

# Exercise in the heat: what factors influence performance and health?

**Dr Julien Périard, PhD**

**Research Scientist**

**Aspetar Orthopaedic and Sports Medicine Hospital**



كلية طب وايل كورنيل في قطر  
Weill Cornell Medical College in Qatar

Member of Qatar Foundation

# DISCLOSURE STATEMENT

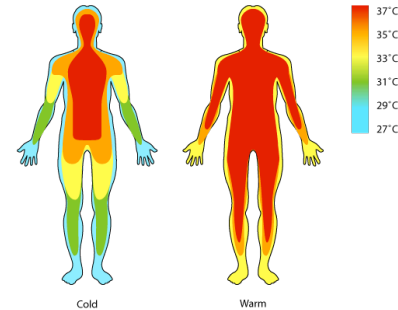
**Speaker:** Julien Périard

- Has no relevant financial relationships to disclose
- Will not be discussing the off-label or investigational use of products



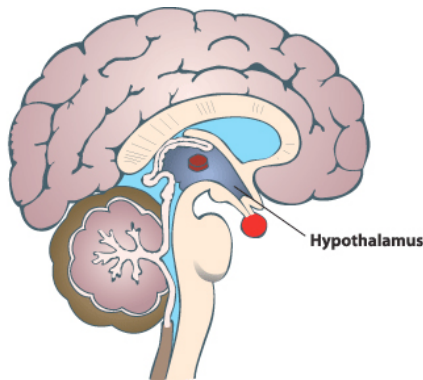
# PRESENTATION OUTLINE

- Basics of thermoregulation
  - Heat production/dissipation
  - Heat illness
- Influence of heat stress on exercise performance
  - Endurance and team/individual sports
  - Exercising in Doha
- Pathways of fatigue in the heat
  - Mechanisms of fatigue (how and why)
  - Thermal and cardiovascular strain
  - Countermeasures



# THERMOREGULATION

- Human body temperature  $\sim 37.0^{\circ}\text{C}$
- Hypothalamus integrates signals from skin and deep core thermosensors



**Circadian Rhythm (Body-Temperature Cycle)**

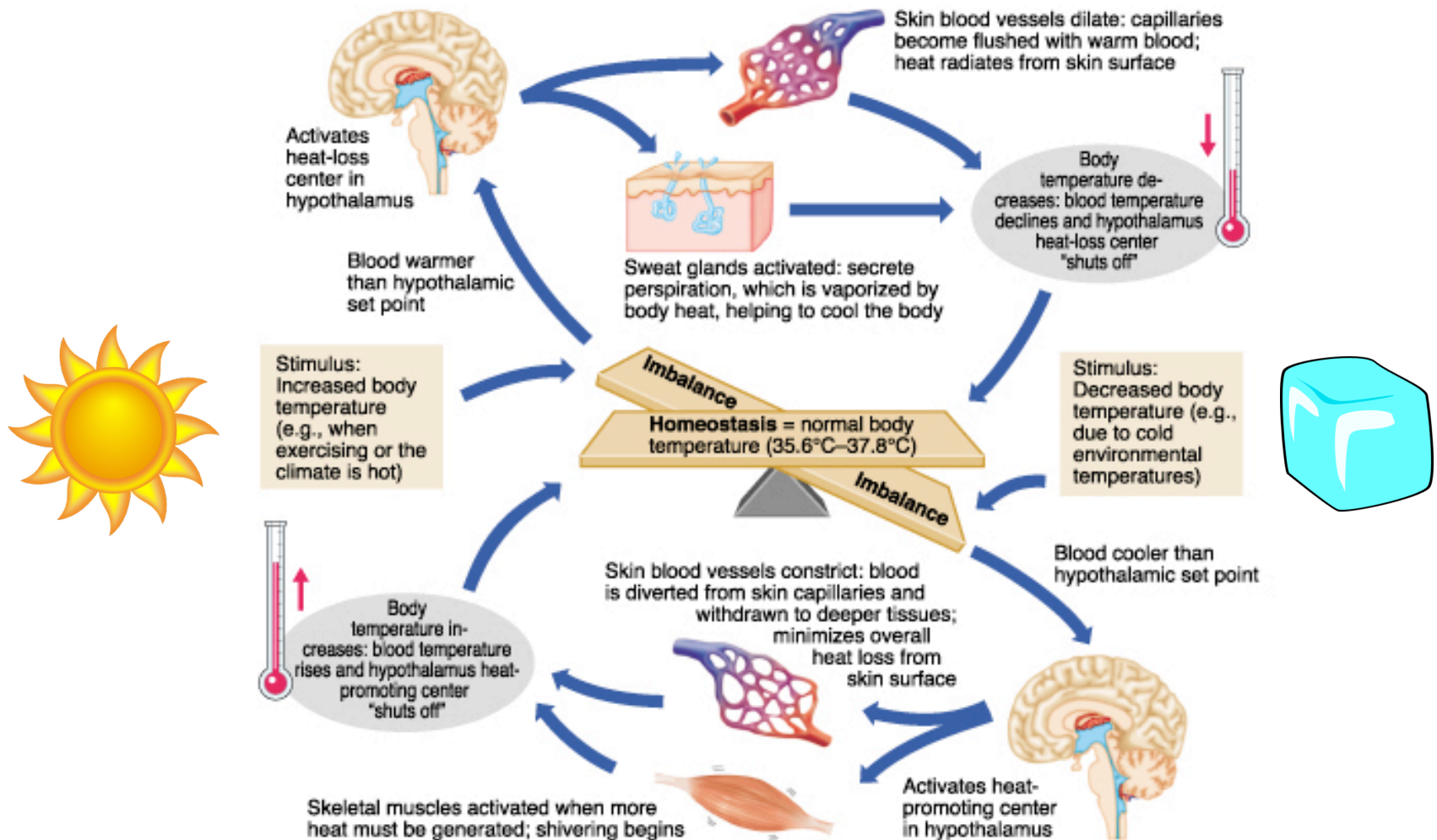


- Exercise, fever, ambient conditions, medication





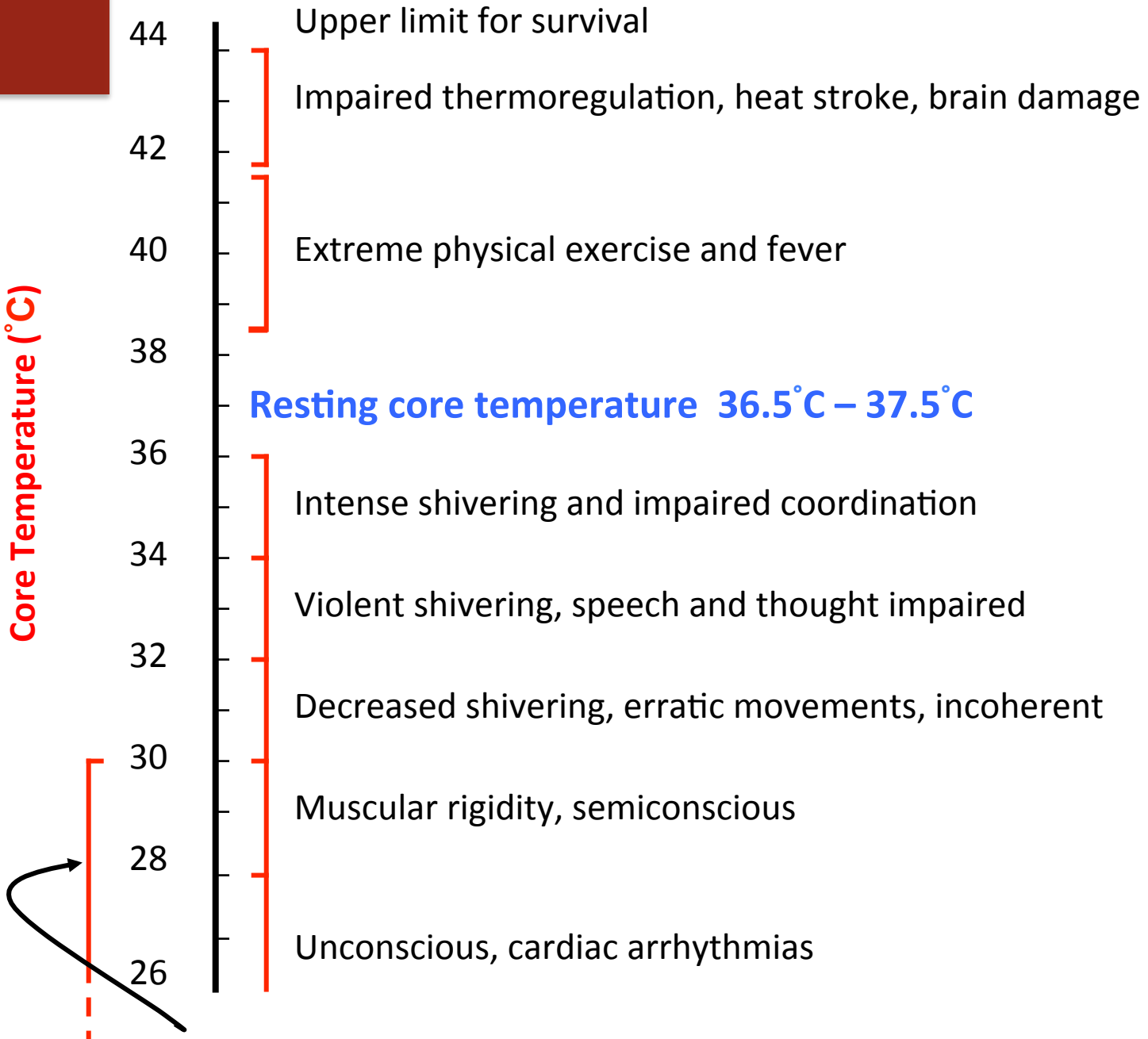
# THERMOREGULATION – SET POINT



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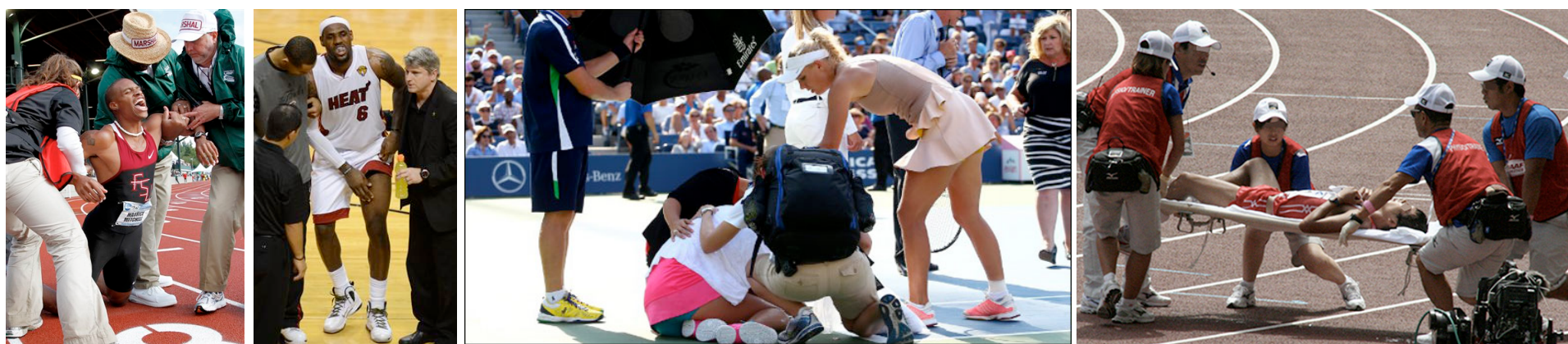


Core Temperature (°C)



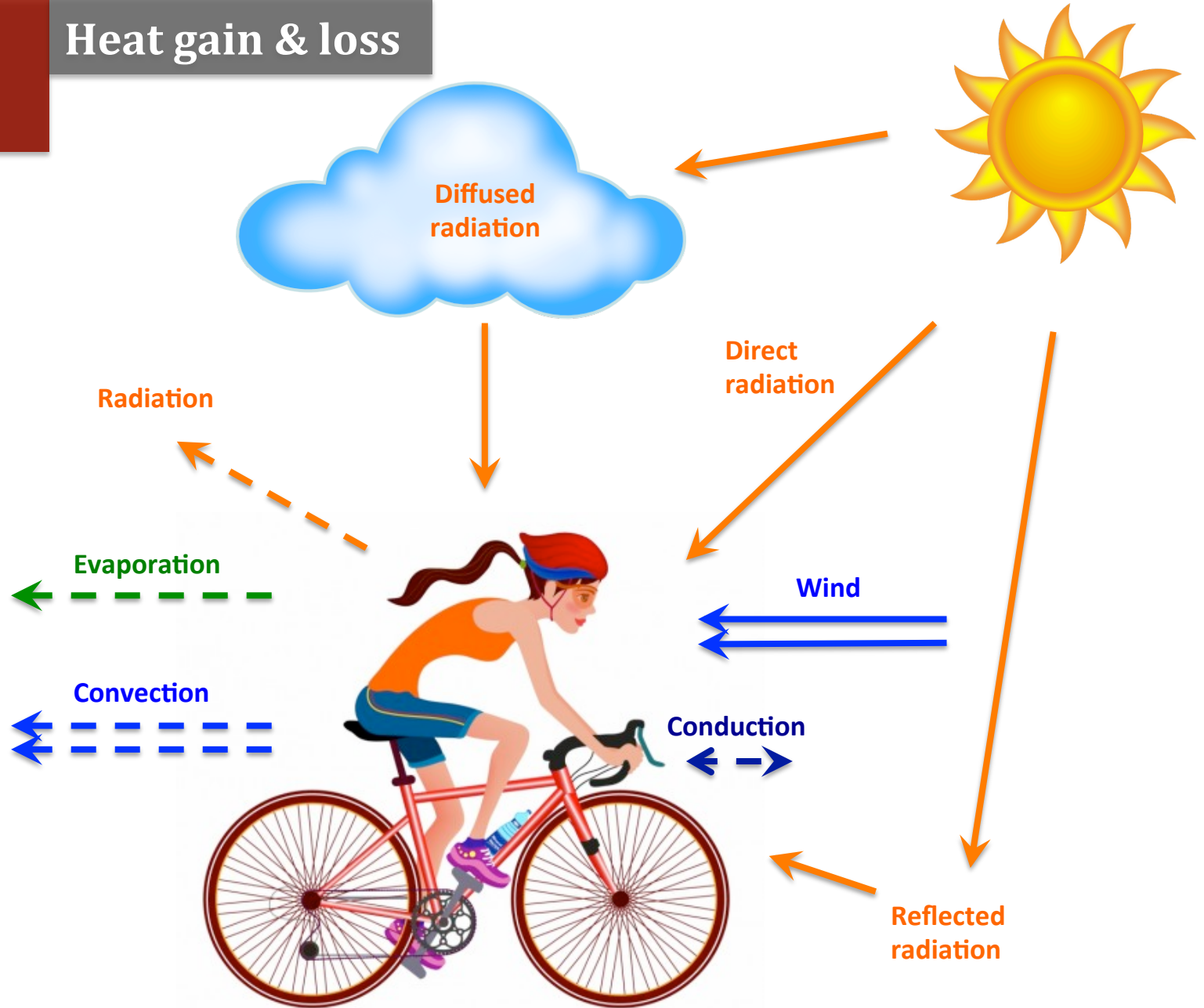
# EXERTIONAL HEAT ILLNESS

Condition	Symptoms	Management
Heat cramps	Brief, painful skeletal muscle spasms	Rest; replacement of electrolytes; avoid salt tablets
Heat exhaustion	Mild to moderate illness with inability to sustain cardiac output; moderate ( $>38.5^{\circ}\text{C}$ [ $101.3^{\circ}\text{F}$ ]) to high ( $>40^{\circ}\text{C}$ [ $104^{\circ}\text{F}$ ]) body temperature; often accompanied by dehydration	Move supine individual to cool, shaded environment, and elevate legs; loosen or remove clothing, and actively cool skin; administer oral fluids
Heatstroke	Profound CNS abnormalities (agitation, delirium, stupor, coma) with severe hyperthermia ( $>40^{\circ}\text{C}$ [ $104^{\circ}\text{F}$ ])	Ensure an open airway, and move to a cool environment. Immediately cool to $<39^{\circ}\text{C}$ ( $102.2^{\circ}\text{F}$ ) using ice packs, water bath, wetting with water and continuous fanning; IV fluid administration; reestablish normal CNS function; avoid antipyretics or drugs with liver toxicity

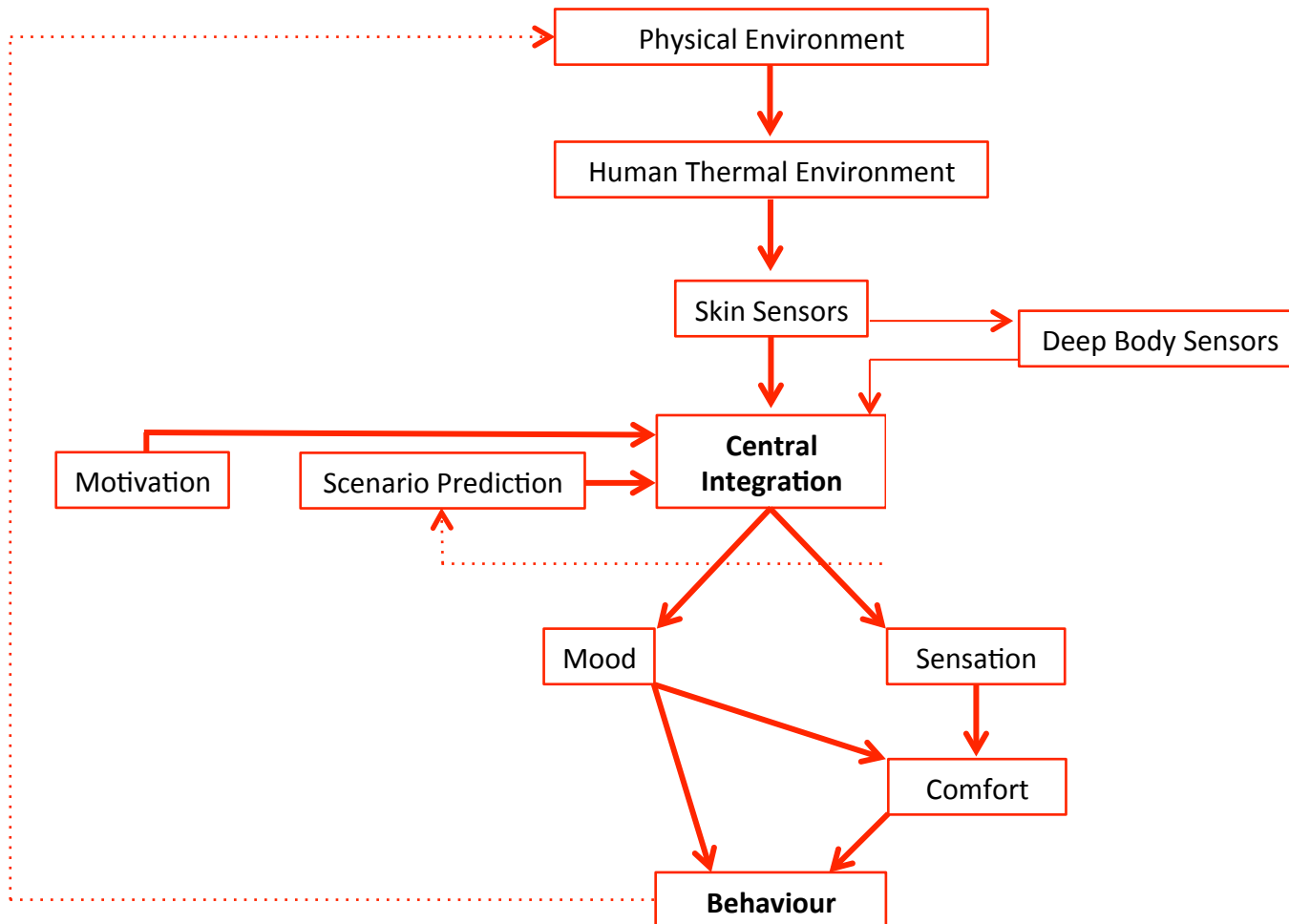


# Heat gain & loss

Radiation  
Conduction  
Convection  
Evaporation



# BEHAVIOURAL THERMOREGULATION



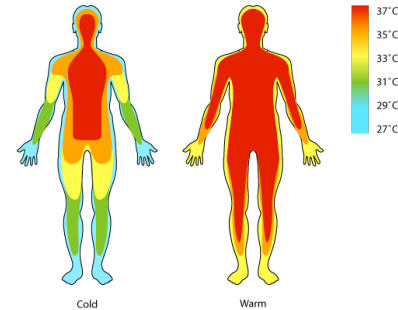
- Responses: posture, clothing, seek shade, voluntary movement





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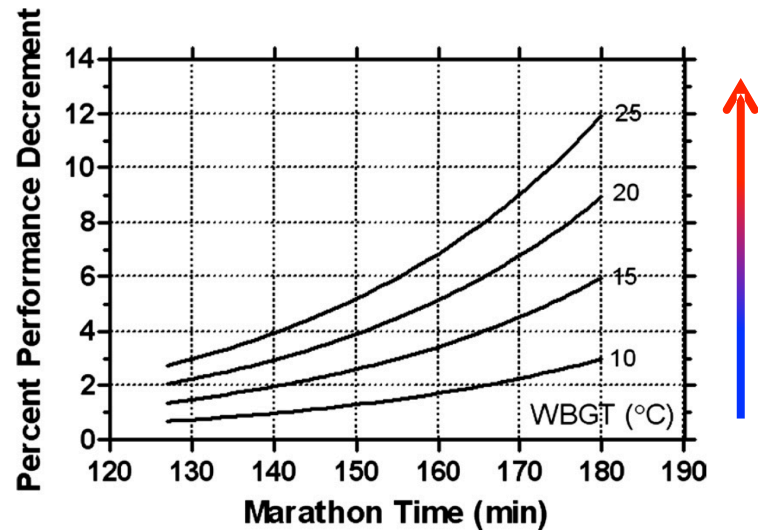


# PERFORMANCE IN THE HEAT



Marathons  
Various WBGTs

## Impact of weather on marathon performance

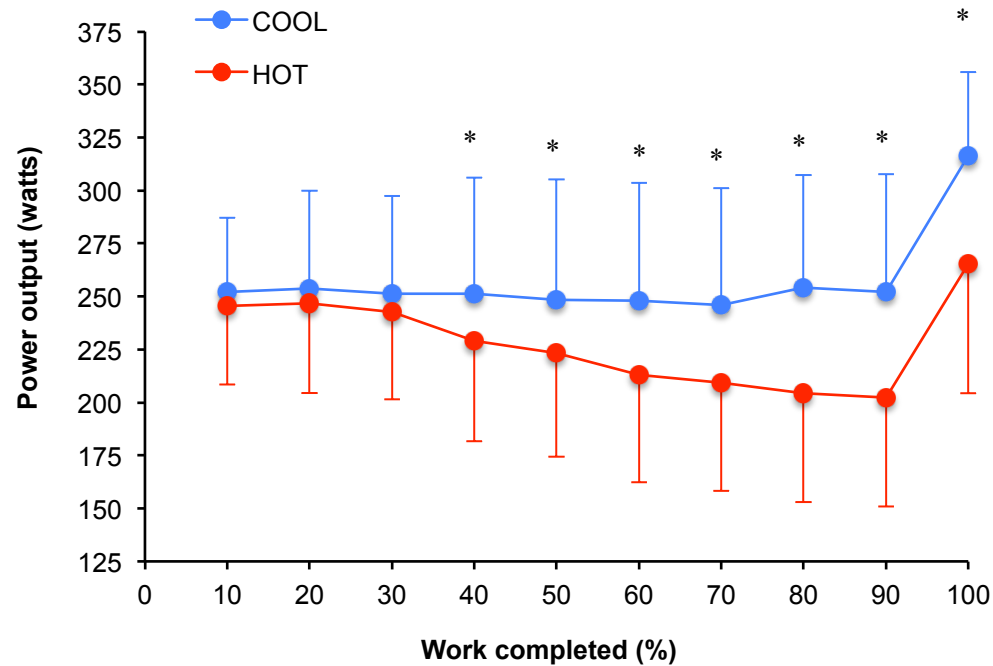


\*WBGT: wet-bulb-globe temperature index (temperature, humidity, solar radiation and wind)



# PERFORMANCE IN THE HEAT

## Impact of heat on cycling performance



**750 kJ cycling time trial**  
COOL: 18°C - 40% RH  
HOT: 35°C - 60% RH





# PERFORMANCE IN THE HEAT

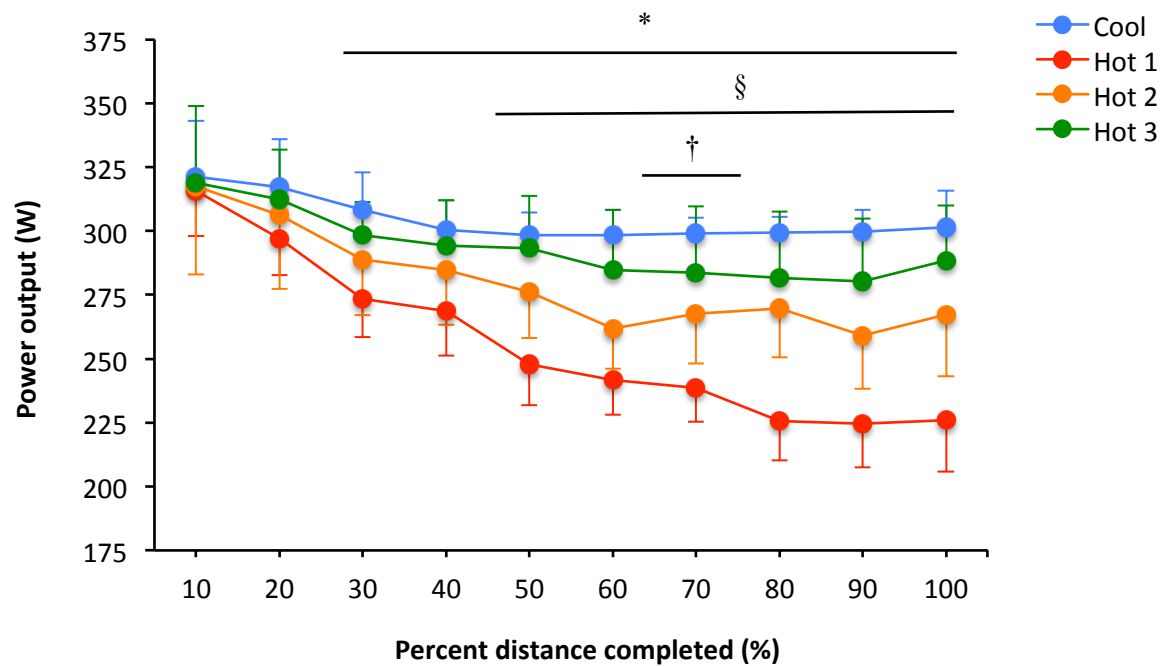
## Impact of heat on cycling performance



43.4 km cycling time trial

COOL: 8°C - 30% RH

HOT: 36°C - 15% RH

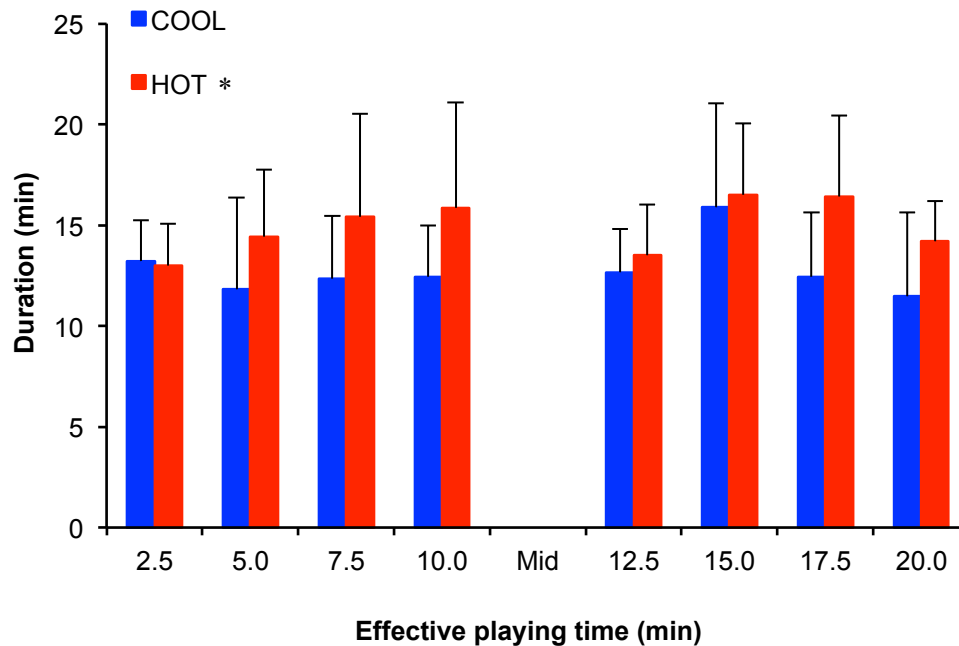


# PERFORMANCE IN THE HEAT



2 x 10 min Effective play  
COOL: 22°C - 70% RH  
HOT: 37°C - 35% RH

## Match-play tennis in the heat



## Match characteristics

- Aces & double faults (%)
- Point duration
- Number of points
- Number of games
- Between point duration (~10 s)
- Effective playing (~3.5%)



# PERFORMANCE IN THE HEAT

## Football match in in the heat (Doha)



Competitive match  
Cool: 21°C  
Hot: 43°C

33.3 km.h<sup>-1</sup>



32.1 km.h<sup>-1</sup>

Sprint speed



~ 12 sprints



~ 20 m

Number / Distance  
sprints



10.3 km / 2.2 km



9.6 km / 1.7 km

Total / High intensity  
running distance



74%

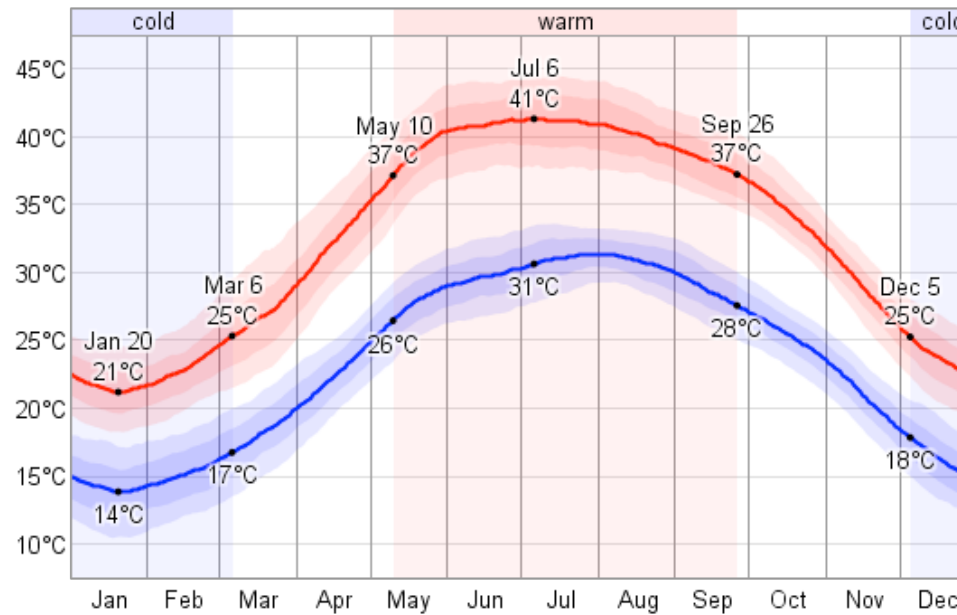


66%

Successful  
crosses & passes

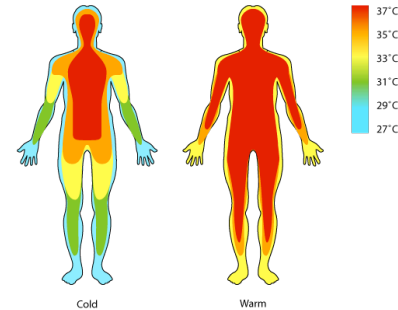


# DOHA YEARLY TEMPERATURE

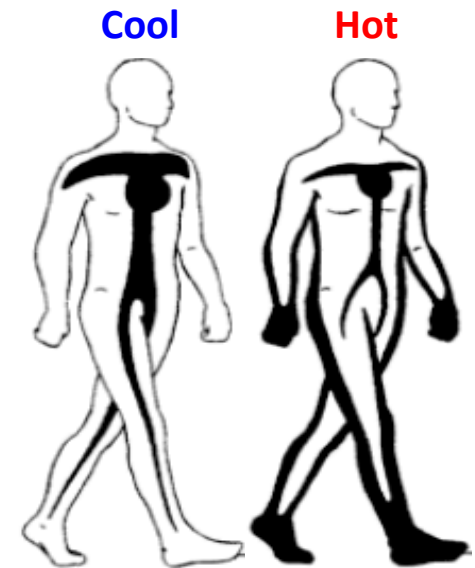
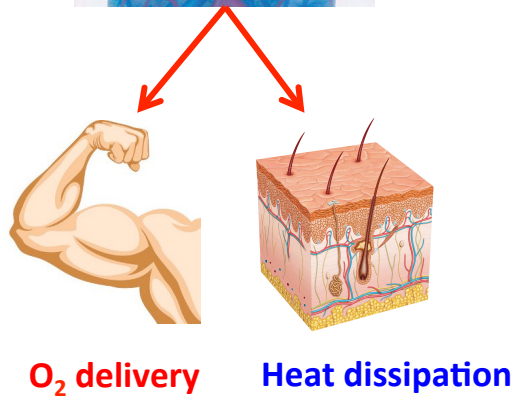
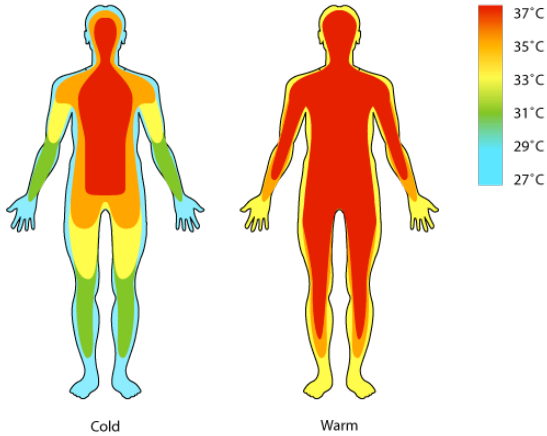


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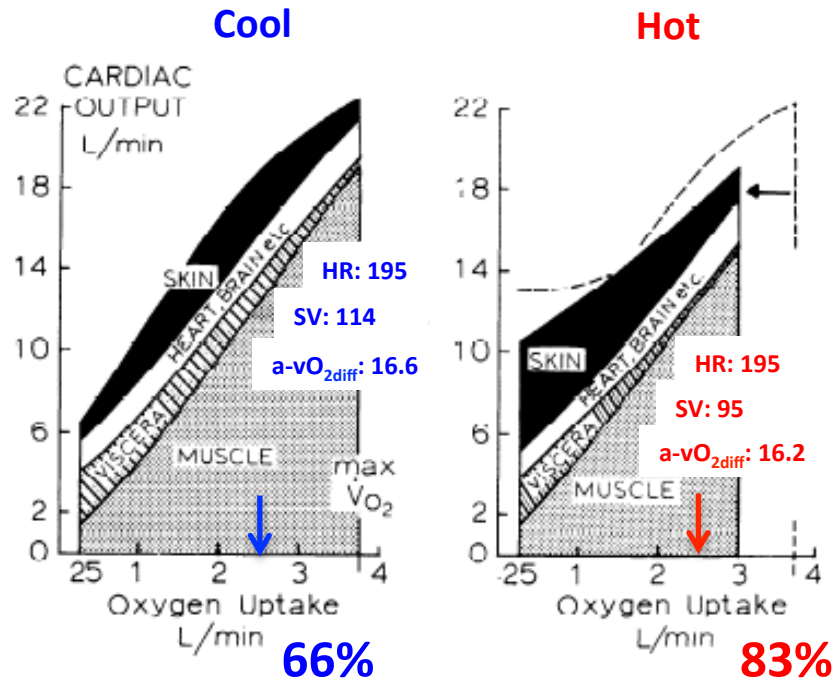


# TEMPERATURE REGULATION AND PERFORMANCE





# CARDIOVASCULAR STRAIN IN THE HEAT



Fick Equation:

$$VO_{2\max} = Q \times a-vO_{2\text{diff}}$$

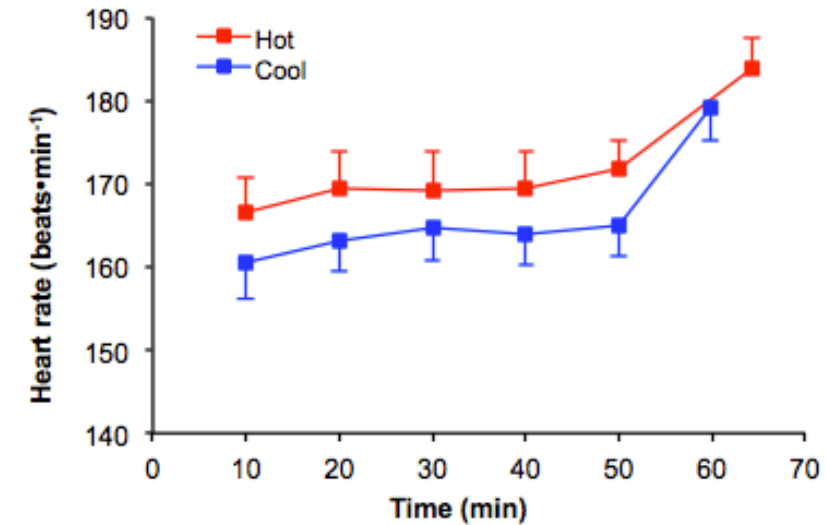
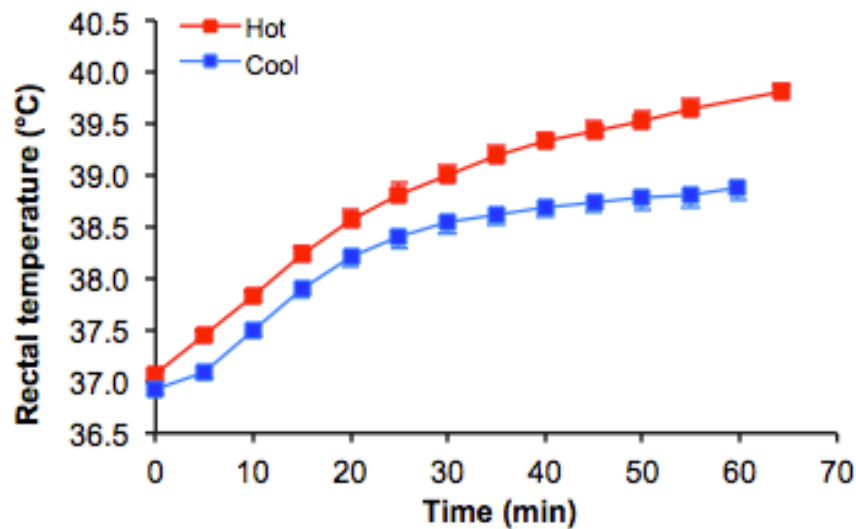
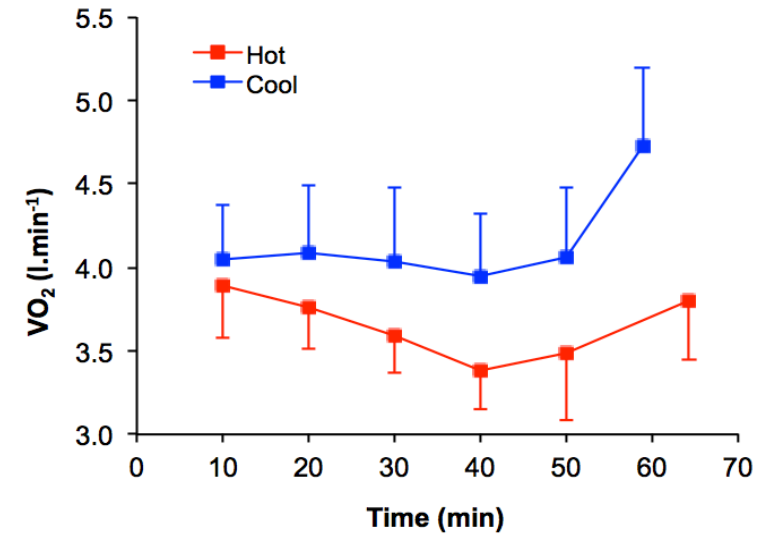
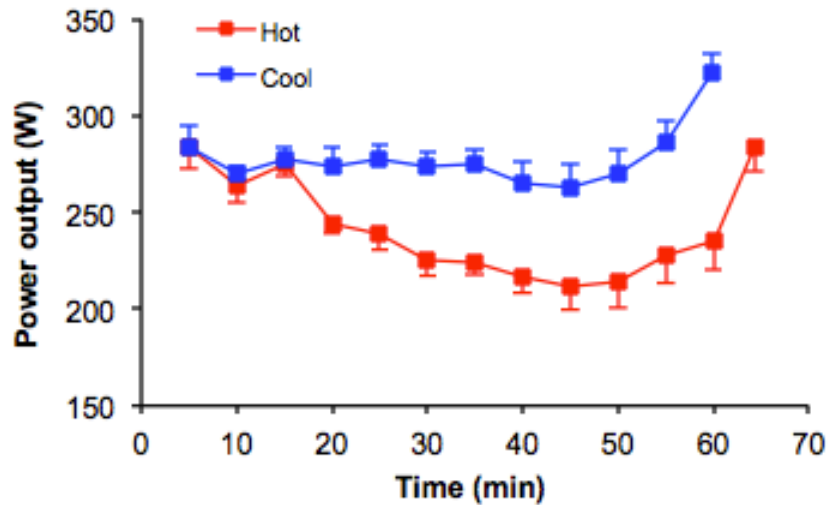
Q = cardiac output

a-vO<sub>2</sub>diff = arteriovenous  
oxygen difference

- Exercising at the same absolute work load is relatively harder

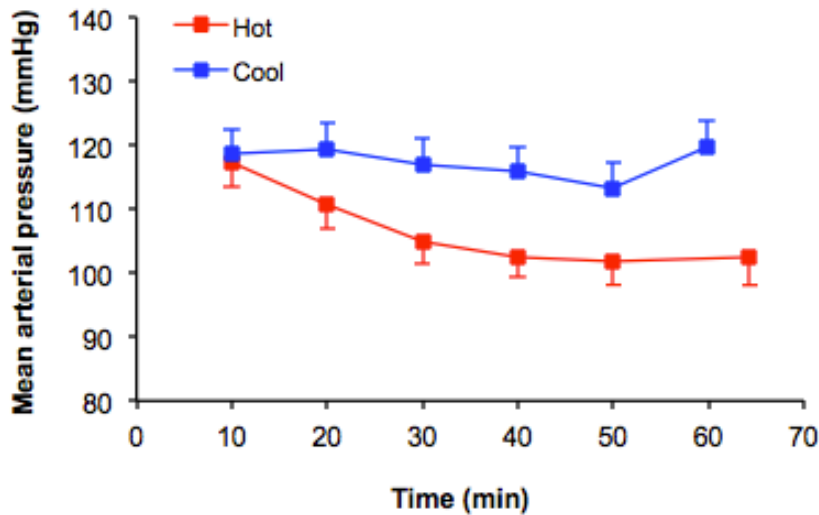
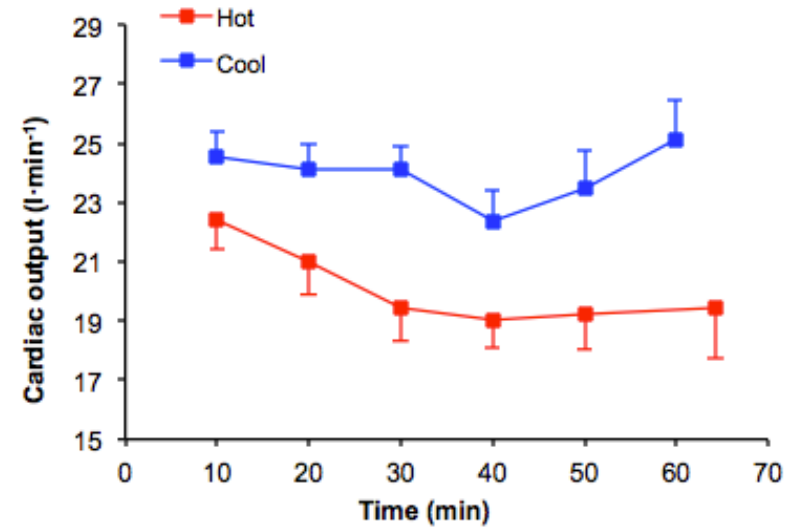
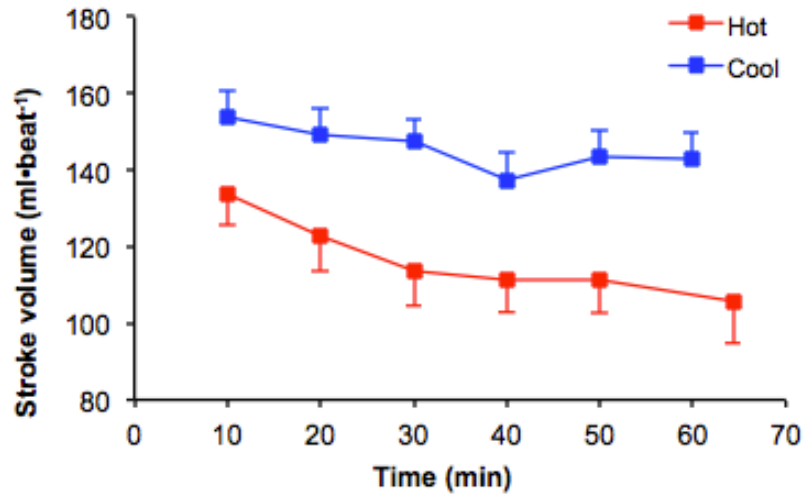


# THERMAL AND CARDIOVASCULAR STRAIN





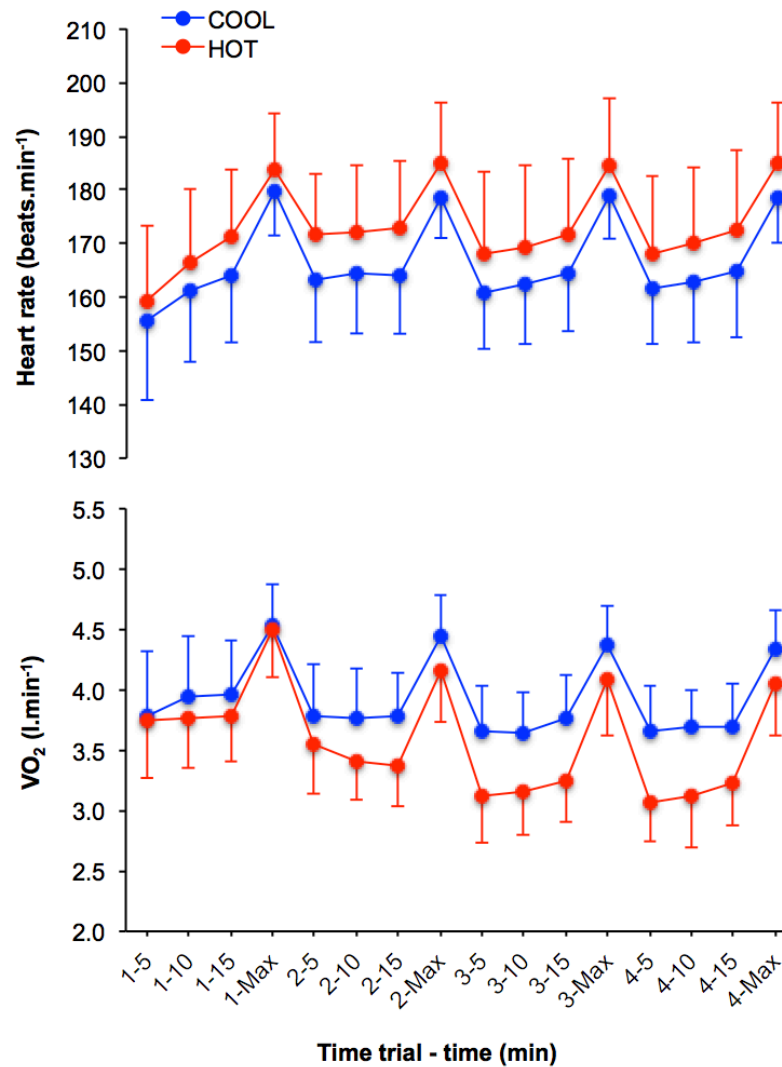
# THERMAL AND CARDIOVASCULAR STRAIN



- Thermoregulatory-mediated rise in cardiovascular strain:
  - ↓ sustainable and maximal  $\text{VO}_2$
  - ↓ sustainable and maximal power output
  - ↑ relative exercise intensity



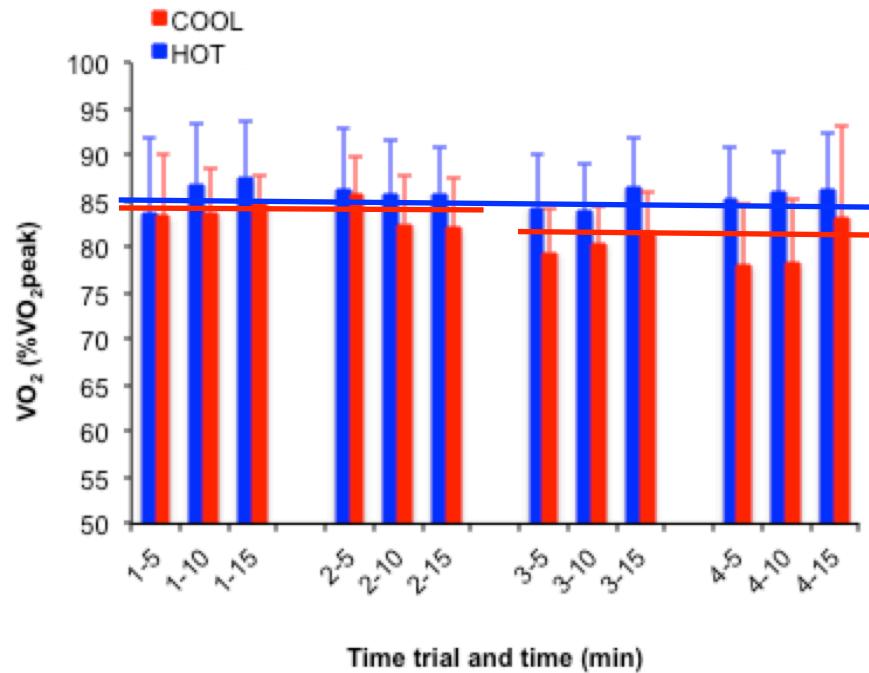
# THERMAL AND CARDIOVASCULAR STRAIN



**4 x 15 min Time Trials**  
COOL: 18°C - 40% RH  
HOT: 35°C - 60% RH



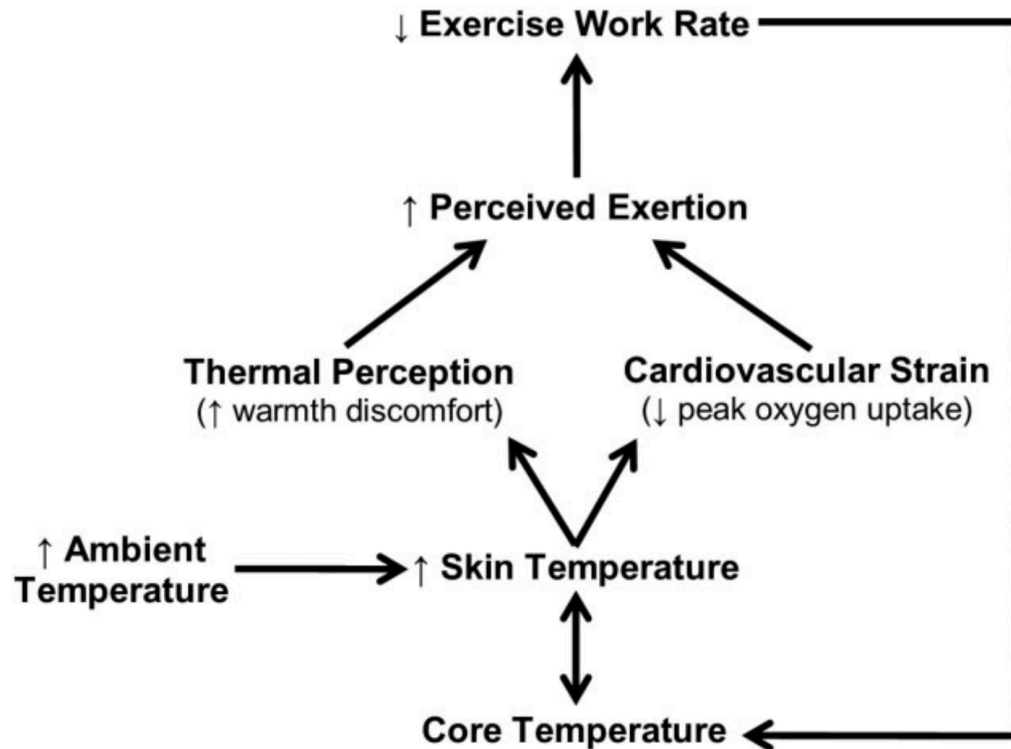
# THERMAL AND CARDIOVASCULAR STRAIN



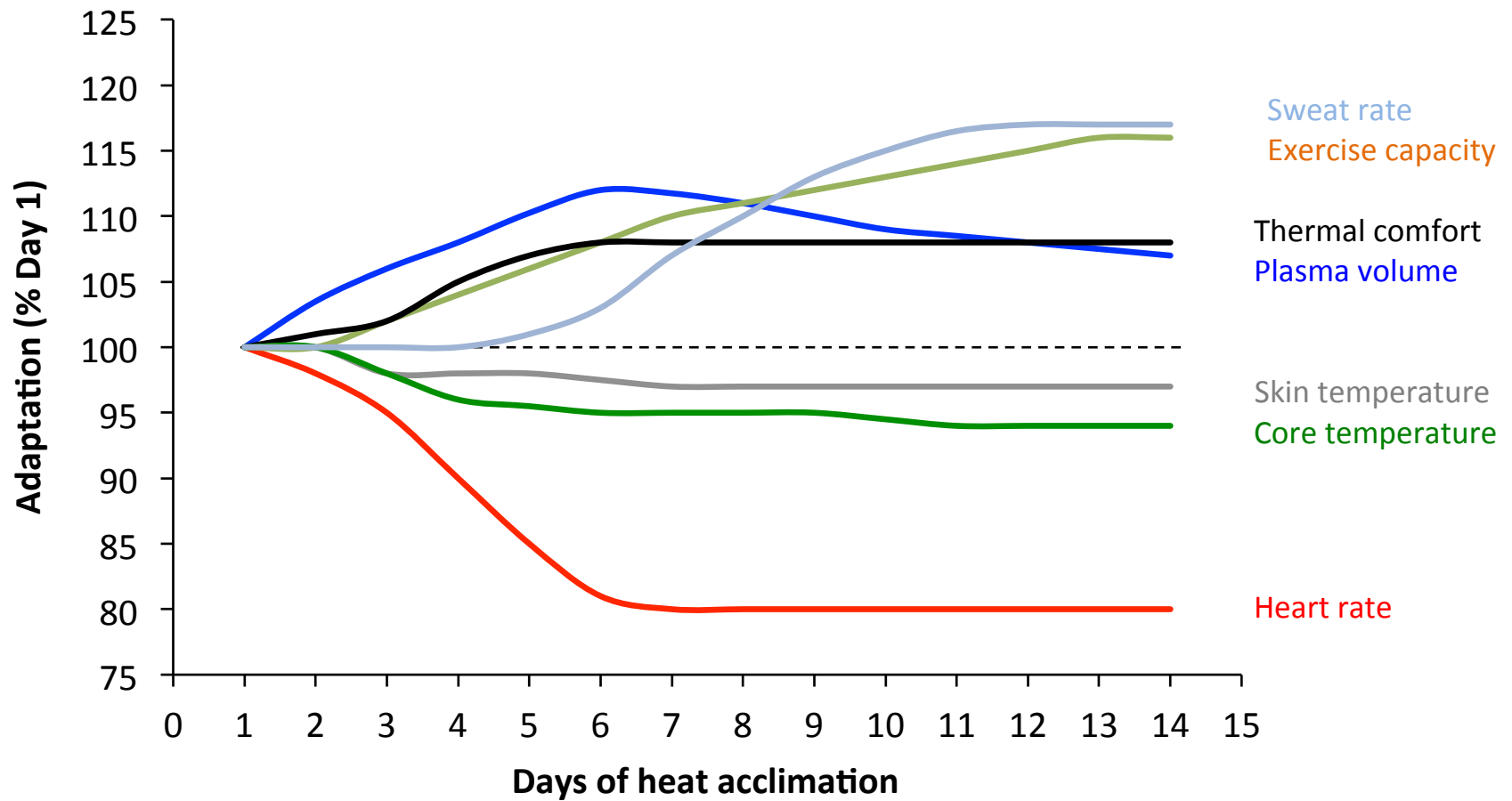
**4 x 15 min Time Trials**  
COOL: 18°C - 40% RH  
HOT: 35°C - 60% RH

- Exercise is regulated by maintenance of relative intensity within narrow range
- In response to sensory information stemming from a thermal strain-mediated increase in cardiovascular strain

# THERMAL AND CARDIOVASCULAR STRAIN



# COUNTERMEASURES – HEAT ACCLIMATION



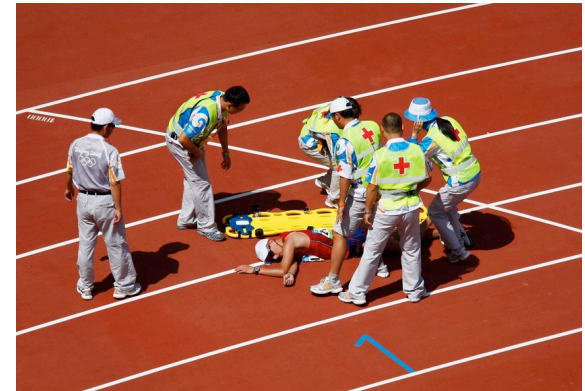
## COUNTERMEASURES – HYDRATION

- Hydrate before, during and after exercise
- Consume 6 ml per kg of body mass every 2-3 h to start exercise euhydrated
  - $6 \times 70 = 420 \text{ ml}$
- Drink 150-200 ml every 15-20 min during exercise
  - Cold, low sugar drink with sodium (salty sweaters)
- Recovery hydration regimens should include sodium, carbohydrates and protein



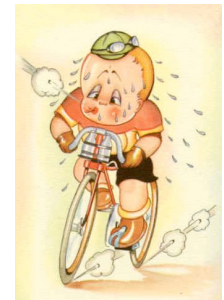
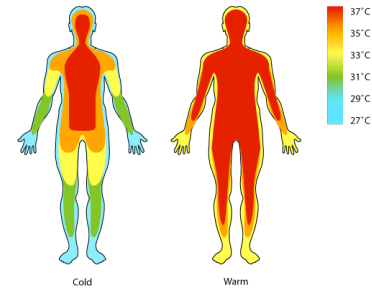
# COUNTERMEASURES – PREVENTING HEAT ILLNESS

- Optimise physical fitness before exercise in the heat
- Awareness of early symptoms of heat illness
- Avoid heavy exercise in the heat during:
  - Infection (fever)
  - Insufficient sleep
  - Glycogen depletion or hypoglycaemia
- Schedule sessions in cooler parts of day
  - Cancel or postpone exercising in extreme heat ( $>36^{\circ}\text{C}$ )



# SUMMARY

- Basics of thermoregulation
  - Autonomic and behavioural thermoregulation
  - Understand and recognize heat illness
- Influence of heat stress on exercise performance
  - Decrease in endurance performance
  - Increase in brief/explosive tasks
  - Heat stress influences perception
- Pathways of fatigue in the heat
  - Thermal and cardiovascular strain interact
  - Increase in relative exercise intensity
  - Countermeasures





# THANK YOU

- Aspire Zone Foundation
- QNRF – Junior Scientists Research Experience Program

