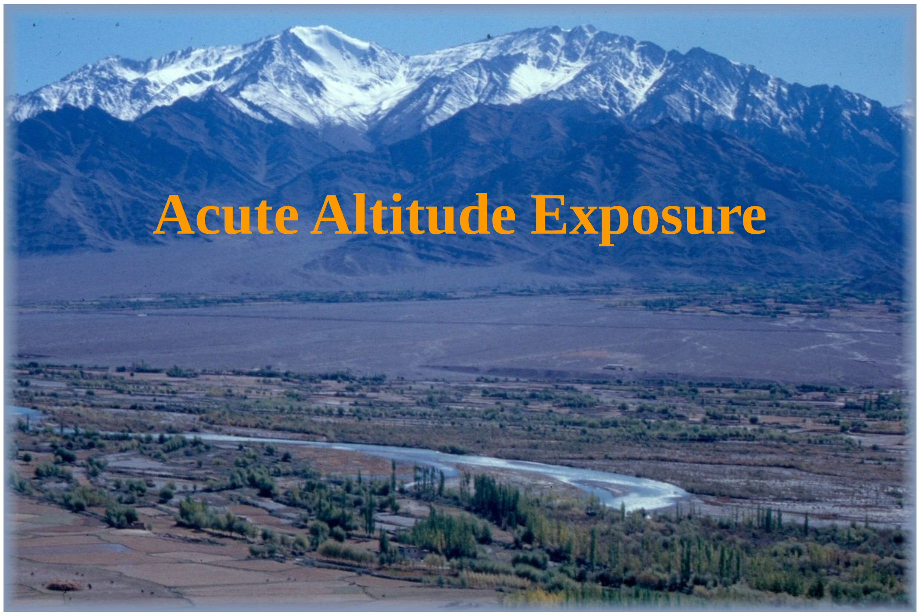


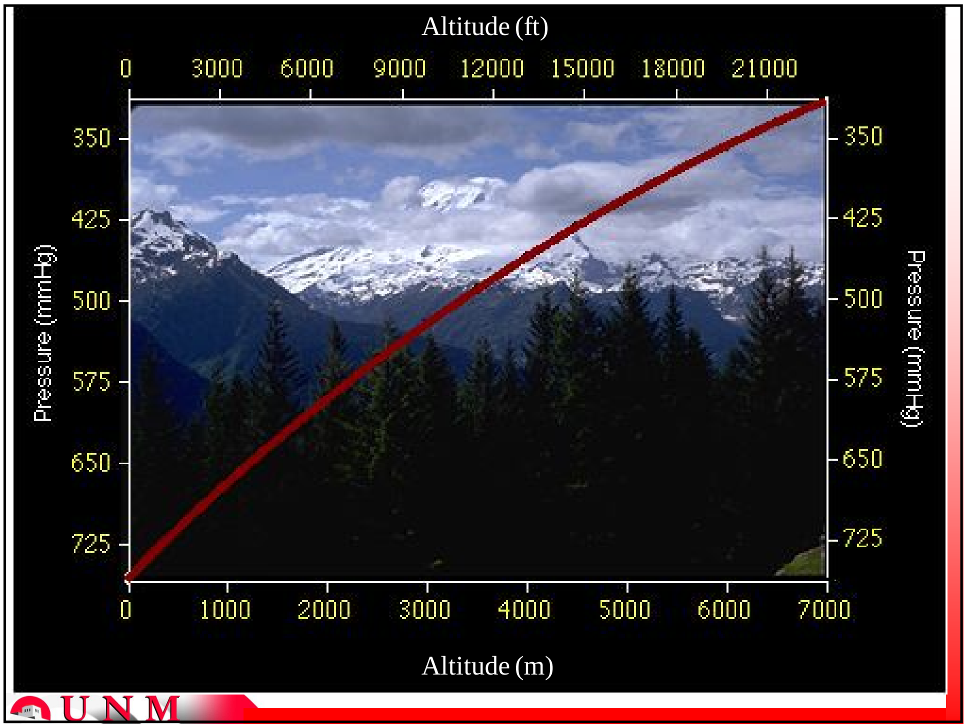
Exercise at Increased Altitude

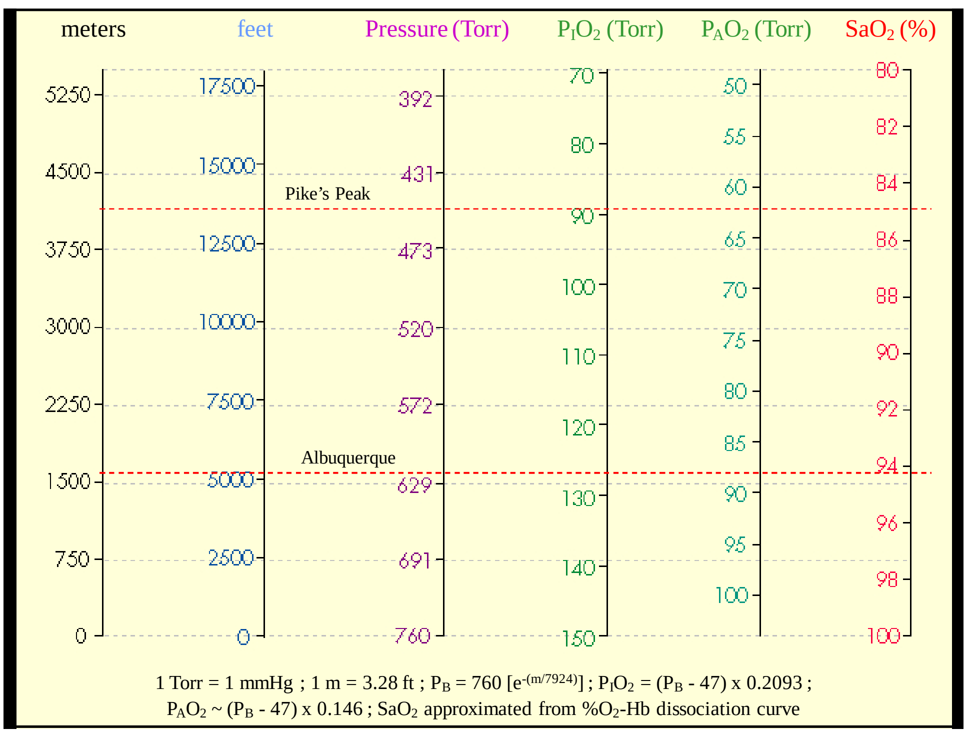
As altitude increases, there is a decrease in pressure. This reduced pressure causes air molecules to be more dispersed. Thus, for a given air volume, even though the relative presence (*gas fraction*) of a gas remains the same, there is less of a given gas.

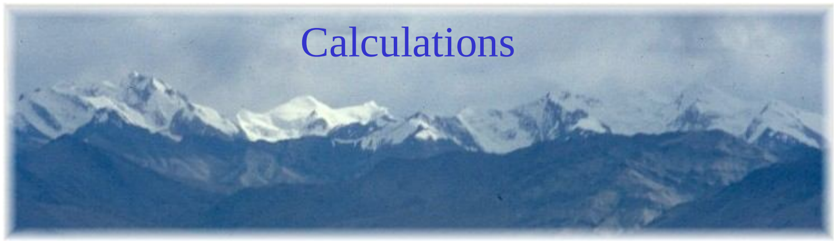
For example,

Sea level
PO_2 in air = 760 mmHg x 0.2093 = 159 mmHg

At Pikes Peak, CO (4,000 m or 14,300 ft)
PO_2 in air = 430 mmHg x 0.2093 = 90 mmHg


Altitude (ft)
0 3000 6000 9000 12000 15000 18000 21000
Pressure (mmHg)
350 425 500 575 650 725
Pressure (mmHg)
350 425 500 575 650 725
0 1000 2000 3000 4000 5000 6000 7000
Altitude (m)
UNM


meters
feet
Pressure (Torr)
P_IO_2 (Torr)
P_AO_2 (Torr)
SaO_2 (%)
5250 4500 3750 3000 2250 1500 750 0
17500 15000 12500 10000 7500 5000 2500 0
392 431 473 520 572 629 691 760
70 80 90 100 110 120 130 140 150
50 55 60 65 70 75 80 85 90 95 100
80 82 84 86 88 90 92 94 96 98 100
Pike's Peak
Albuquerque
1 Torr = 1 mmHg ; 1 m = 3.28 ft ; $P_B = 760\ [e^{-(m/7924)}]$; $P_IO_2 = (P_B - 47) \times 0.2093$;
$P_AO_2 \sim (P_B - 47) \times 0.146$; SaO_2 approximated from $\%O_2$-Hb dissociation curve



Calculations

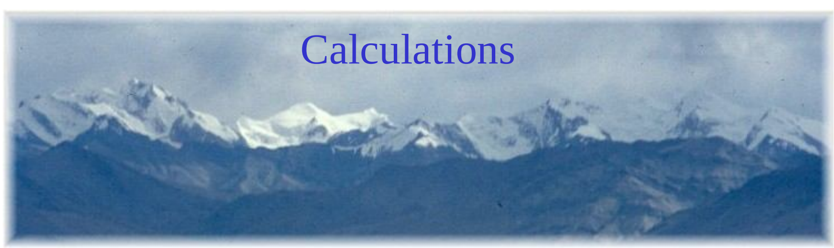
5,200 ft = __________ = __________ P_B = __________ P_AO_2

10,600 ft = __________ = __________ P_B = __________ P_AO_2

14,200 ft = __________ = __________ P_B = __________ P_AO_2

26,600 ft = __________ = __________ P_B = __________ P_AO_2

UNM



Calculations

5,200 ft = 1585 m = 622 mmHg P_B = 83.9 mmHg P_AO_2

10,600 ft = 3232 m = 505 mmHg P_B = 66.9 mmHg P_AO_2

14,200 ft = 4329 m = 440 mmHg P_B = 57.4 mmHg P_AO_2

26,600 ft = 8110 m = 273 mmHg P_B = 33 mmHg P_AO_2

UNM

Why Study Human Physiology during Hypoxia ?

* Basic Science
  - altered cardio-pulmonary function
  - altered autonomic regulation
  - what causes AMS ?

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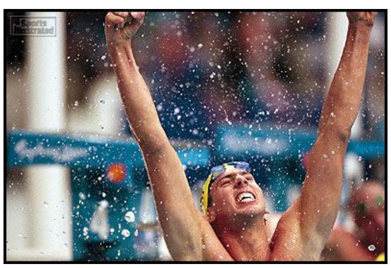

* Applied Science
  - physical performance
  - strategies to decrease decrements

* Clinical Science
  - hypoxia is associated with many clinical disorders
    heart failure ; peripheral vascular disease ;
    coronary atherosclerosis
  - hypoxia “ages” the autonomic nervous system

UNM

How do researchers study hypoxia ?

Hypobaric hypoxia

- ↓ pressure (↑ altitude) & normal F_IO_2

terrestrial altitude

hypobaric chamber

Normobaric hypoxia

- environmental pressure with ↓ P_IO_2

Ischemic hypoxia

- ↓ blood flow with normal PaO_2

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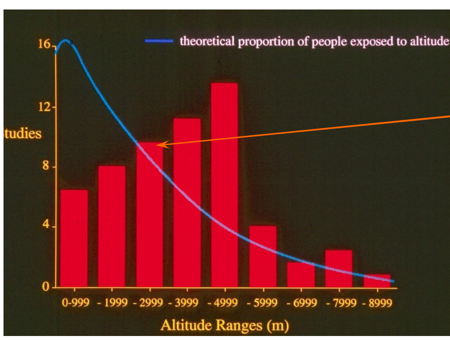
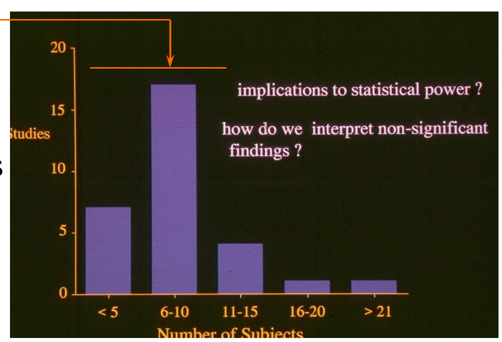


Shouldn't most studies be done at altitudes < 3000m?

Does this mean that many studies need to be redone with larger sample sizes and improved statistics?



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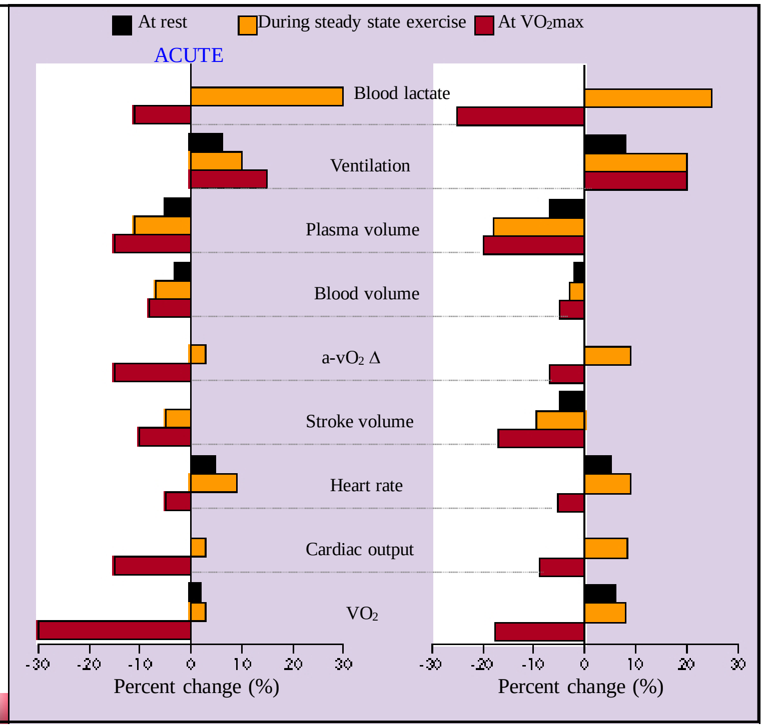
ACUTE

Variable

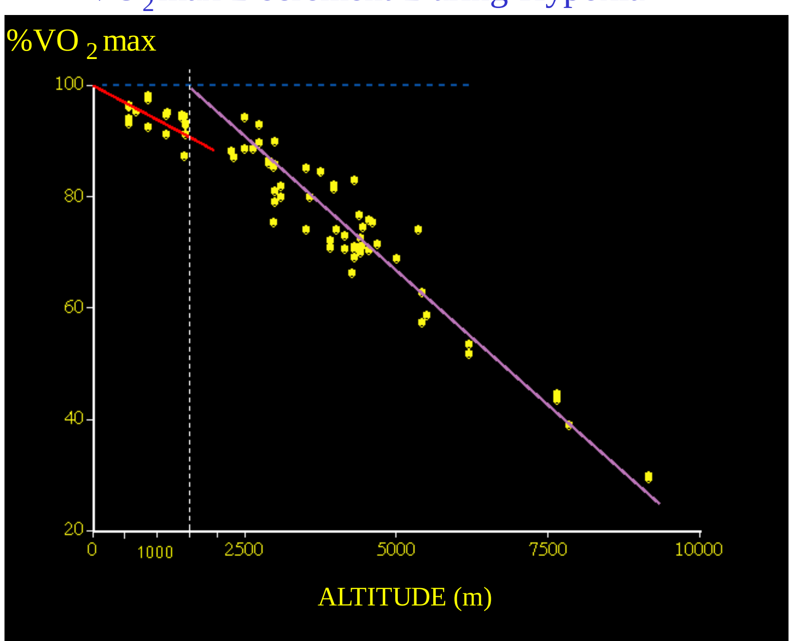
a. rest

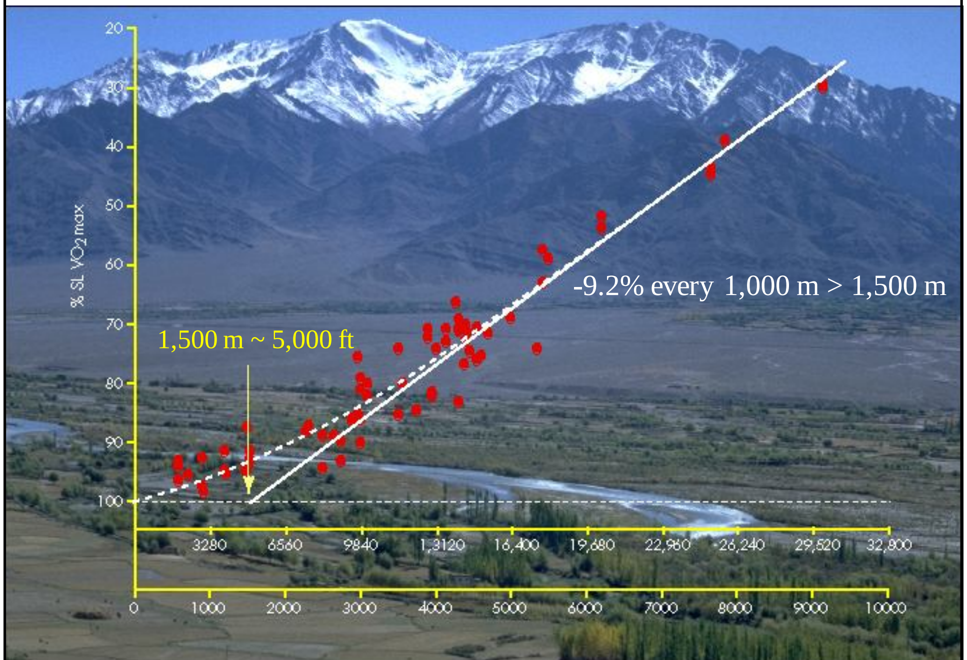
b. steady state

c. at VO_2 max



VO_2max Decrement During Hypoxia





Problem

Even though SaO_2 seems to relate well to the decrement in VO_2max at altitude, each of the data from Young, Ferretti, Anderson and Lawler reveal considerable between subject variability in the VO_2max decrement for a given alteration in oxygen transport.

Surely additional variables might also explain the decrement in VO_2max during acute hypoxia!!

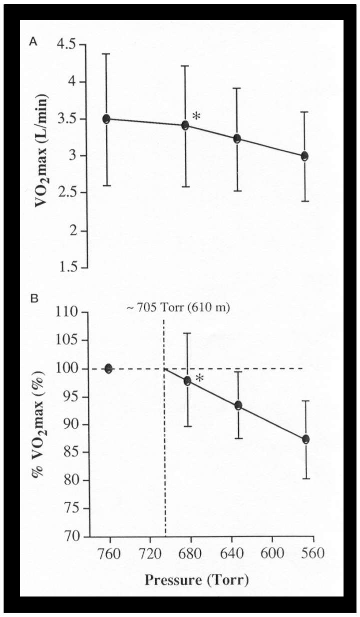
Fitness ? **Gender?**

Lactate Threshold ?

Acclimation/Acclimatization ?

Muscle fiber types ?

Muscle fiber size/mass ?

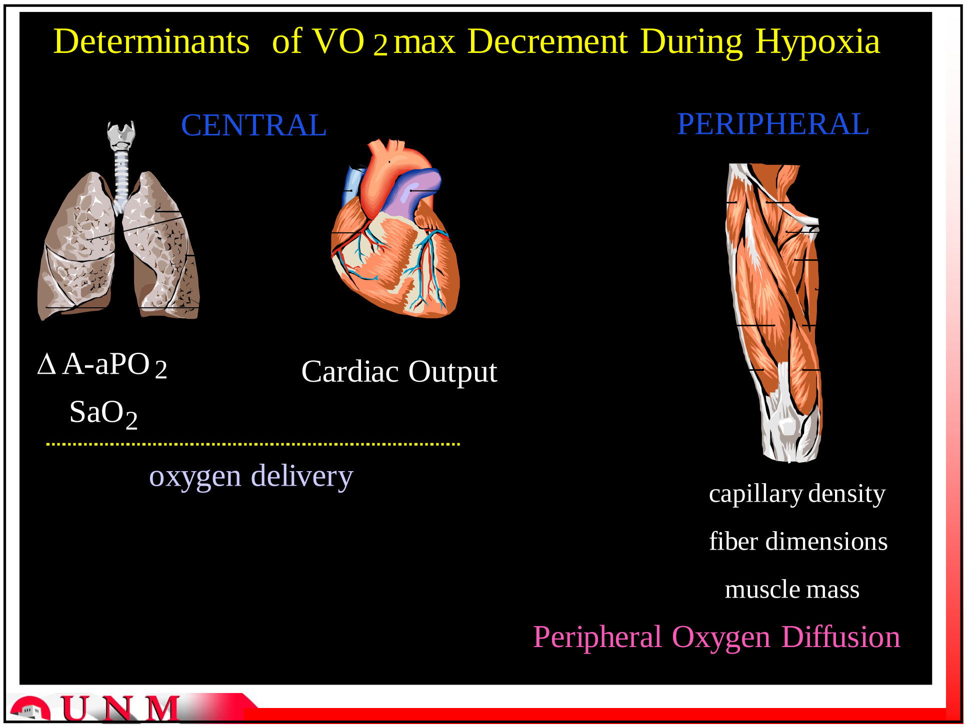


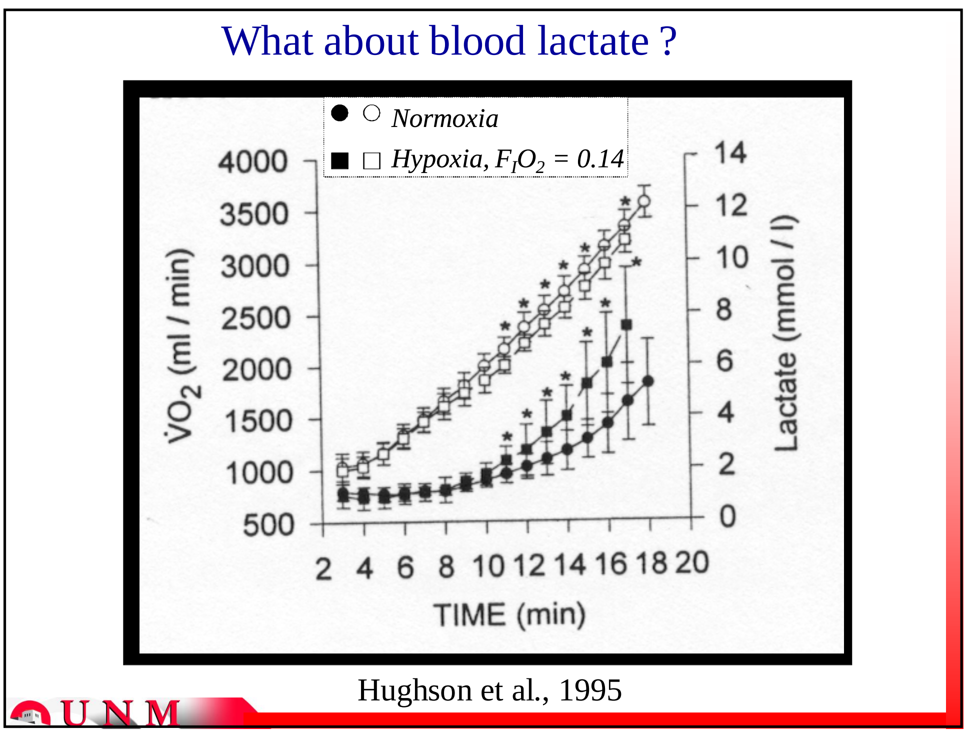
Robergs et al., 1998

Table 4.

Variable	r	R	R^2	ΔR^2
ΔVO_2max				
$SL\text{-}VO_2max$	0.8685	0.8685	0.7543	0.7543
SL-LT	-0.4567	0.8975	0.8056	0.0512
ΔSaO_2	0.3967	0.9144	0.8362	0.0306
LBM	0.4136	0.9296	0.8642	0.0280
Gender	0.4385	0.9436	0.8903	0.0261

Robergs et al., 1998


Determinants of VO 2 max Decrement During Hypoxia
CENTRAL
PERIPHERAL
Δ A-aPO 2
SaO2
Cardiac Output
oxygen delivery
capillary density
fiber dimensions
muscle mass
Peripheral Oxygen Diffusion
UNM


What about blood lactate ?
Normoxia
Hypoxia, FIO2 = 0.14
VO2 (ml / min)
4000
3500
3000
2500
2000
1500
1000
500
Lactate (mmol / l)
14
12
10
8
6
4
2
0
2 4 6 8 10 12 14 16 18 20
TIME (min)
Hughson et al., 1995
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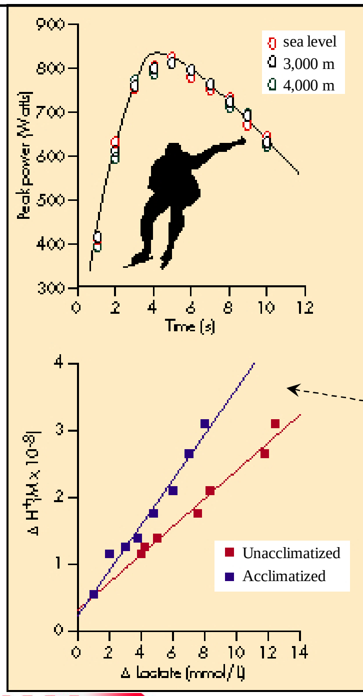
Anaerobic Capacity and Performance



Is this difference a beneficial or detrimental adaptation?