Tents: LHTL
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Altitude model aims

Type	Aim	Duration
A	Improve general fitness – especially aerobic capabilities	21-28 days
B	To prepare for high intensity training following altitude	21-28 days
C	Improve competitive performance	14-21 days

Altitude location

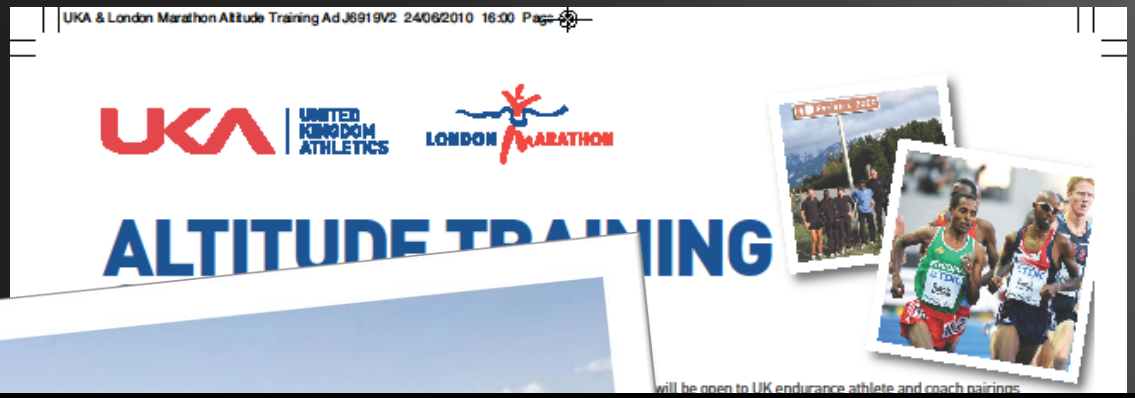
Category A

Category B

Category C

LHTH

LHTH/LHTL



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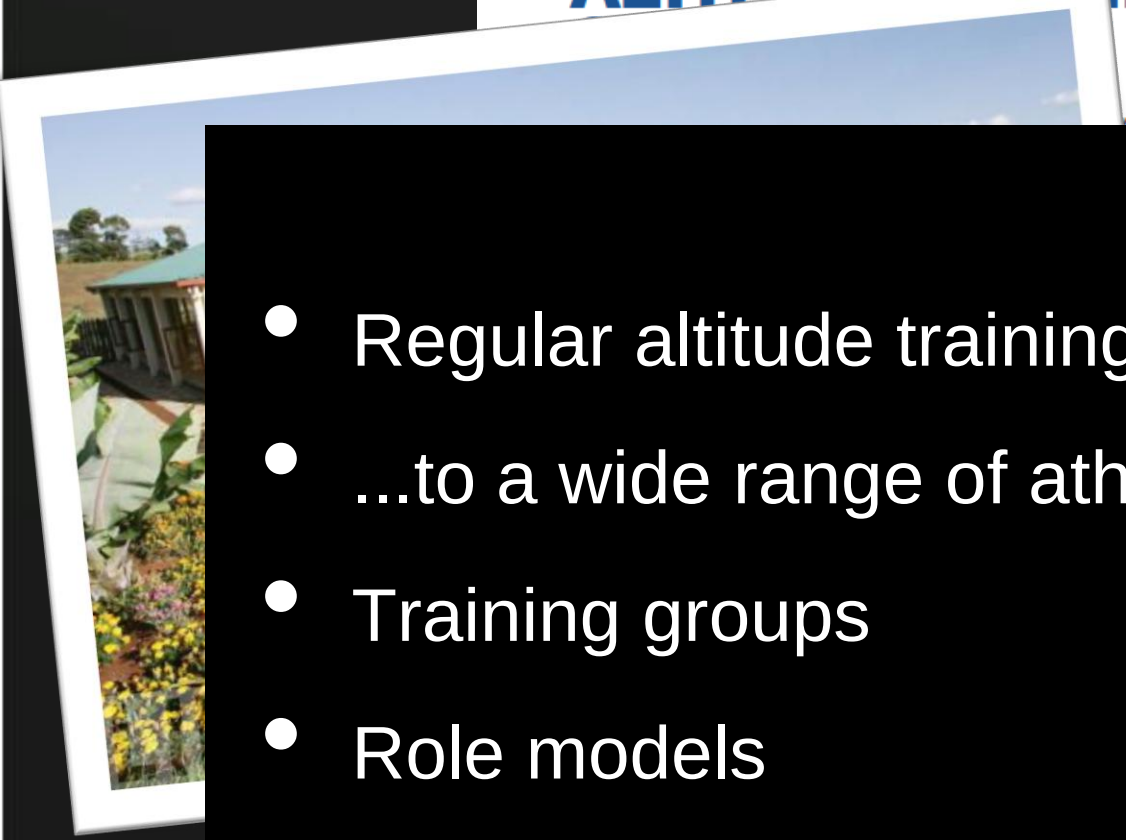
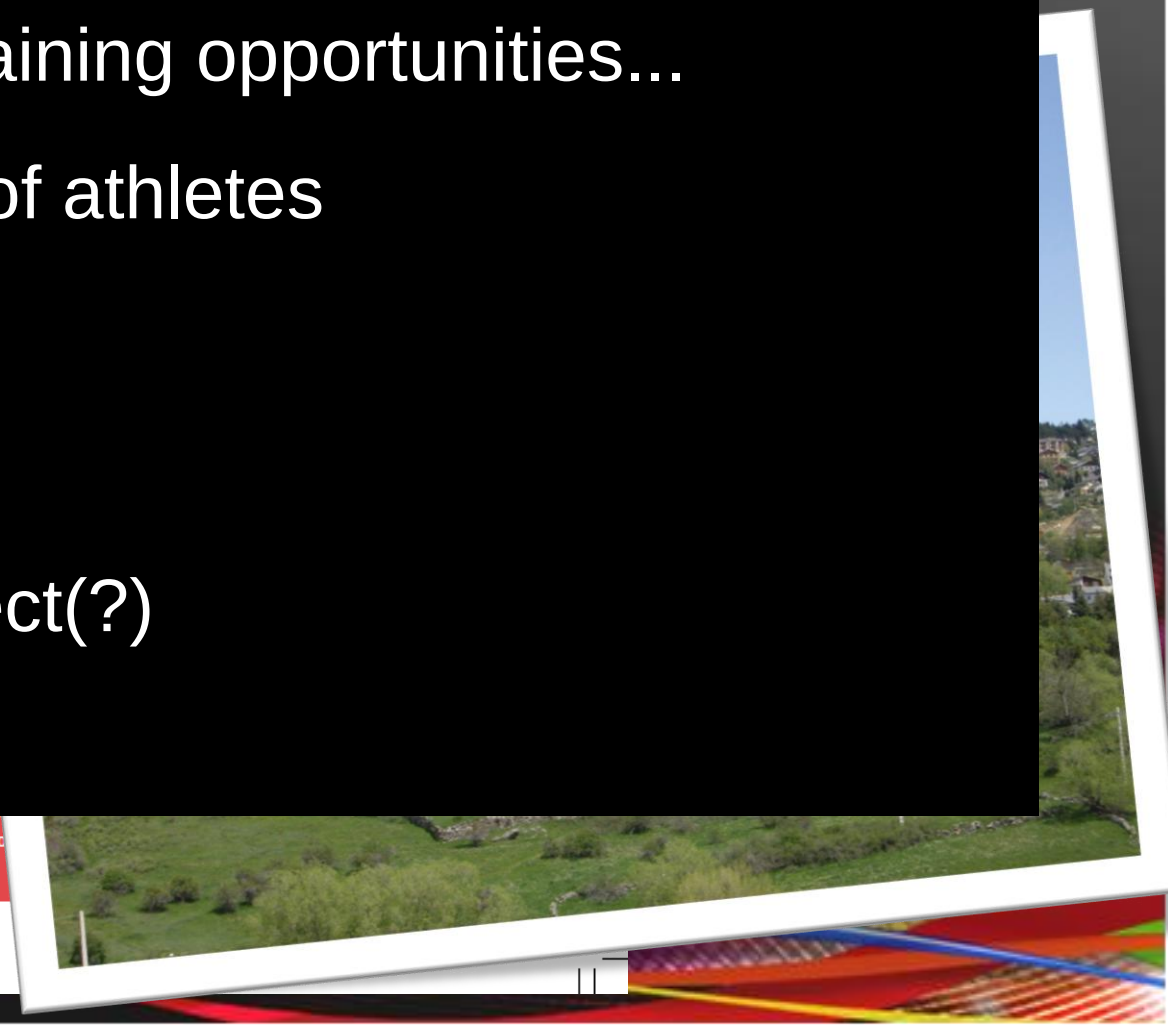
- Regular altitude training opportunities...
- ...to a wide range of athletes
- Training groups
- Role models
- Training camp effect(?)





UKA National Endurance Senior Coordinato
by email sbarden@uka.org.uk

Pitfalls – altitude training

- Altitude is a harsh environment
- Many anecdotal reports of bad performance following altitude training
- Therefore requires careful consideration and planning prior to going and well executed programs when there

Measurements

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UKA UNITED KINGDOM ATHLETICS

Altitude Training Camp:

Information and recommendations for coaches and athletes

Contents:

Things to do pre-altitude camp
Things to do when at altitude
Things to do post-altitude camp

Measurements

@Altitude

- Hydration
- Body mass
- Blood chemistry (acid-base balance)
- Key sessions (i.e. [La], HR, GPS etc)
- Oxygen saturation
- Health & lifestyle monitoring
- Time...

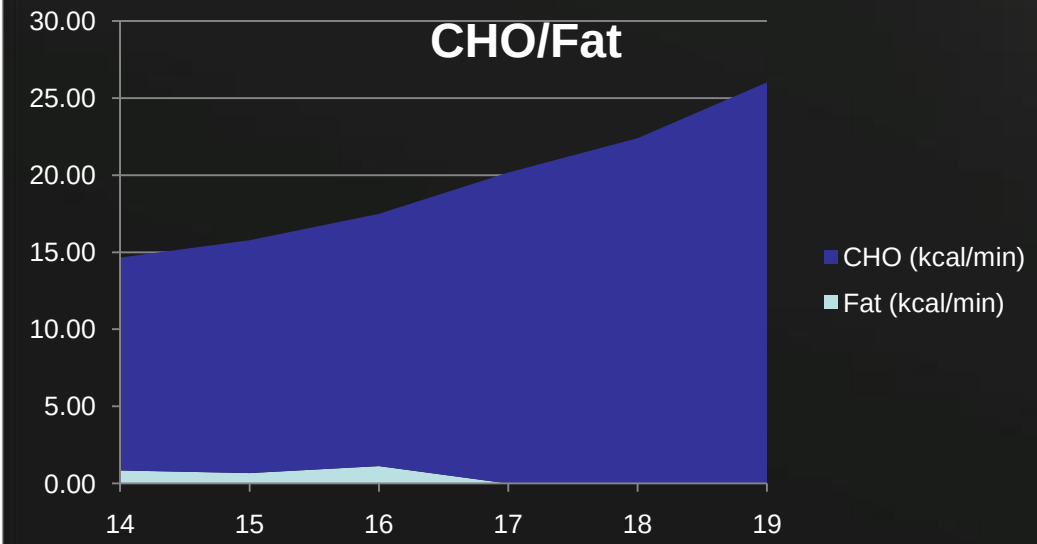
Results – Group level

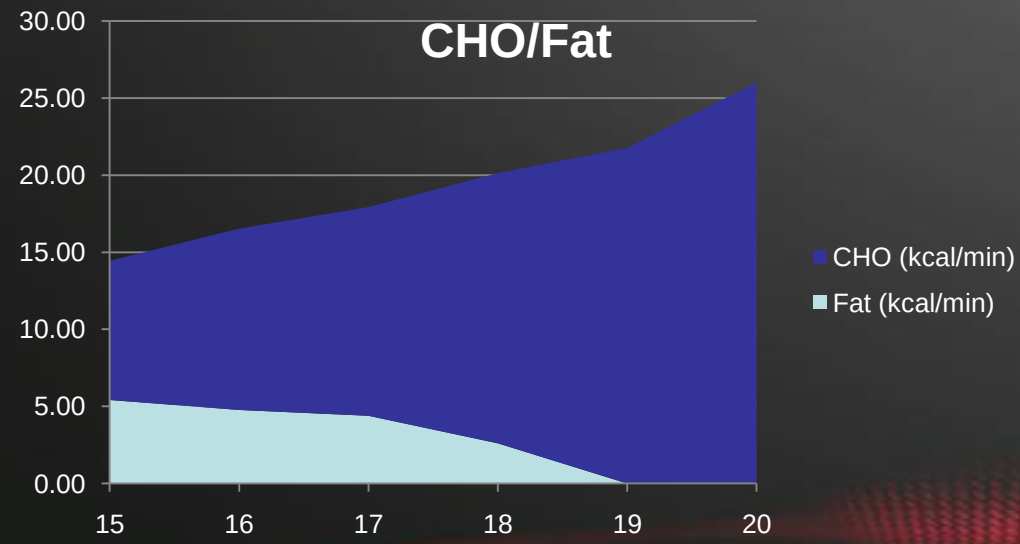
Athlete	VO_2max (mL/kg/min)	
	Pre Altitude	Post Altitude
	78.5	81.2
	69.9	76.6
	75.6	77.6
	70.4	79.9
	77.1	80.2
	74.3	77.9
	70.2	74.3
	78.8	80.8
Mean	74.4	78.6
Change	5.7%*	

Haemoglobin mass changes

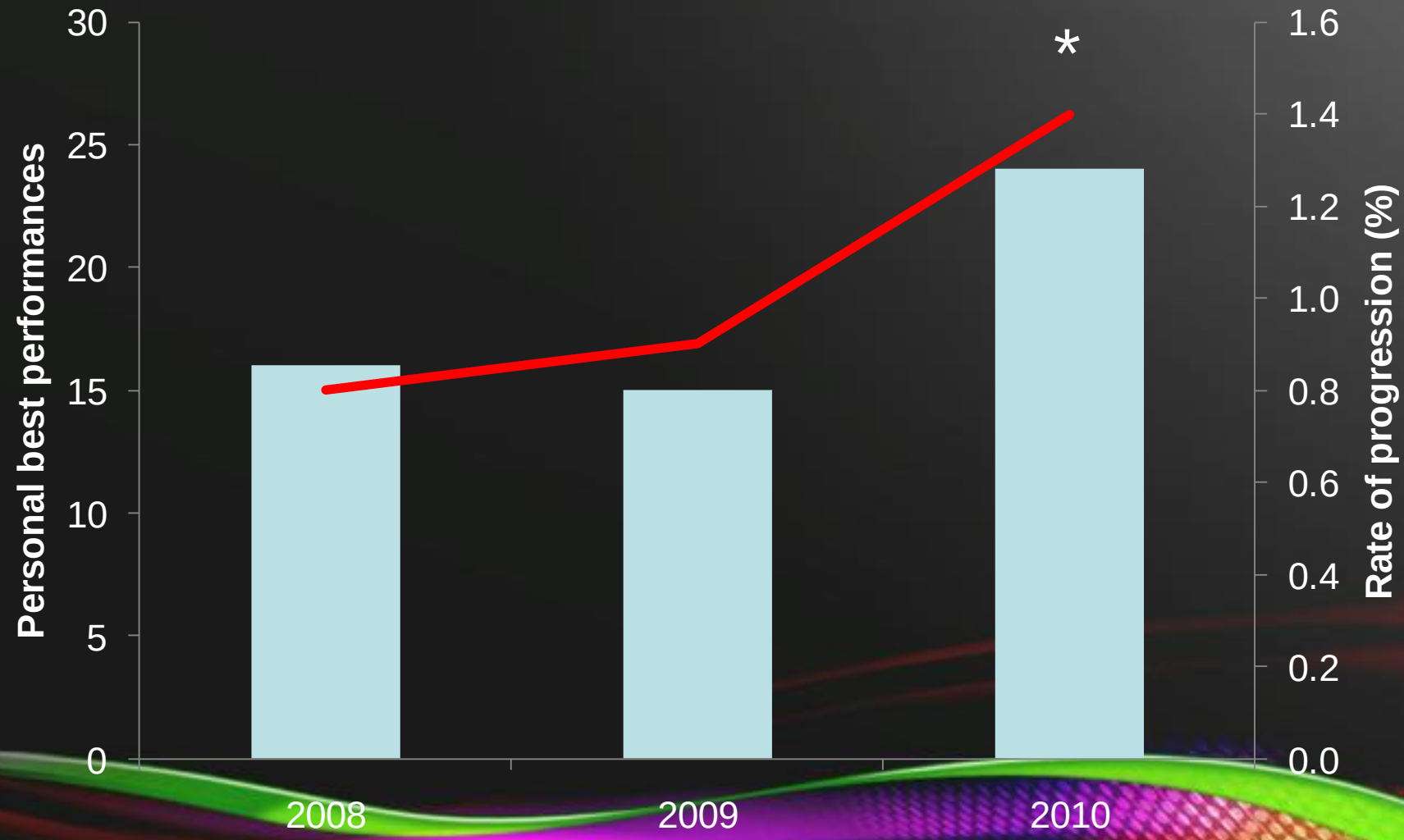
- Kenya (2450m a.s.l. for 4 weeks): mean ~5%, max ~9% (6 weeks)
- Font Romeu (1800m a.s.l for 4 weeks): tbd but expect around 3-5%
- Tent (2800m a.s.l for 6 weeks): tbd but expect around4-6%

Pre & Post LHTH - Kenya





Results – Group level



Result

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So making progress, but no cigar!

Section summary

- UK endurance runners have a unique opportunity to live and train at altitude
- The program is year round which allows the opportunity to complete different types of altitude training (i.e. A, B and C)
- Fully supported program (medicine, science, etc)

General Summary

- Without a conducive/optimum environment true genetic potential shall not be realised
- Best endurance runners in the world use altitude training
- Science appears to back this up
- GB are achieving positive results


Thanks for listening
Questions & discussions