NORGE

Olympiatoppen

Altitude Training

Physiological mechanisms and application in rowing

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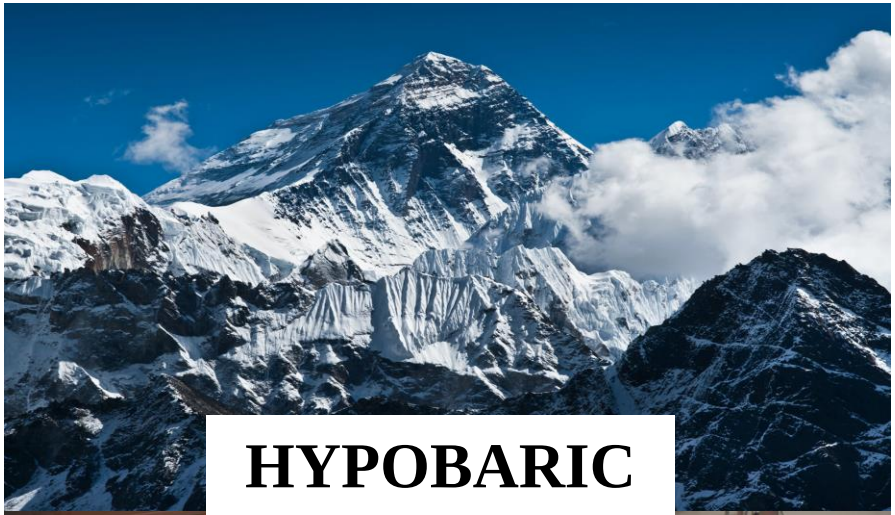
1968 Olympics

Mexico City
(2240m)

Record performances in sprints, jumps and throws

Poor performances in endurance events → large proportion of medalists were altitude natives



HYPOBARIC HYPOXIA

NORMOBARIC HYPOXIA


THE ALTITUDE CENTRE


NASA


edge

ALTITUDE TRAINING MODELS

1. LHTH :

Athlete lives and trains at altitude

2. LHTL :

a) Athlete lives at altitude, but performs some training at a lower elevation
b) Athlete sleeps in a hypoxic tent/chamber and trains at sea-level

3. LLTH :

Athlete lives at sea-level, but performs some training in hypoxia

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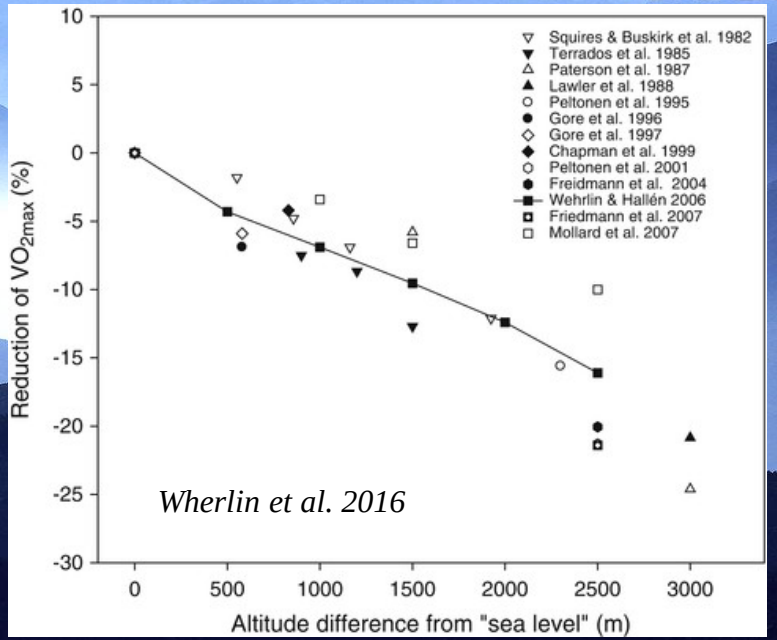
Athlete lives at sea-level, but performs some training in hypoxia

2000m vs. sea-level:

- ~20% fewer oxygen molecules in every breath inhaled
- ~10-13% lower VO_{2max} (non-acclimated)
- Increased ventilation, heart rate and blood lactate at submaximal intensities
- ~8-12 beats/min higher heart rate at same power output



Physiological adaptations at altitude

1. **Increased hemoglobin mass**

→ Reduced oxygen saturation in the blood

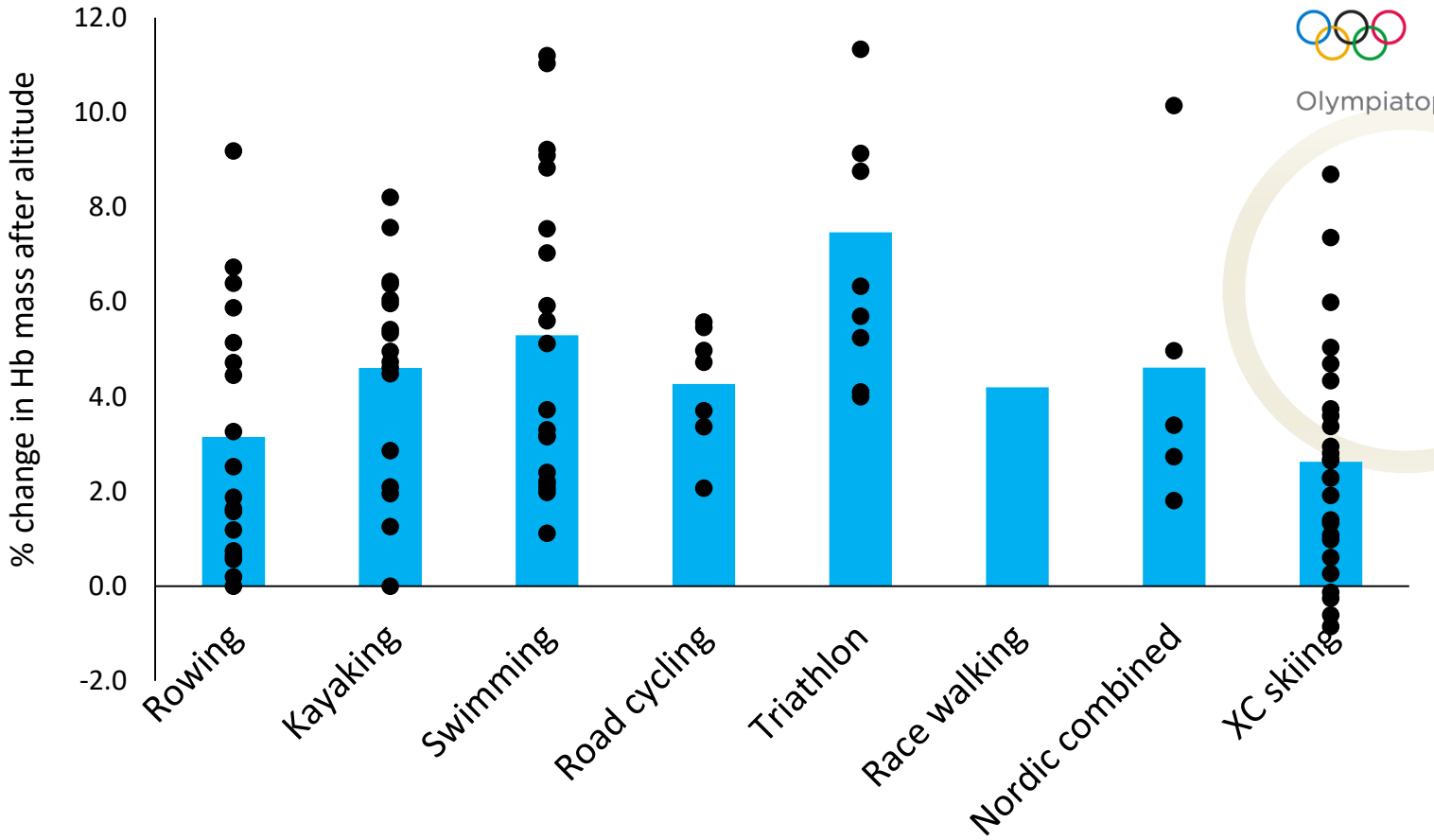
→erythropoetin (EPO) produced in the kidneys

→ increased production of red blood cells in the bone marrow

2. Ventilatory adaptations

3. Increased myoglobin in the muscles

4. Improved buffering capacity



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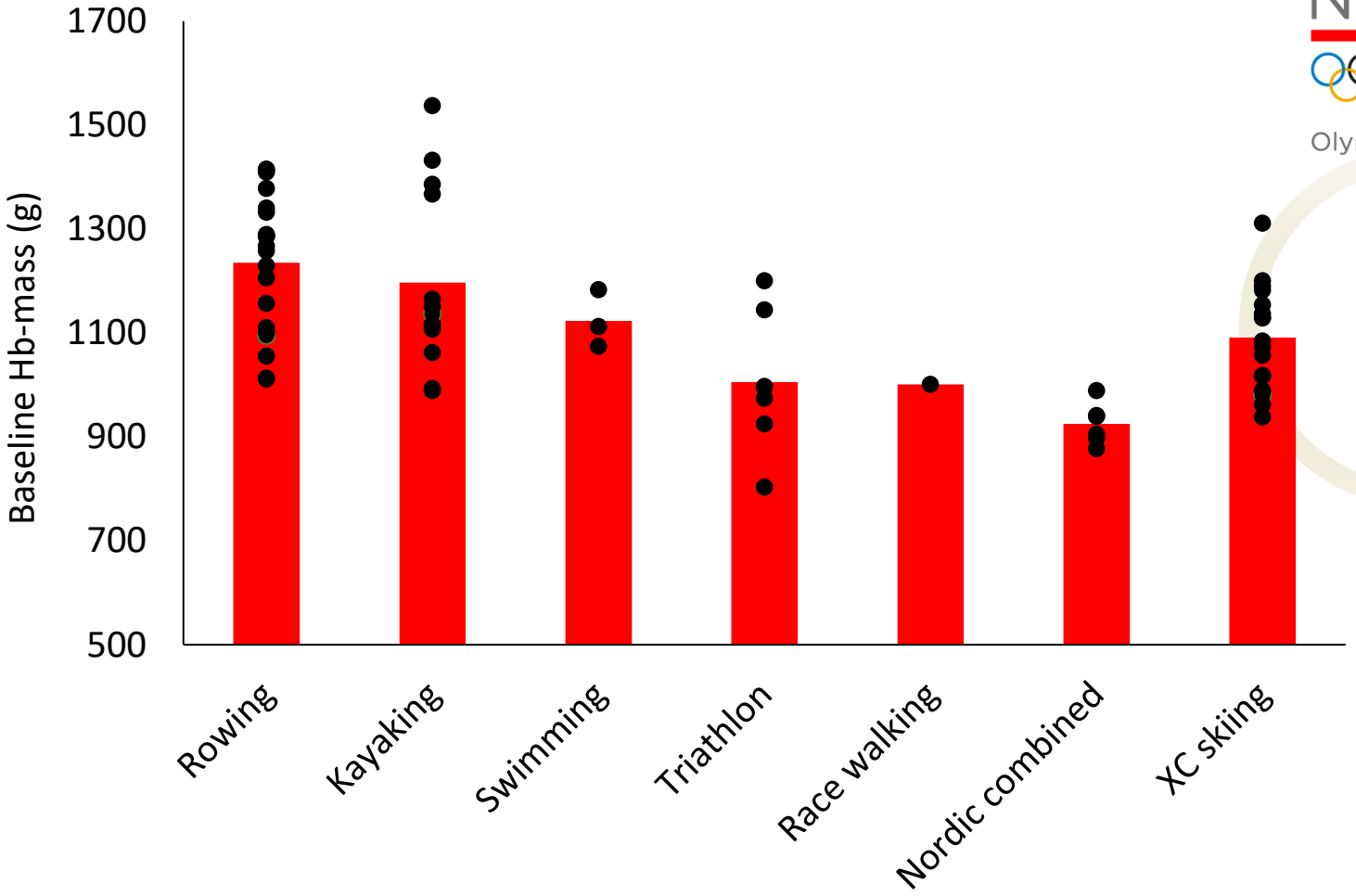
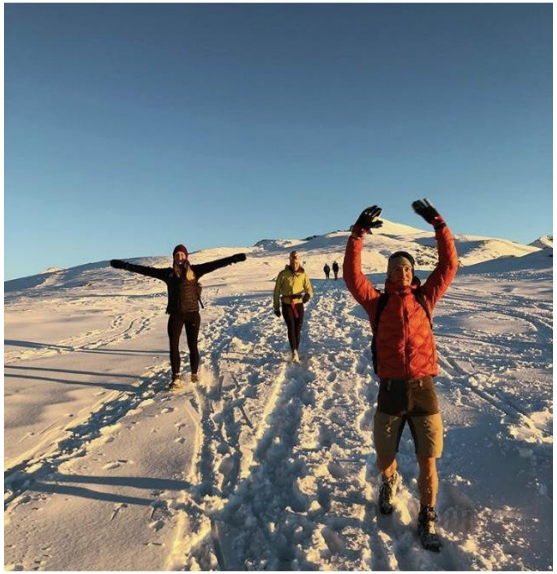

1700
1500
1300
1100
900
700
500
Baseline Hb-mass (g)
Rowing
Kayaking
Swimming
Triathlon
Race walking
Nordic combined
XC skiing



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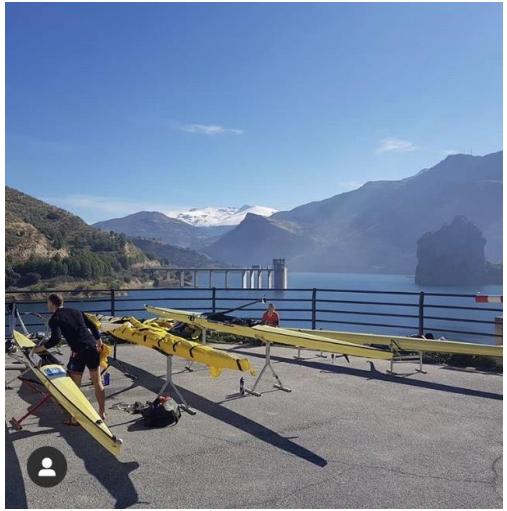
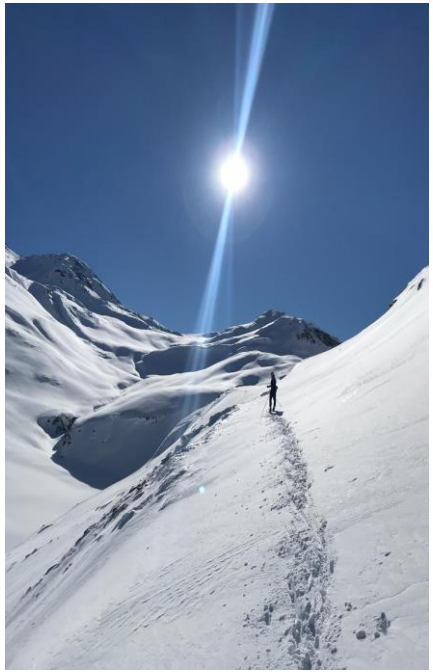
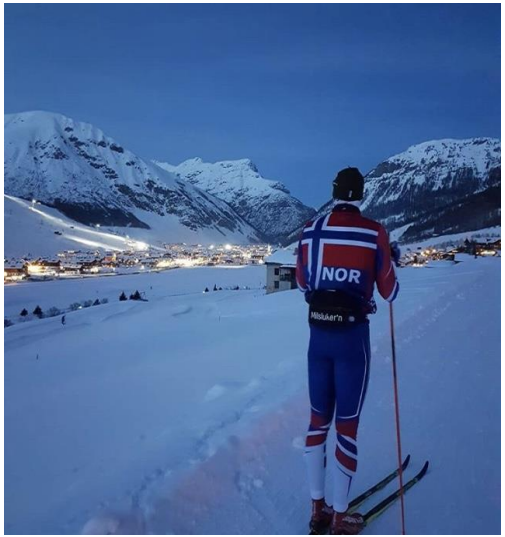
AUTUMN: SIERRA NEVADA
LHTL

- Live at 2300m

-Train at 900m (rowing) + 2300m-3000m (strength, hiking, jogging, cycling)







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WINTER : LIVIGNO
LHTH

- Live and train at 1900-2000m
- XC skiing, rowing ergometer, strength

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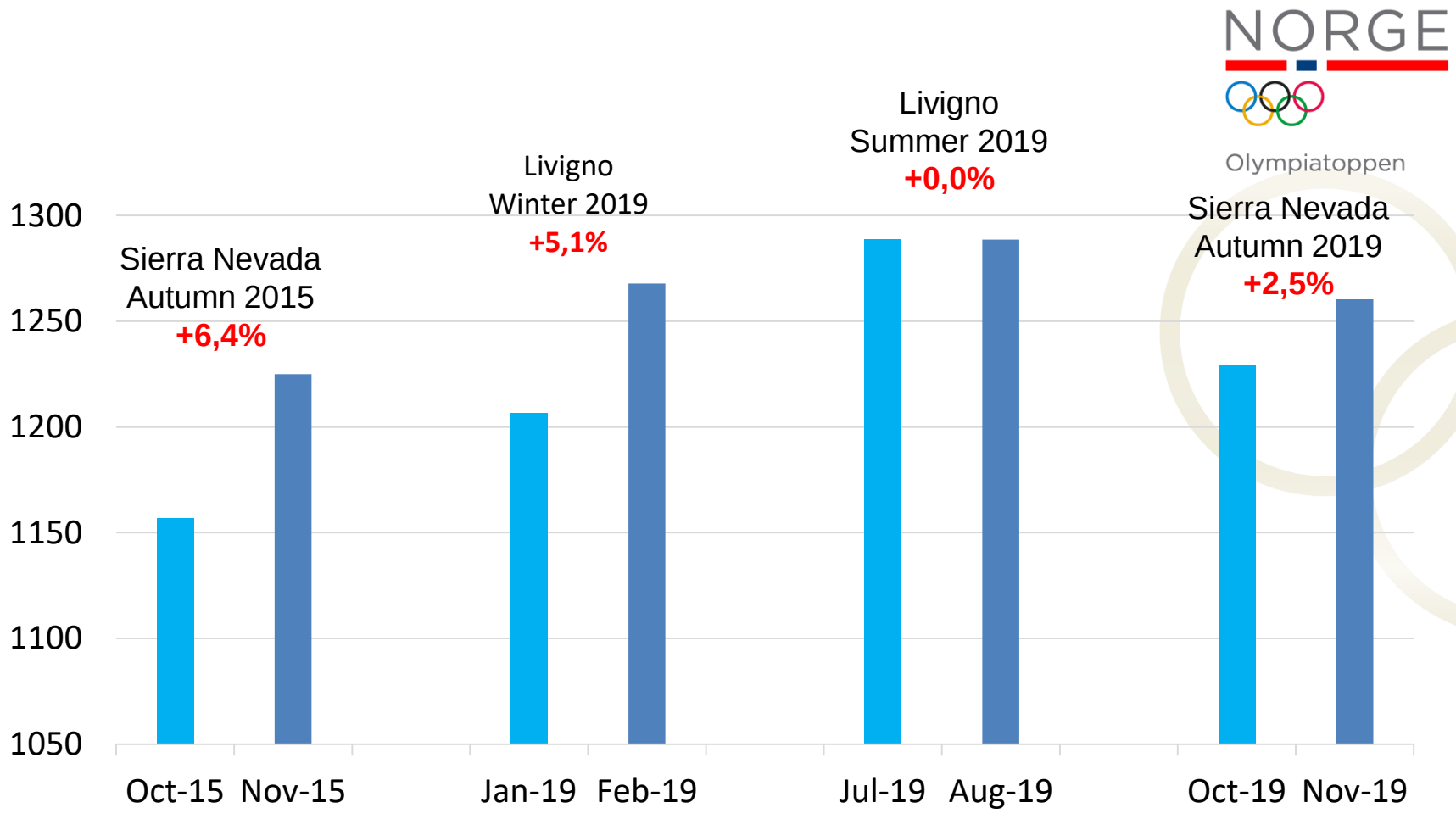
SUMMER: LIVIGNO

LHTH

- Live at 2000m
- Train at 1800-2500m (rowing, cycling, strength)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Sierra Nevada
Autumn 2015
+6,4%
Livigno
Winter 2019
+5,1%
Livigno
Summer 2019
+0,0%
Sierra Nevada
Autumn 2019
+2,5%
1300
1250
1200
1150
1100
1050
Oct-15
Nov-15
Jan-19
Feb-19
Jul-19
Aug-19
Oct-19
Nov-19

TRAINING AT ALTITUDE

- Increased volume, reduced intensity
- Too much high-intensIty can impair RBC production
- No anaerobic endurance training
- Strength training = longer rests and fewer sets
- Avoid novel exercises that cause substantial muscle damage / soreness

Priority at altitude is aerobic capacity

INJURY & INFECTION

If an athlete is sick, they should not be at altitude

→ Inflammation reduces RBC production + hypoxia may delay recovery

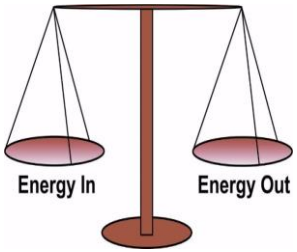
Increased infection risk at altitude?

- Greater stress hormone response = immunosuppression?
- BUT, often also a reduced exposure to pathogens
- No increase in risk if good routines for hygiene, nutrition, sleep etc.

SLEEP & RECOVERY

- Longer recovery time from training at altitude
- Reduced sleep quality (particularly during first week and/or at high elevations)
- Training and meal times should allow for sufficient sleep

NUTRITION & HYDRATION



1. Energy balance

- Avoid weight loss at altitude
- Resting metabolism is somewhat increased + higher training volume = increased energy expenditure at altitude

2. Iron status

- Sufficient iron is required to produce red blood cells
- Iron status should be checked prior to departure

3. Hydration

- Increased fluid loss (increased ventilation and urination + low humidity)

SUMMARY

- A number of physiological adaptations occur at altitude
- Of these, an increase in hemoglobin mass is likely the most important
- Individual response is influenced by baseline value, hypoxic dose (duration and elevation), training content, nutritional status ++
- LHTH and LHTL can both be used effectively – limited evidence for LLTH
- Even without an increase in Hb-mass, altitude training may still have a positive effect on performance via other mechanisms