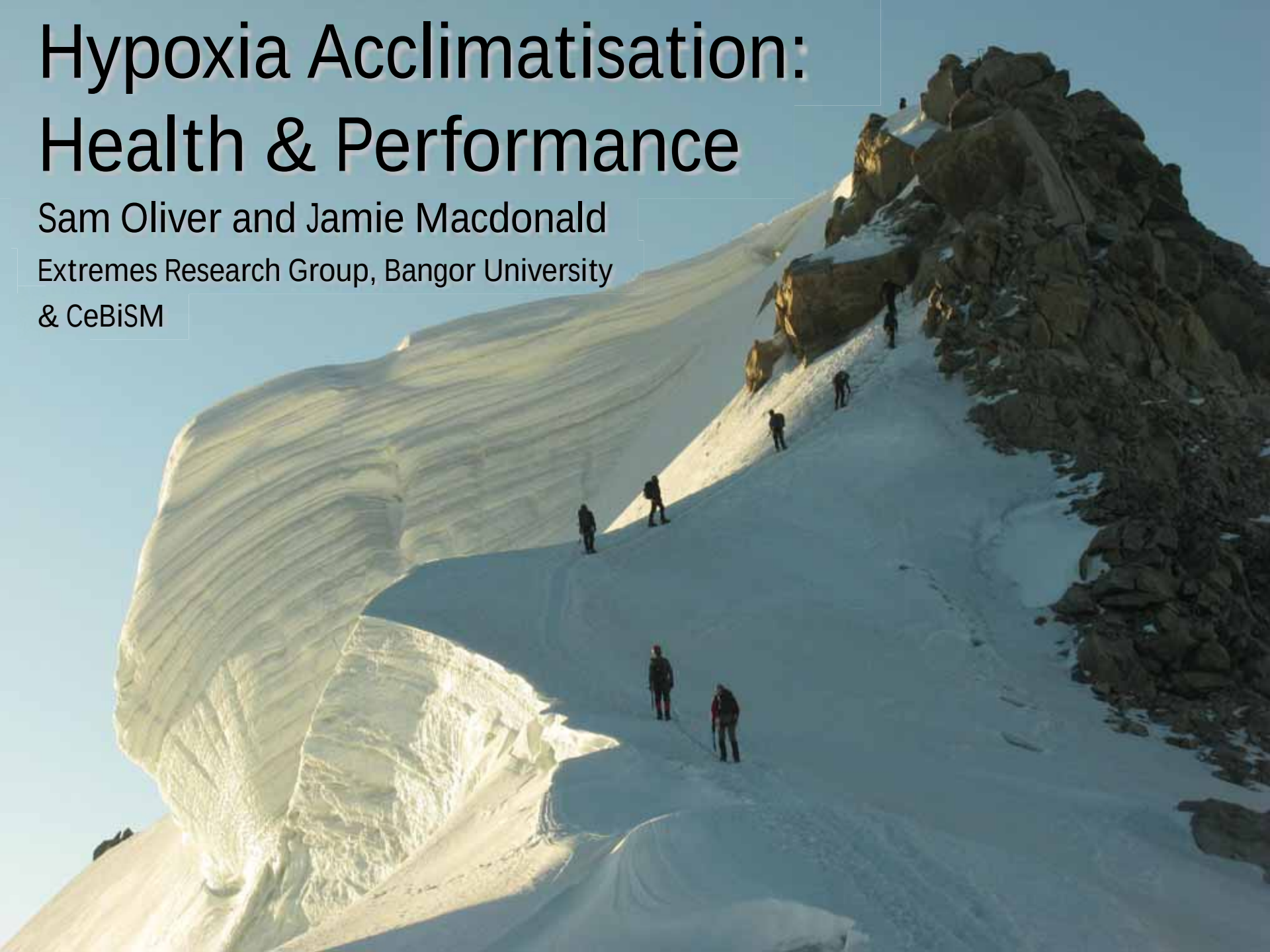
Hypoxia Acclimatisation: Health & Performance

Sam Oliver and Jamie Macdonald

Extremes Research Group, Bangor University

& CeBiSM

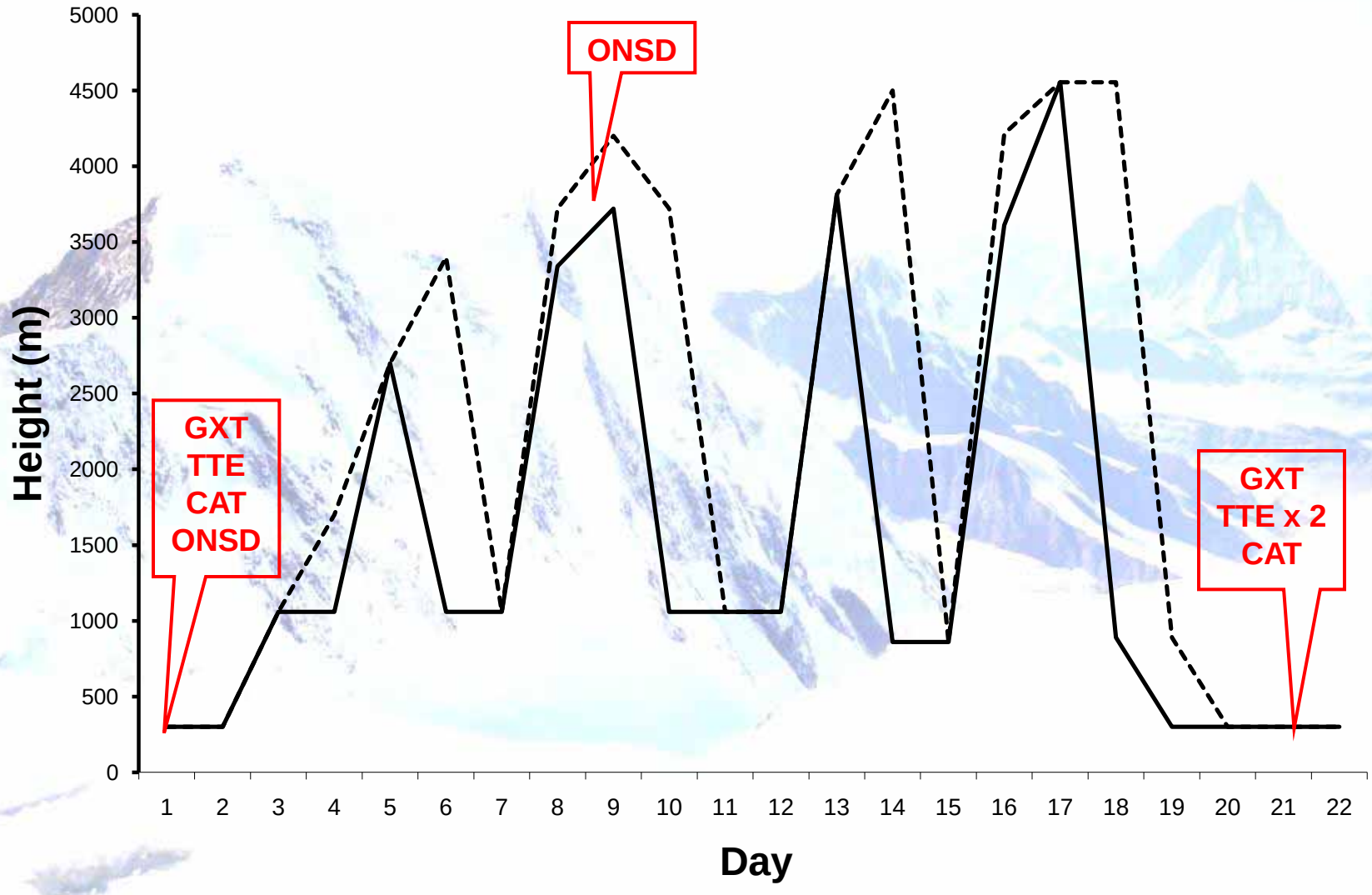


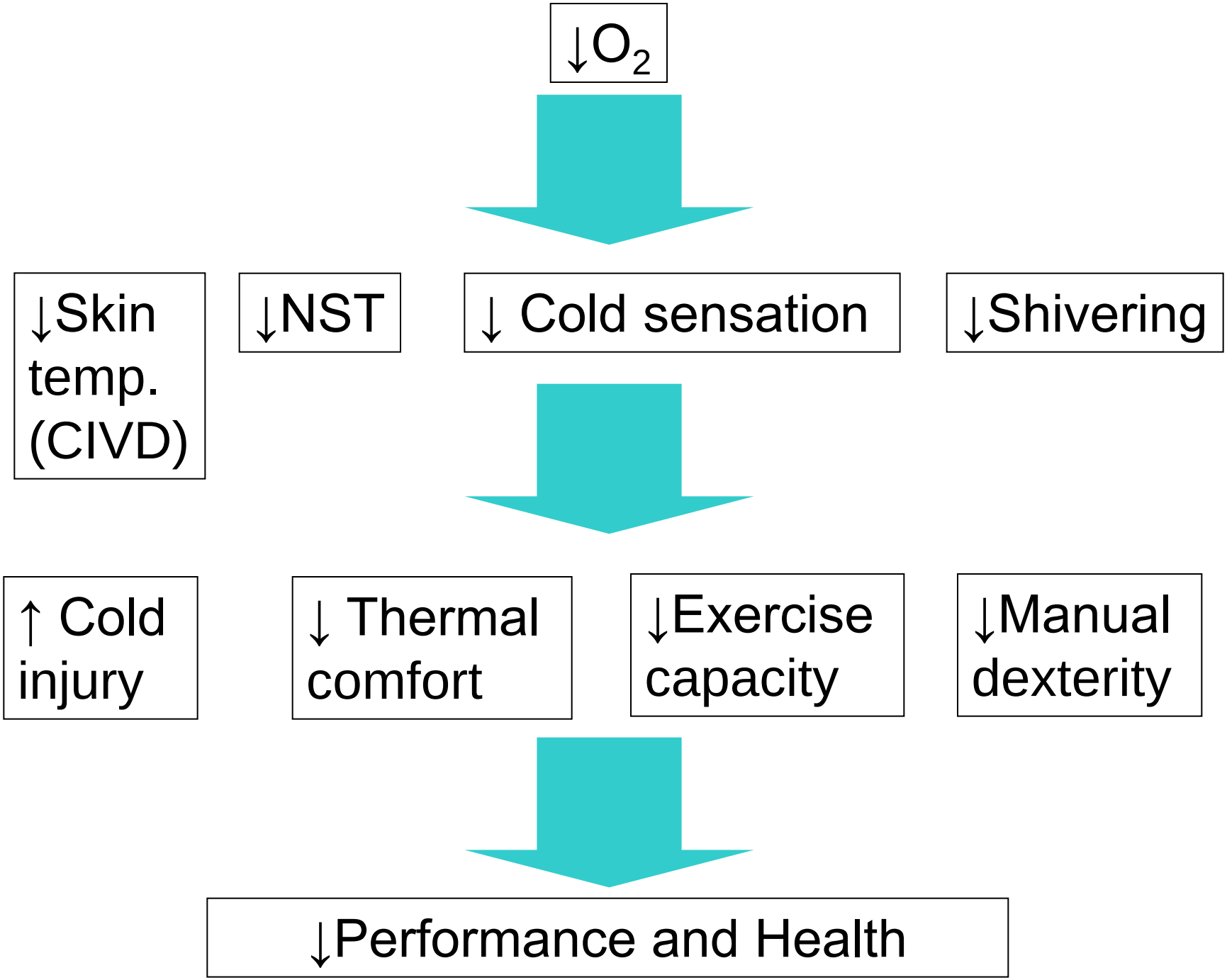
Optimising Performance at Altitude

- Hypoxia
- Hypobaria
- Hypocapnia
- Cold exposure
- UV radiation
- Negative energy balance
- Dehydration
- Sleep deprivation

- ↓ Endurance capacity
- ↓ Cognitive function
- Thermoregulation
- ↑ Cold injury
- ↓ Manual dexterity

Protocol


Height (m)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Day
ONSD
GXT
TTE
CAT
ONSD
GXT
TTE x 2
CAT


↓O_2
↓Skin temp. (CIVD)
↓NST
↓ Cold sensation
↓Shivering
↑ Cold injury
↓ Thermal comfort
↓Exercise capacity
↓Manual dexterity
↓Performance and Health

Cold Air Test

Methods

- 2 hours at 0.2 ± 0.7°C
- Inspired O_2 = 12.4 ± 0.2%

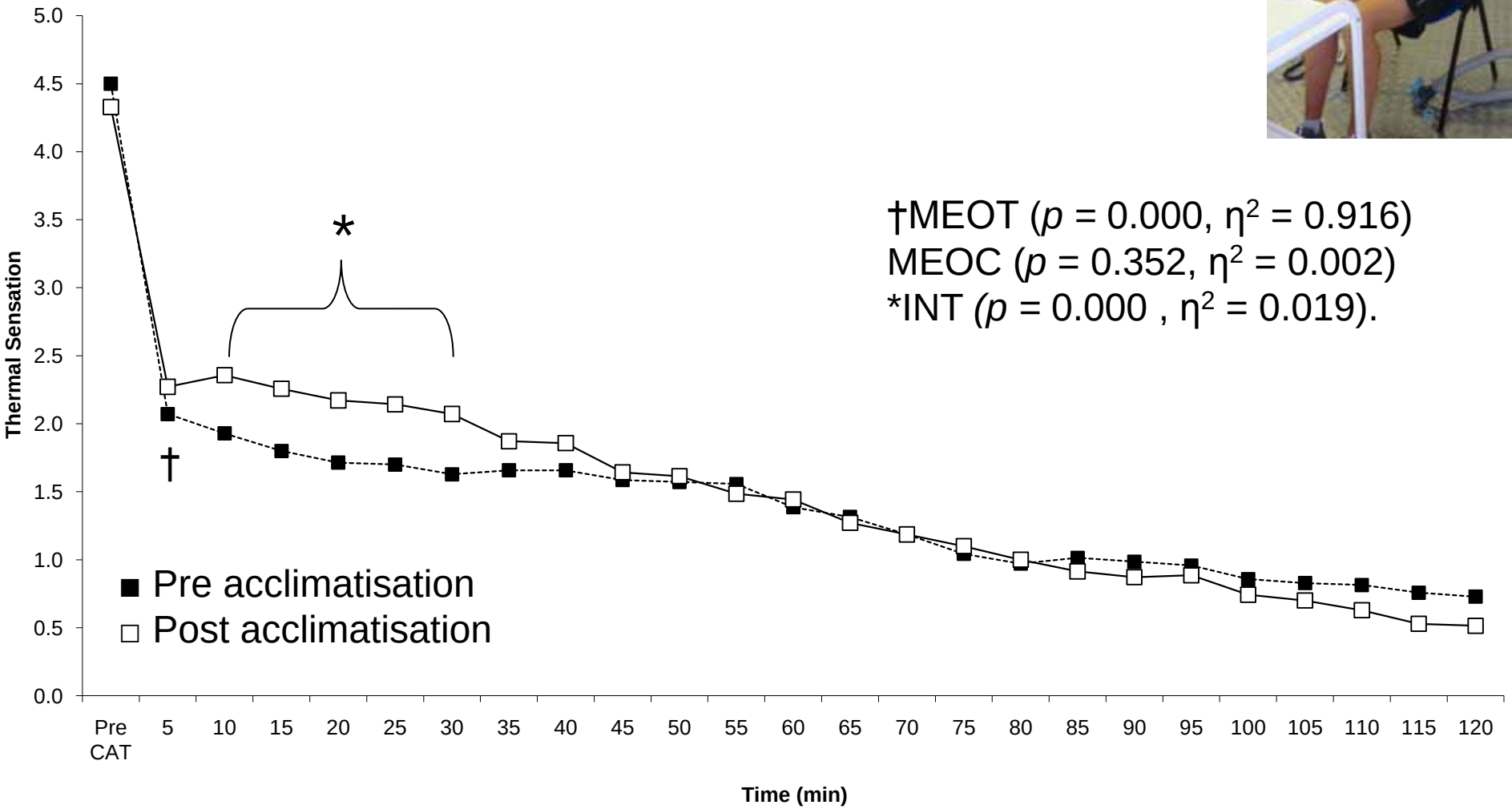
Measures

- Core temperature
- 8 site skin temperature
- Shivering
- Thermal sensation

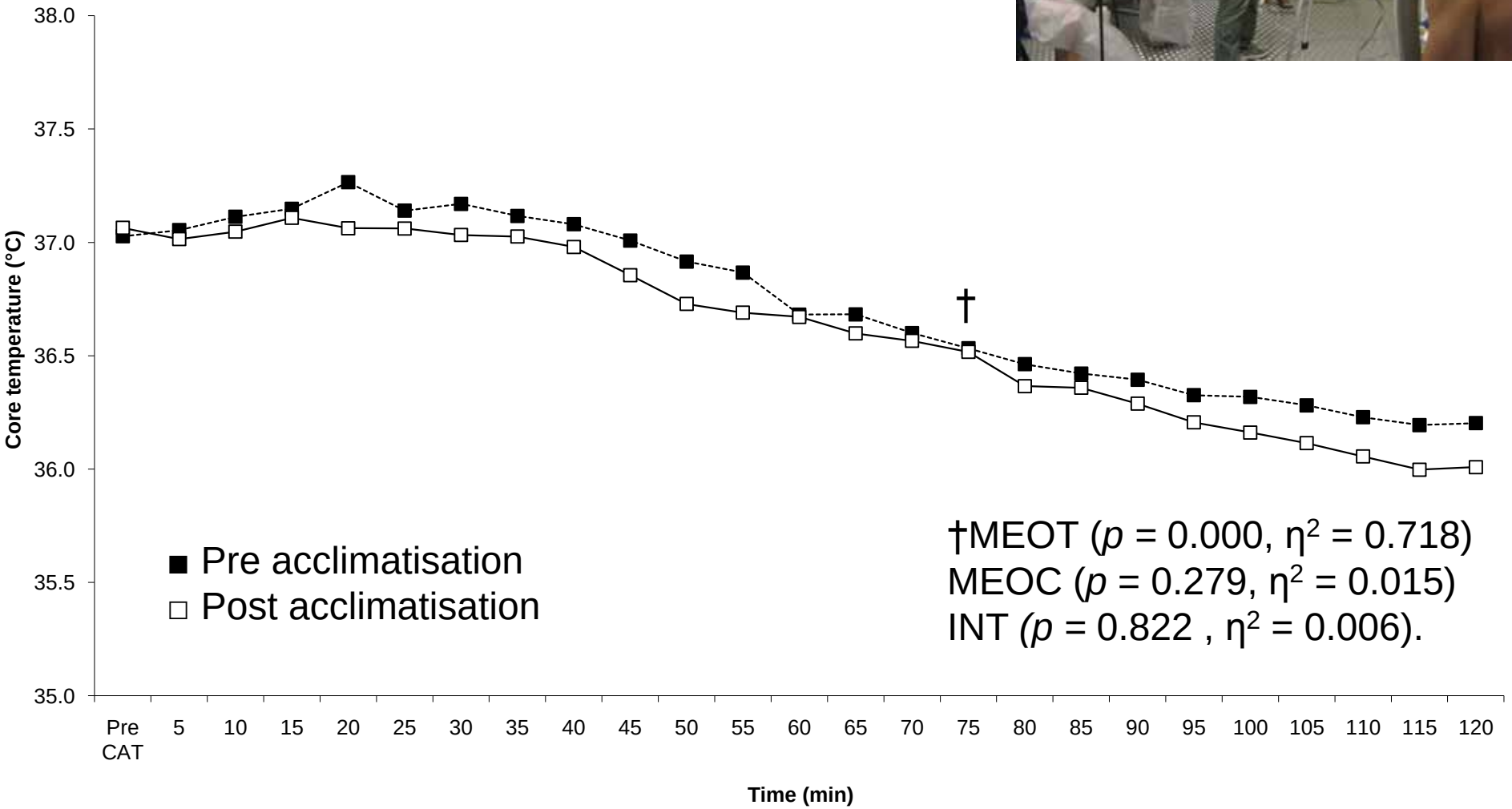
THERMAL SENSATIONS

0.0	UNBEARABLY COLD
0.5	
1.0	VERY COLD
1.5	
2.0	COLD
2.5	
3.0	COOL
3.5	
4.0	COMFORTABLE
4.5	
5.0	WARM
5.5	
6.0	HOT
6.5	
7.0	VERY HOT
7.5	
8.0	UNBEARABLY HOT

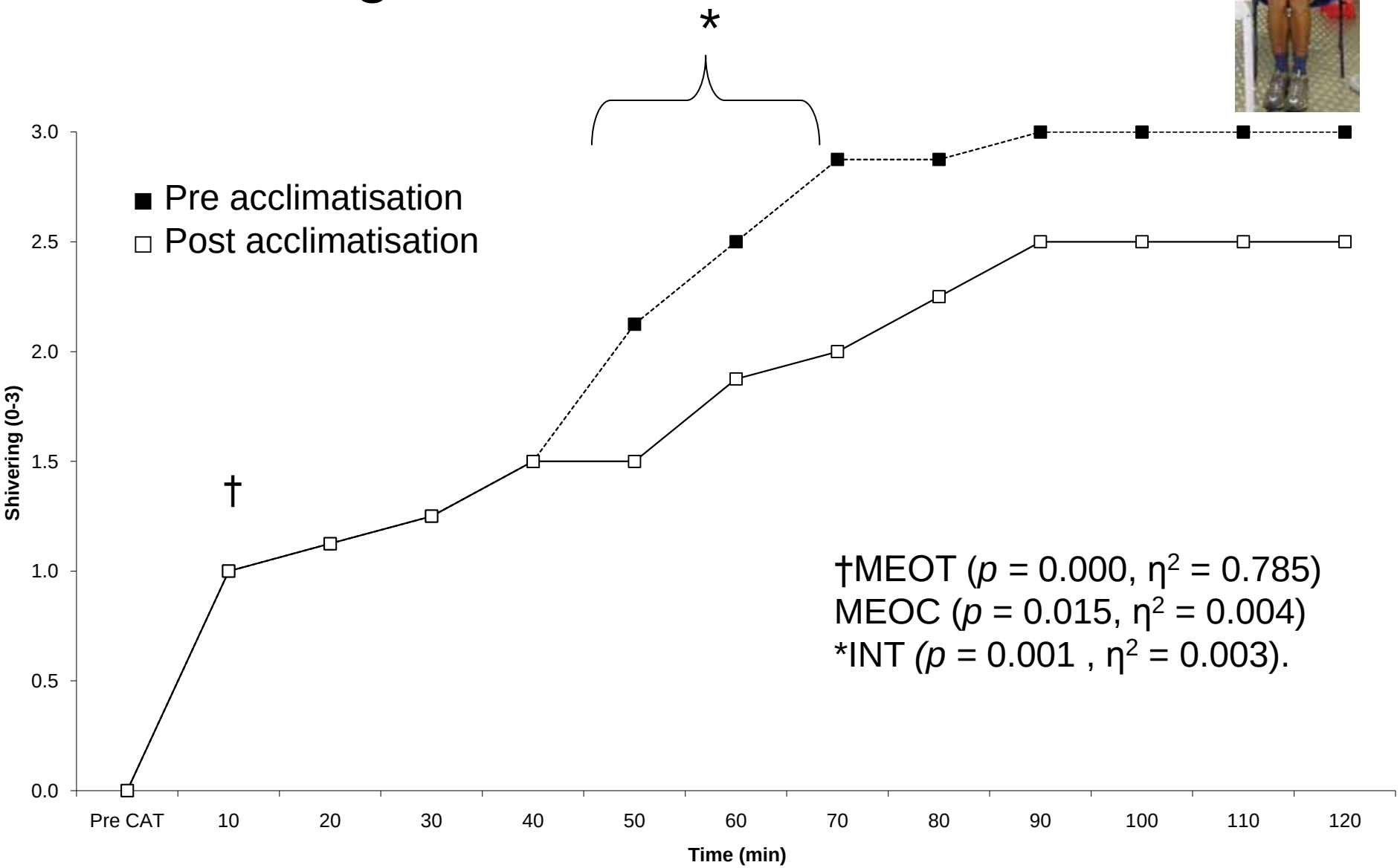
Thermal Sensation



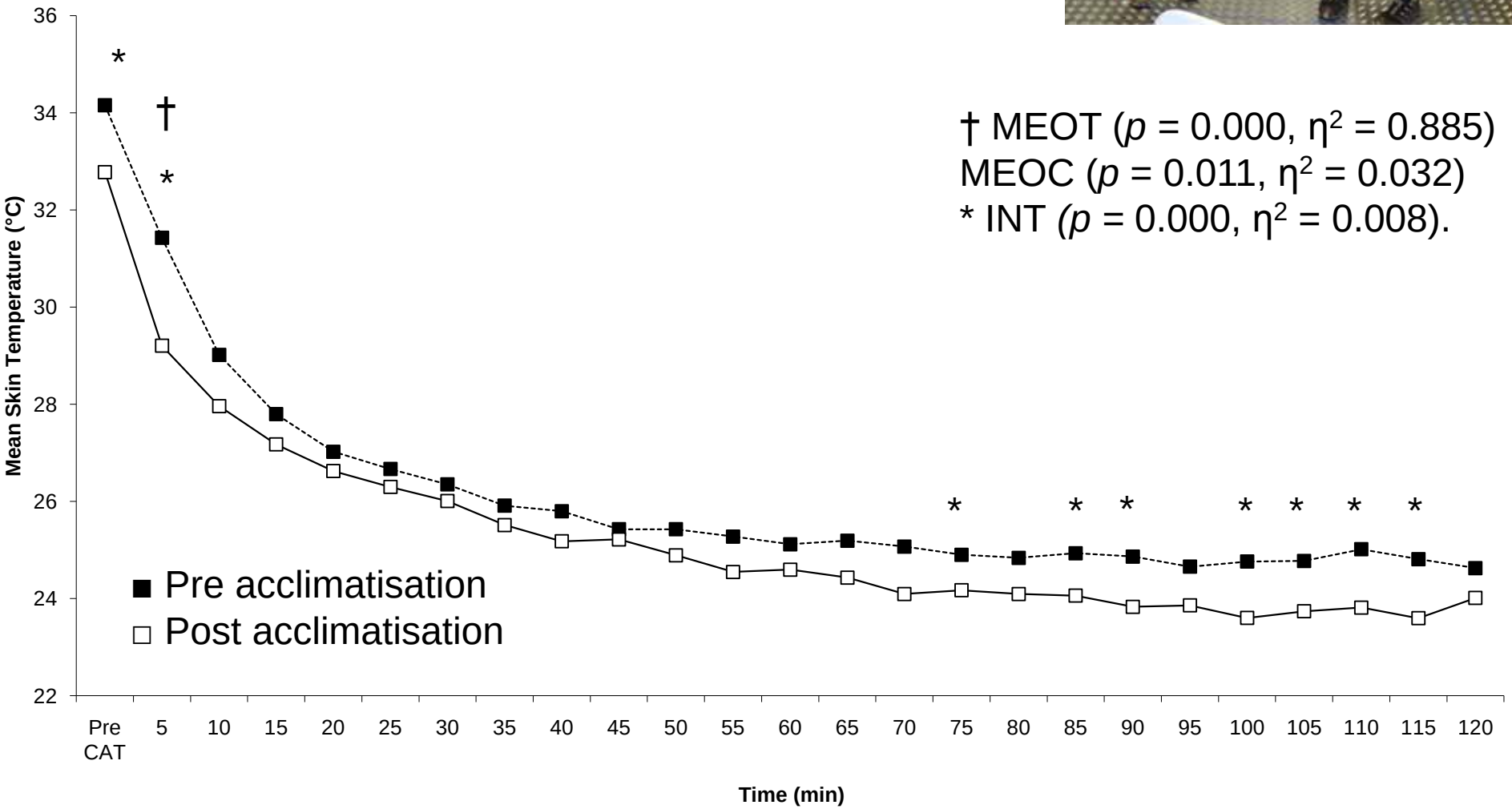
Core Temperature



Shivering


*
Pre acclimatisation
Post acclimatisation
†
†MEOT (p = 0.000, η2 = 0.785)
MEOC (p = 0.015, η2 = 0.004)
*INT (p = 0.001 , η2 = 0.003).
Shivering (0-3)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Pre CAT
10
20
30
40
50
60
70
80
90
100
110
120
Time (min)

Skin Temperature

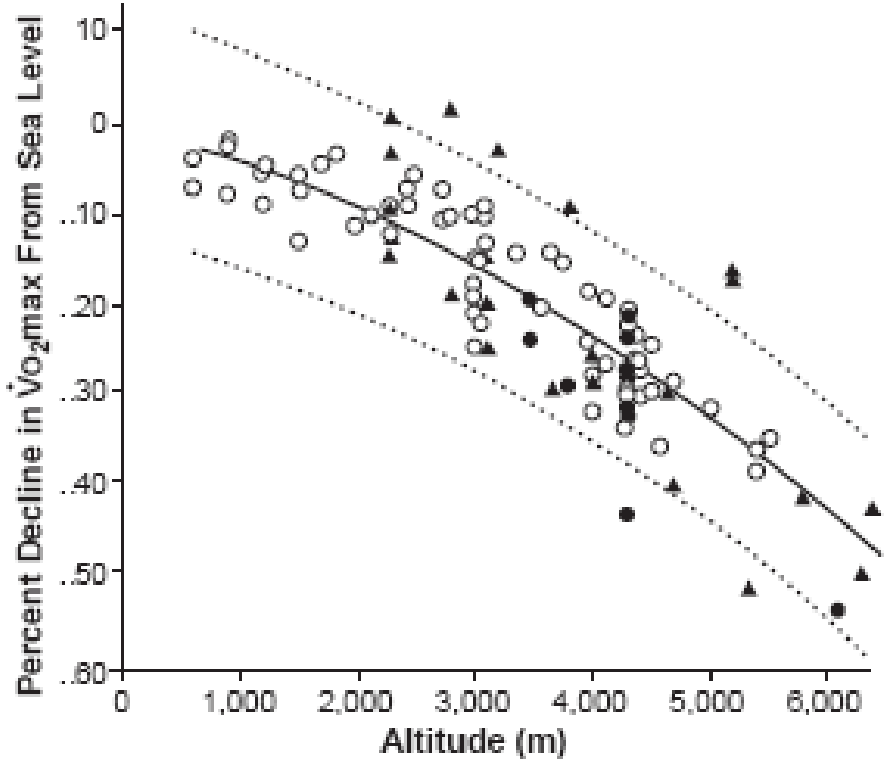


Thermoregulation: Summary

Short-term altitude acclimatisation may:

- Decrease shivering
- Increase non shivering thermogenesis
- Decreased sensitivity to cold exposure
- Increased predisposition to cold injury

Acclimatisation: Performance



(Fulco, 1998)

- Synergistic effect of hypoxia and exercise on ventilation (Weil *et al*., 1972)

Hypothesis

- Acclimatisation will increase performance
  - Without an increase in aerobic capacity
  - With an increase in respiratory muscle function
    - Dyspnoea & sense of effort? (Marcora, 2009)
    - Blood flow distribution (Dempsey *et al.*, 2006)

Graded exercise test: Oxygen delivery

O_2 uptake, CO_2 production & other ventilatory parameters

Cosmed

Cardiac output

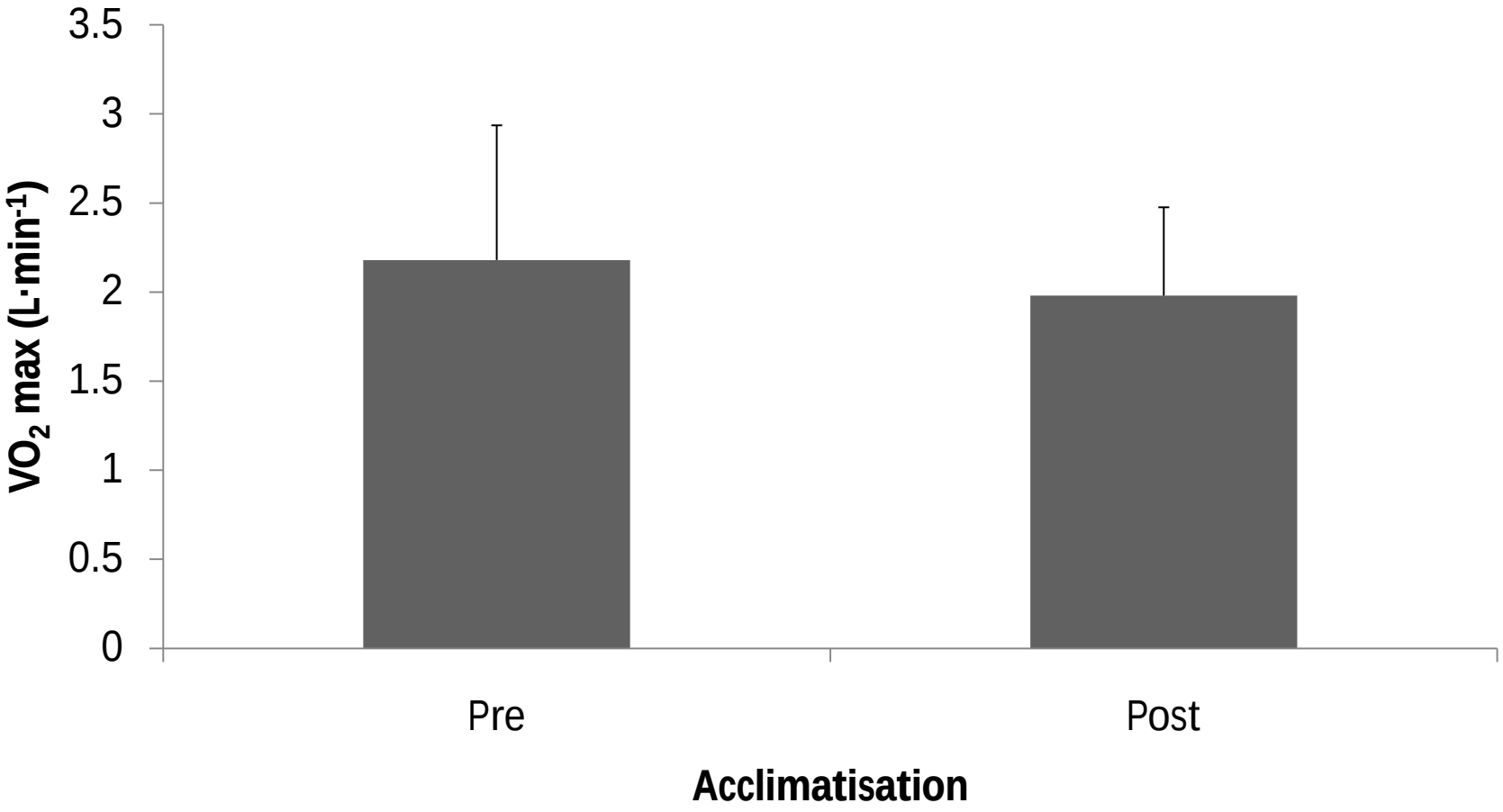
Physioflow

Oxygenation

Arterial blood-Nonin

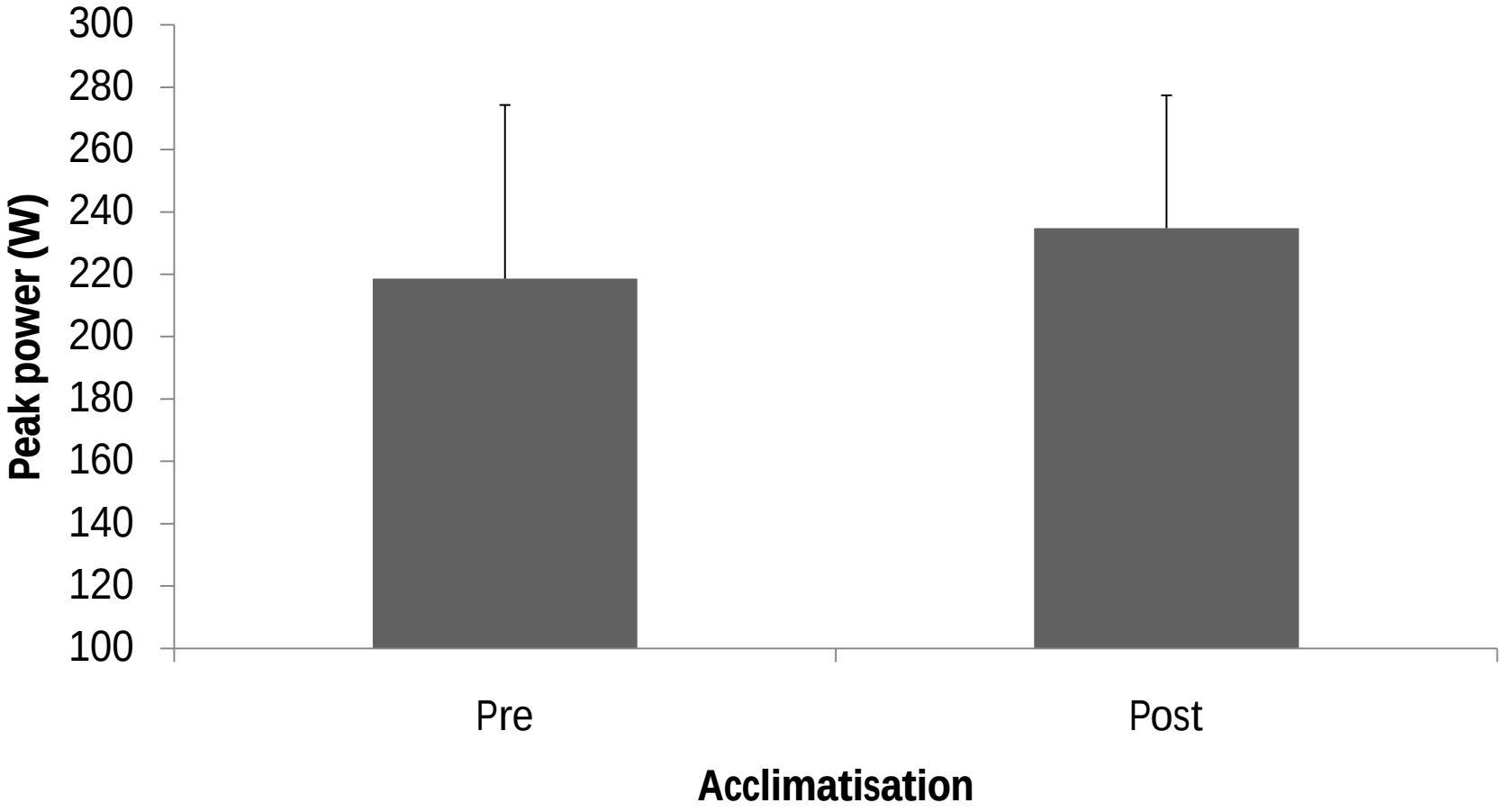
Leg & chest muscle-Nirox

Aerobic capacity



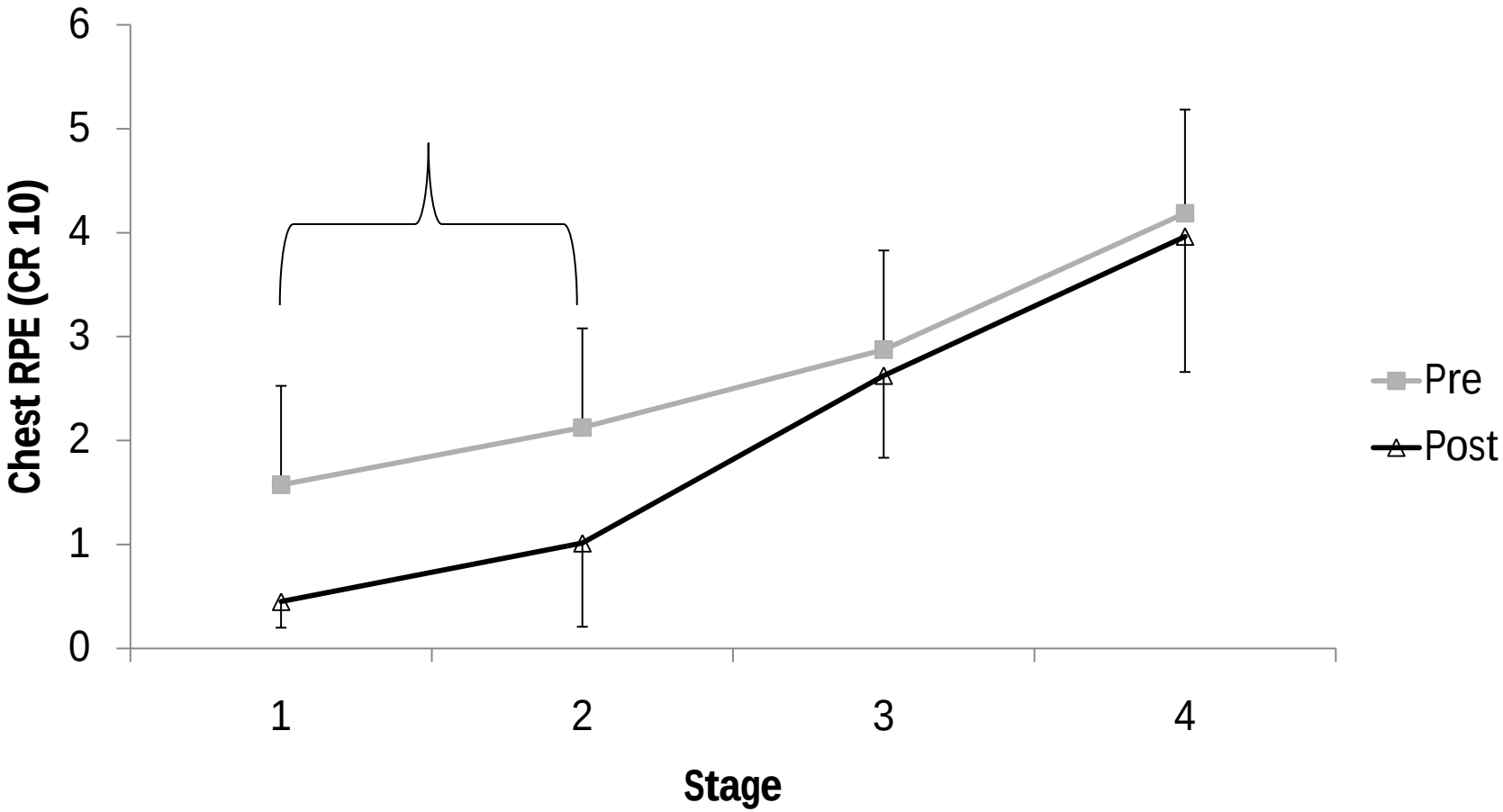
p = 0.16, d = 0.32 (small to medium)

Increased performance?



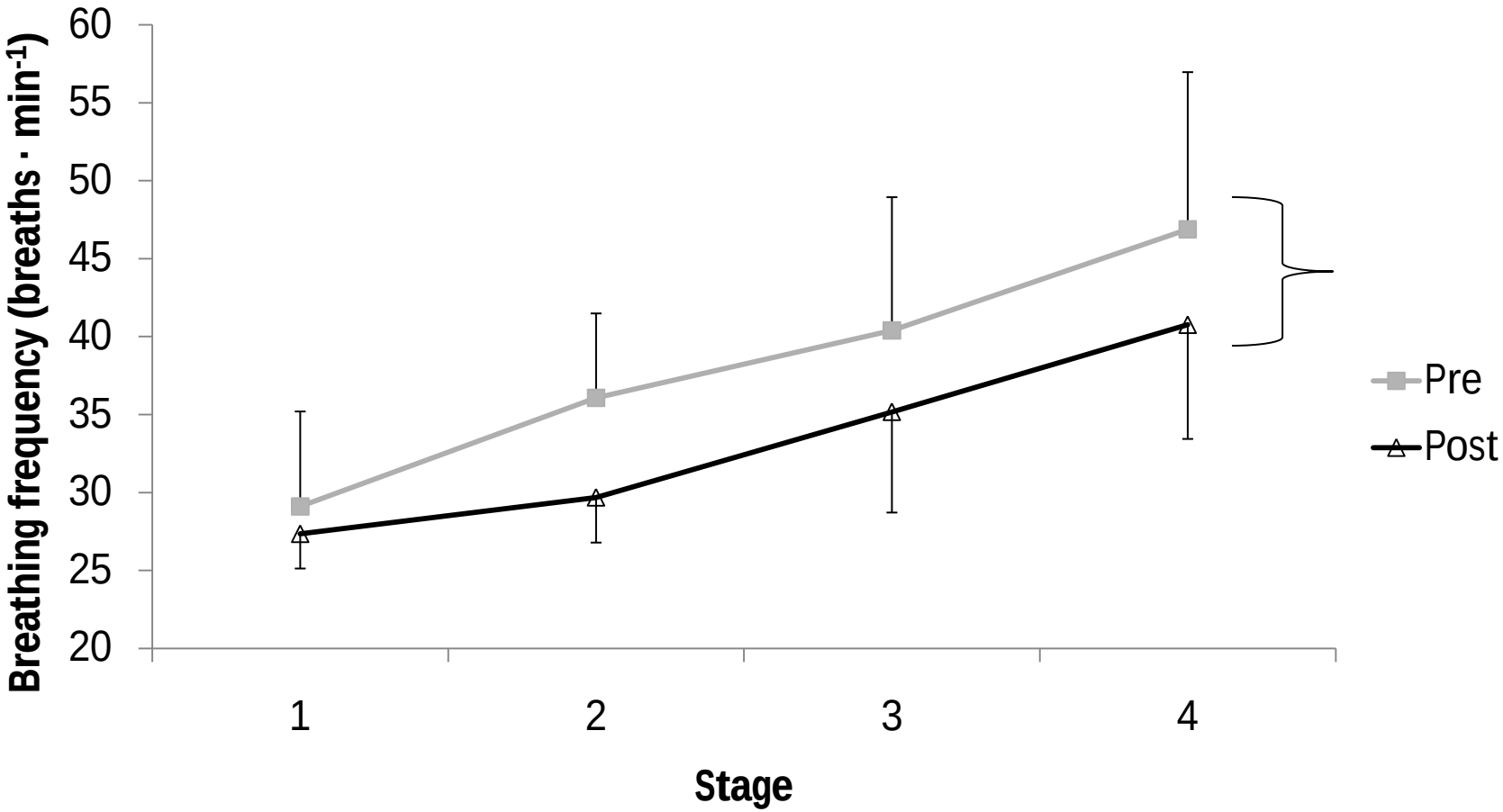
p = 0.09, d = 0.38 (small to medium)

Perception of effort



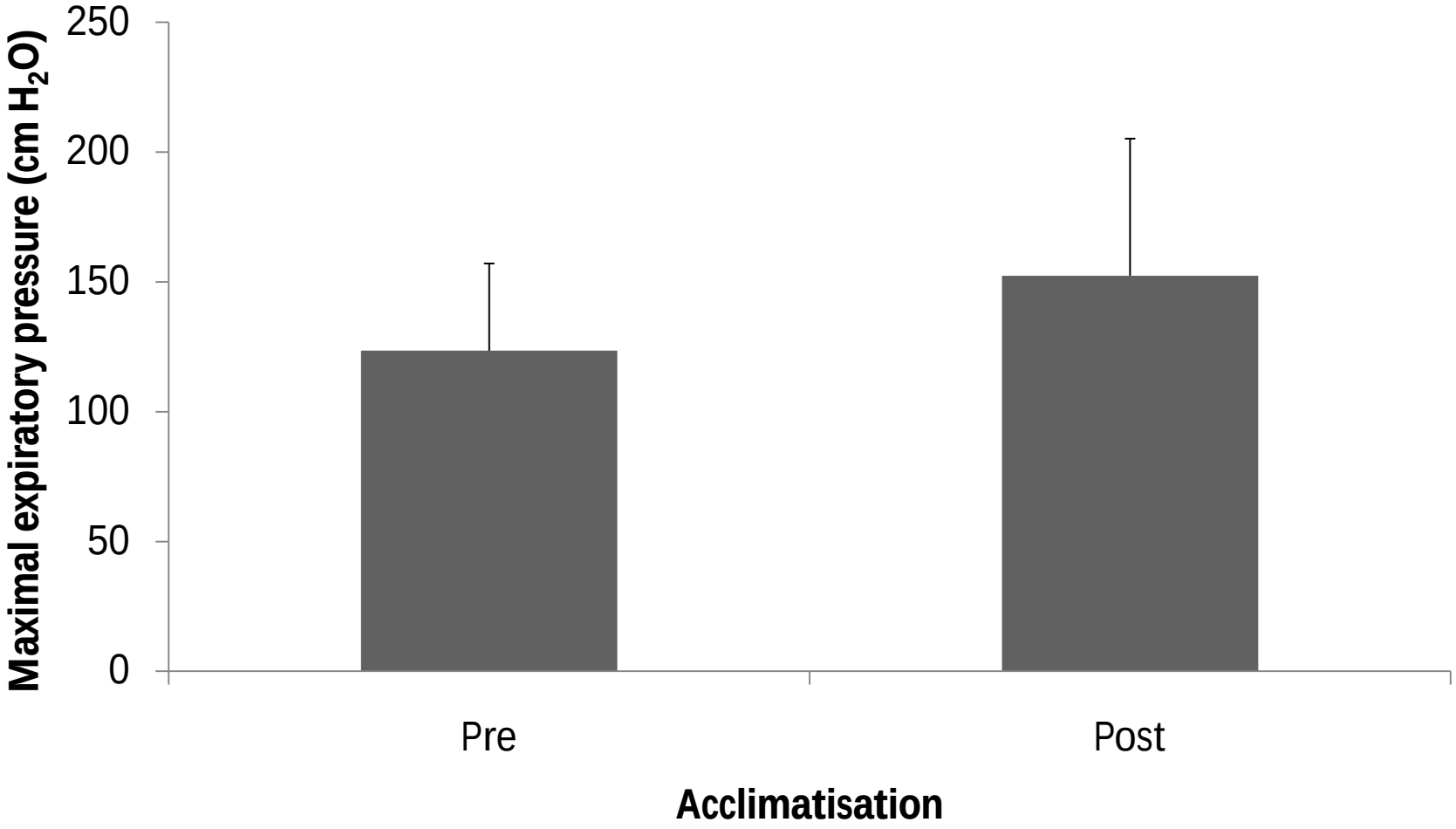
Significant interaction: $p = 0.009$, $\eta^2 = 0.03$ (small to medium)

Ventilation



Acclimatisation main effect: $p = 0.012$, $\eta^2 = 0.11$ (medium to large)

Increased respiratory muscle strength



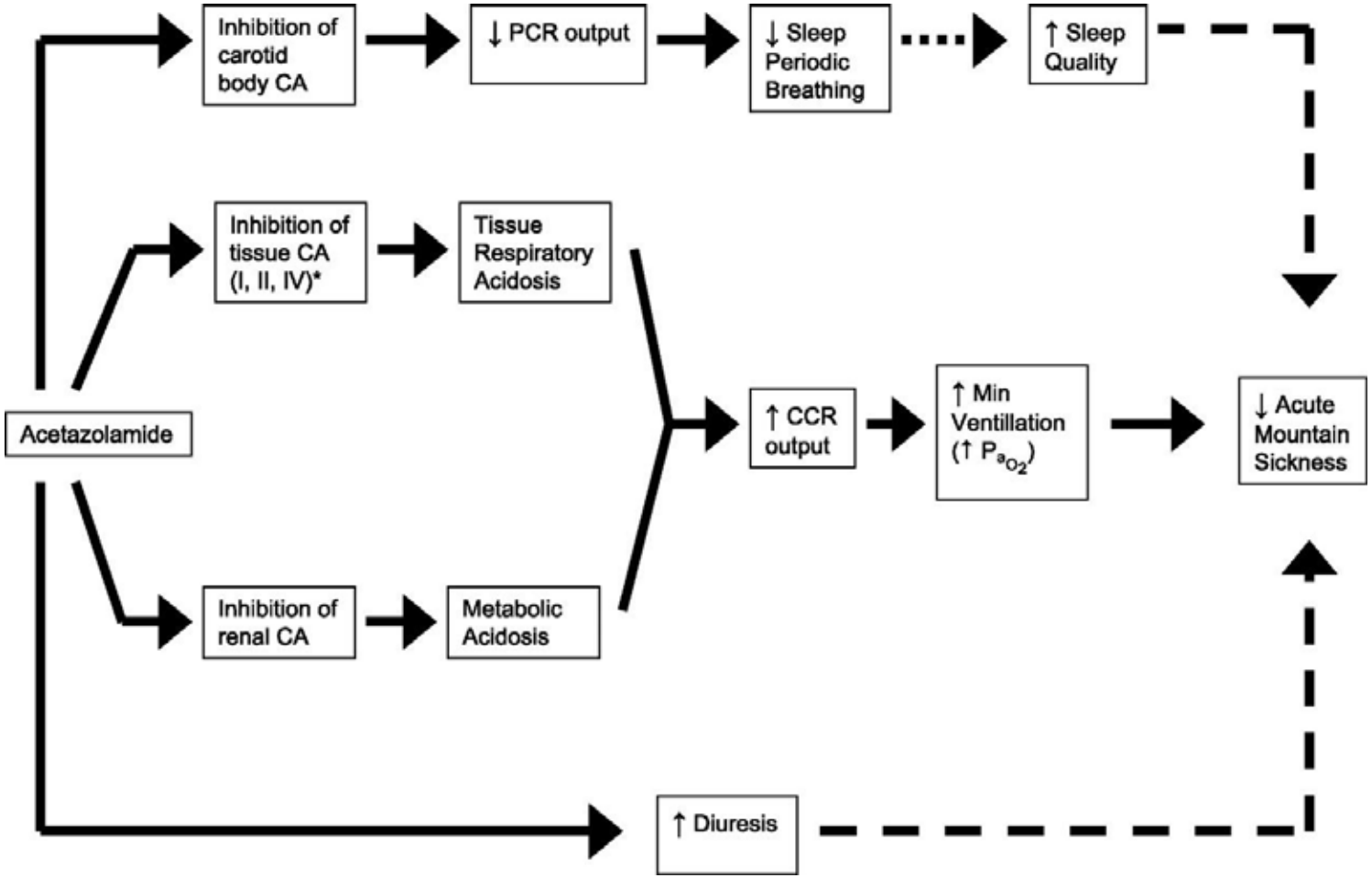
p = 0.15, d = 0.86 (large)

Performance: Summary

- Change in respiratory parameters = RPE?
  - Why is RPE not improved at higher intensities? (Vogel *et al*., 1974 & Alexander *et al*., 1967)
  - Does acclimatisation increase ventilation? (Calbet & Lundby, 2009)

- Heterogenic response of acclimatisation on performance

Acetazolamide



(Leaf & Goldfarb, 2007)

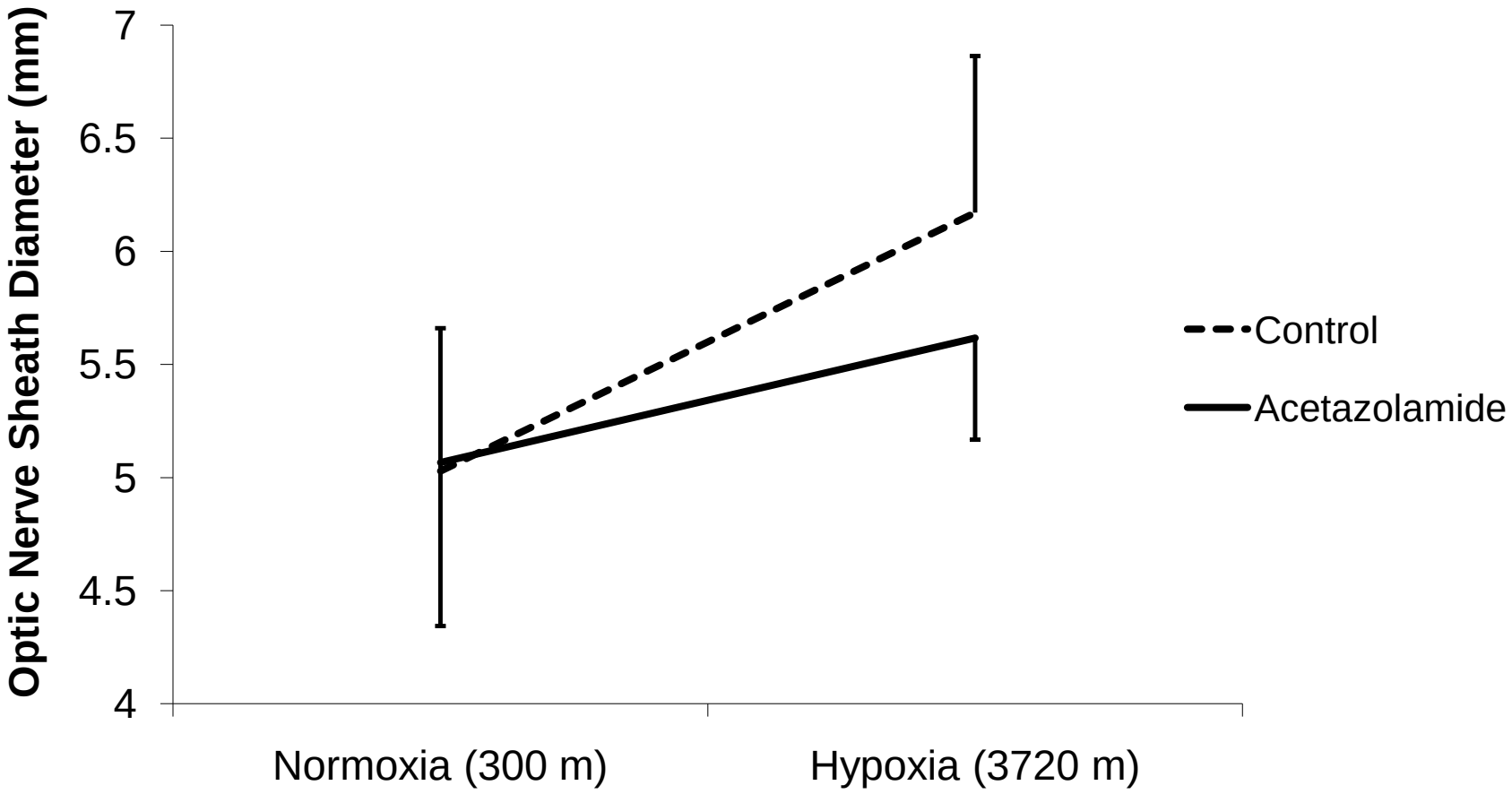
Acetazolamide

- Time trial
  - 15 or 13.5 kg rucksack
  - 100m submaximal preload
  - 400m hill climb (60° slope) (Montain, 1997)
- Inter cranial pressure
  - Optic nerve sheath diameter (Sutherland *et al.*, 2008)

Performance “in the field”

- Time trial performance
  - Non significant findings
  - Small effect sizes
- Perception of effort
  - Non significant findings
  - Small effect sizes

Intra cranial pressure



Interaction: $p = 0.240$, $\eta^2 = 0.07$ (medium to large)

Acetazolamide: Summary

- No effect on performance
  - Dehydration? (Fulco, 2006)
  - AMS? (Bradwell *et al.*, 1986)
  - Impaired buffering capacity (Jones *et al*., 1997)
- Experimental support for role of intra cranial pressure in AMS (Cummings, 2009)

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Thank you