Brock University

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Adapting to training and competing in the heat

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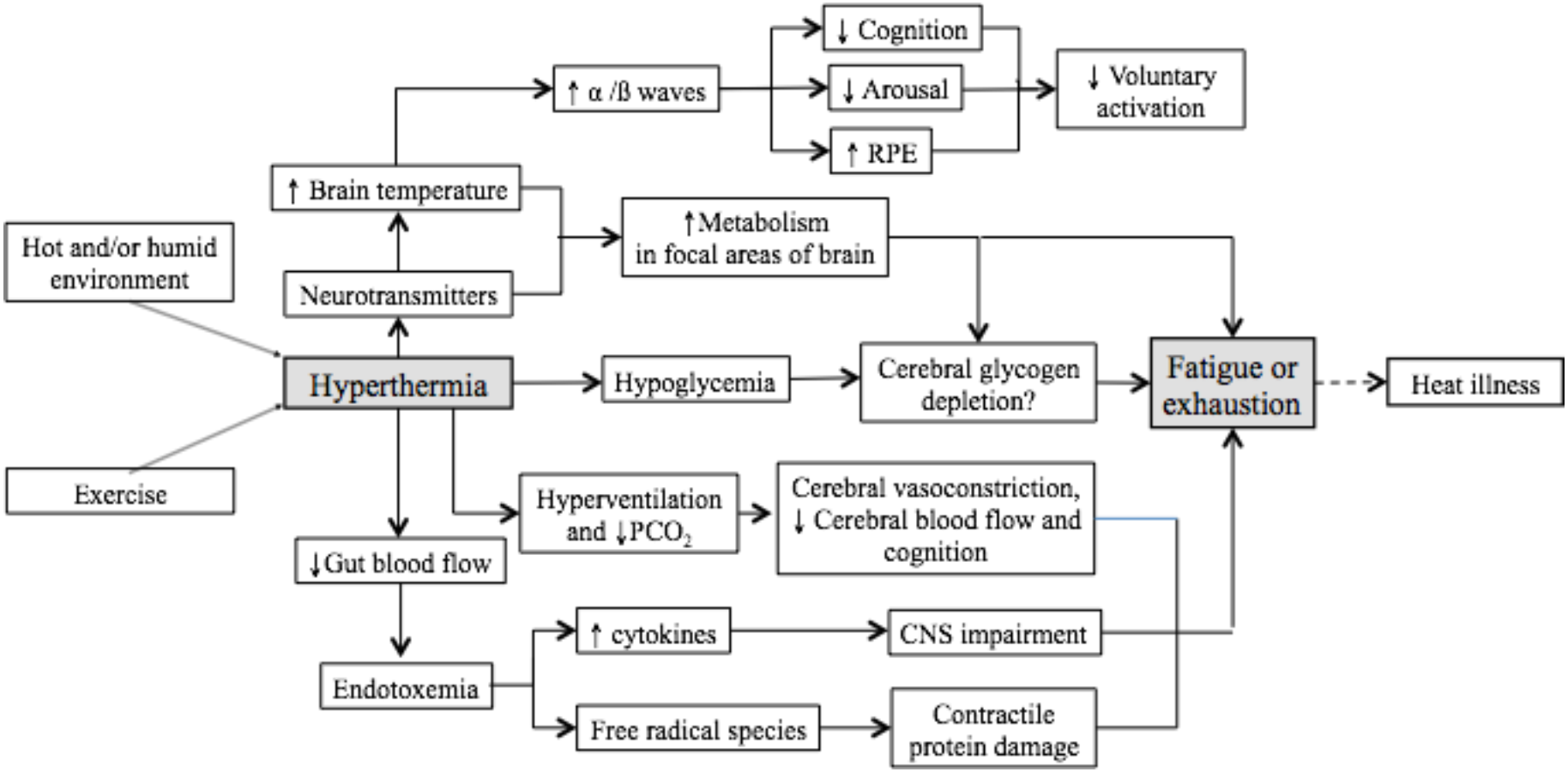
Science & Cycling
4-5 Juli 2018, Nantes, France

Modelling Risk

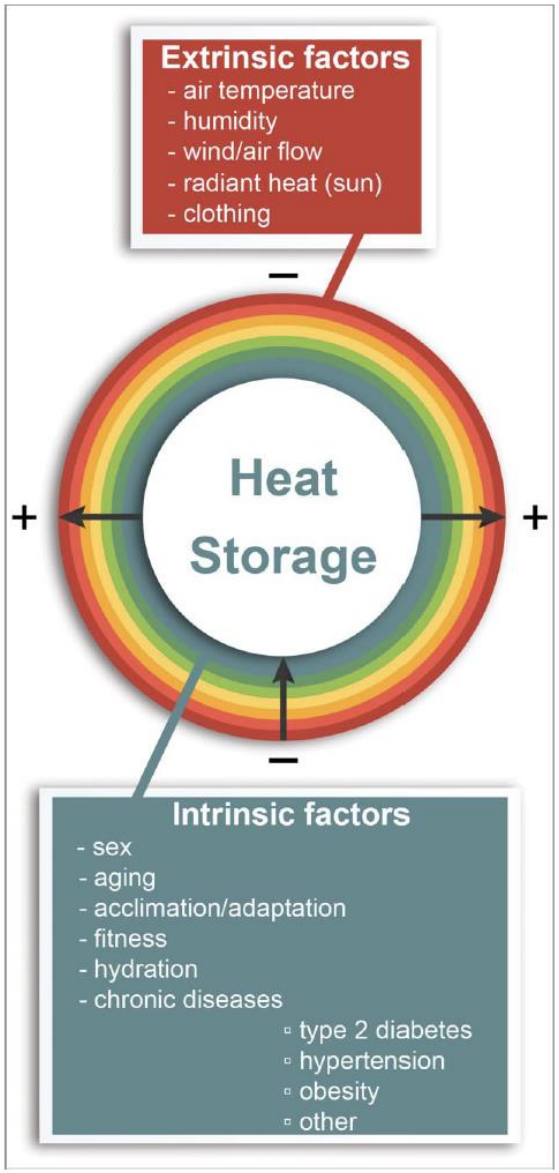
Multi-factorial Fatigue



Cheung & Sleivert 2004

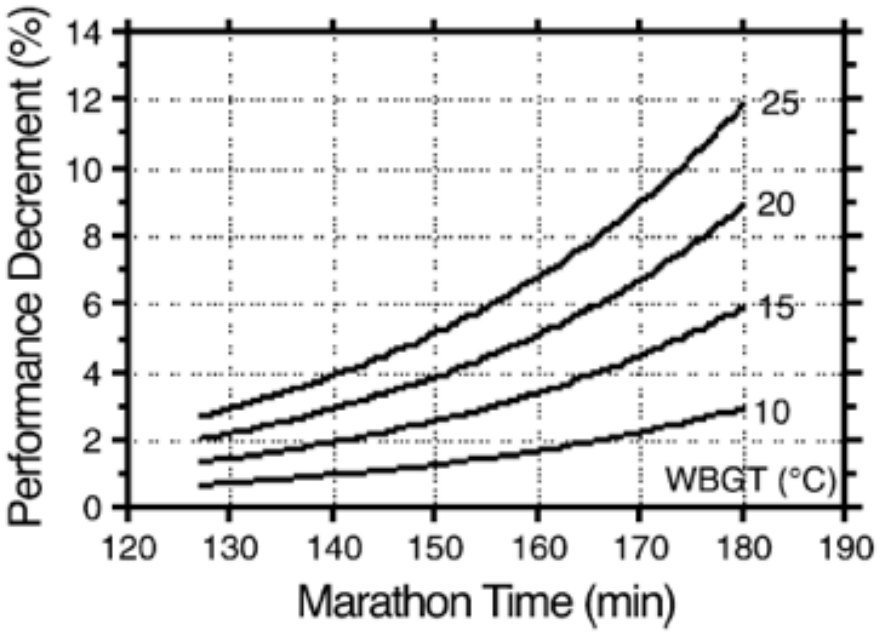
Modeling Challenges

- 24/7 issue
  - Indoor heat stress possible
  - A/C availability
  - Urban “heat island”
- Acute vs Chronic
  - Sudden spikes
  - Time of year (Spring vs Vuelta)



Kenny et al. 2018

Temperature Effect on Marathons

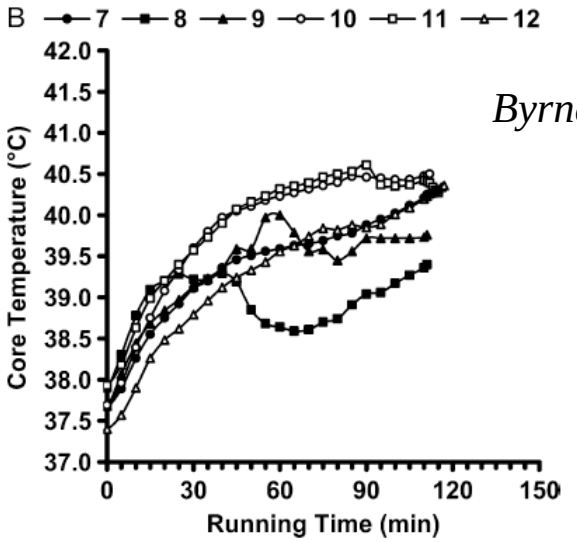


- Impairment already at relatively “moderate” temperatures
- Marathon times impaired at all ability levels
- Relative effect worse with slower runners
- Effect also holds for elite female runners

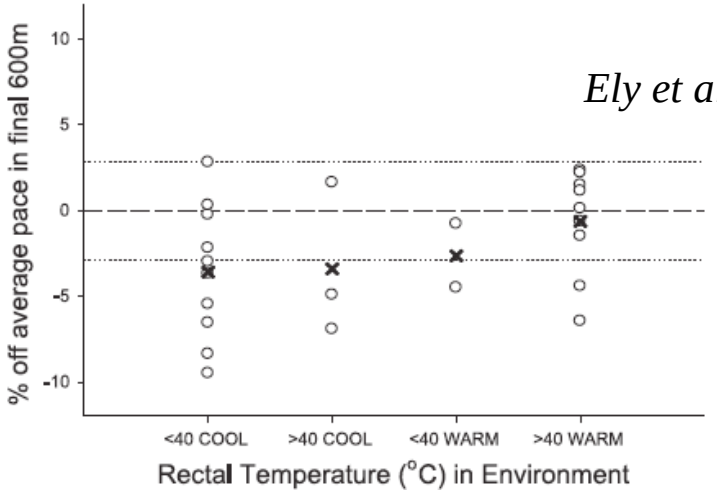
Ely et al. 2007

Is There a Threshold T_{core}?

- Singapore 1/2 Marathon
  - 18 trained/acclimatized
- All asymptomatic
  - All > 39.0ºC
  - Many > 40.0ºC
  - 2/18 > 41.0ºC
- Sprinting ability preserved
  - Final 600 m faster than 7400 m pace.
  - Cool or warm environment



Byrne et al. 2006



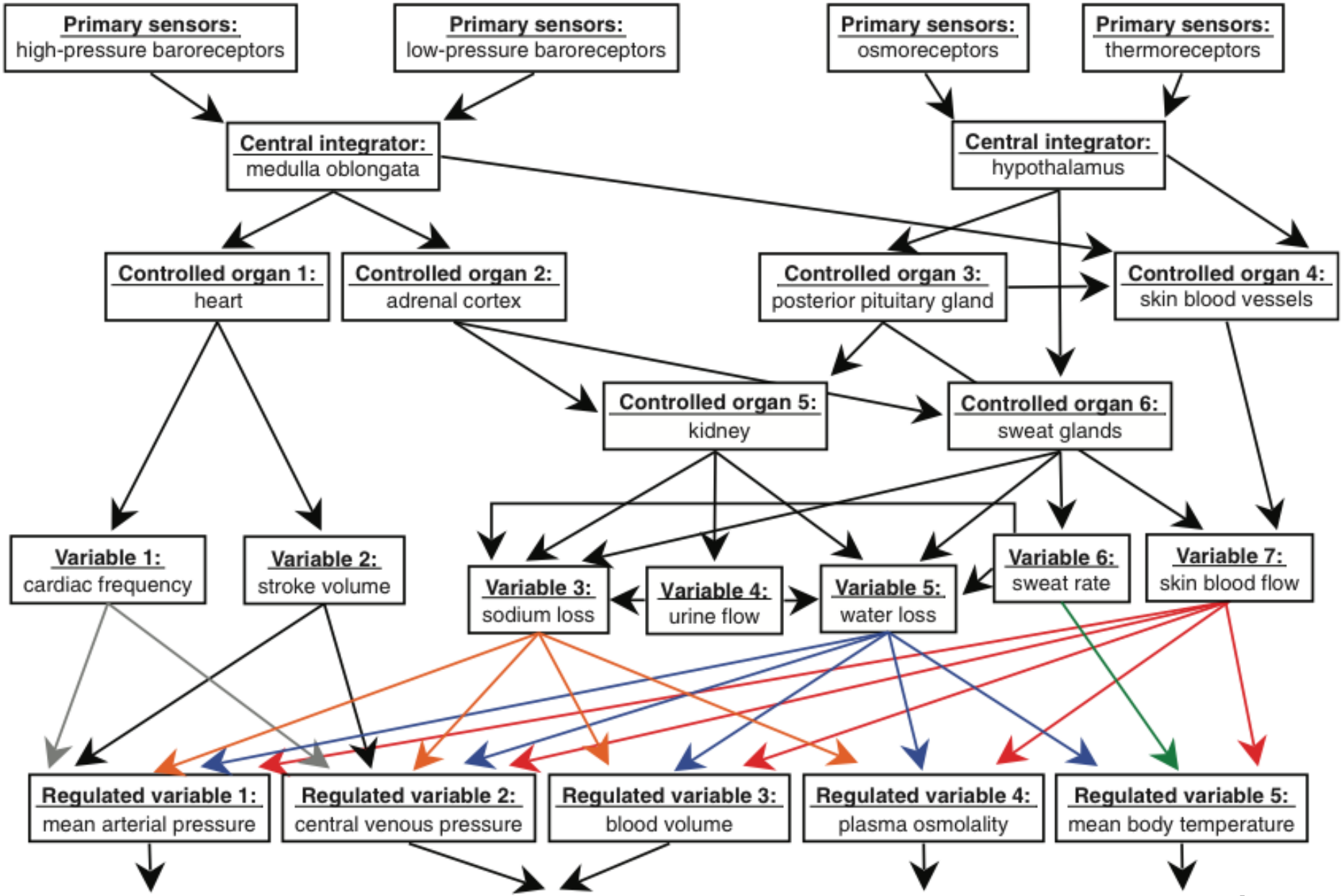
Ely et al. 2009

Running is not Cycling!

- Air resistance dominant
  - Ergogenic benefit to heat?
  - Air density and resistance?
  - Velodrome surface speed?
- Cooling from wind/speed
  - Lack adequate airflow
  - Dampened evaporative cooling

Morrison et al. 2014
Otani et al. 2018

Heat Adaptation


Primary sensors: high-pressure baroreceptors
Primary sensors: low-pressure baroreceptors
Primary sensors: osmoreceptors
Primary sensors: thermoreceptors
Central integrator: medulla oblongata
Central integrator: hypothalamus
Controlled organ 1: heart
Controlled organ 2: adrenal cortex
Controlled organ 3: posterior pituitary gland
Controlled organ 4: skin blood vessels
Controlled organ 5: kidney
Controlled organ 6: sweat glands
Variable 1: cardiac frequency
Variable 2: stroke volume
Variable 3: sodium loss
Variable 4: urine flow
Variable 5: water loss
Variable 6: sweat rate
Variable 7: skin blood flow
Regulated variable 1: mean arterial pressure
Regulated variable 2: central venous pressure
Regulated variable 3: blood volume
Regulated variable 4: plasma osmolality
Regulated variable 5: mean body temperature

Taylor 2011

Meta-analysis Questions

- Magnitude
  - Physiology
  - Performance
- Dose response?
  - Frequency/intensity
- Mediating factors?
  - Age
  - Fitness
  - Sex

Tyler et al. 2016

Meta-analysis Results

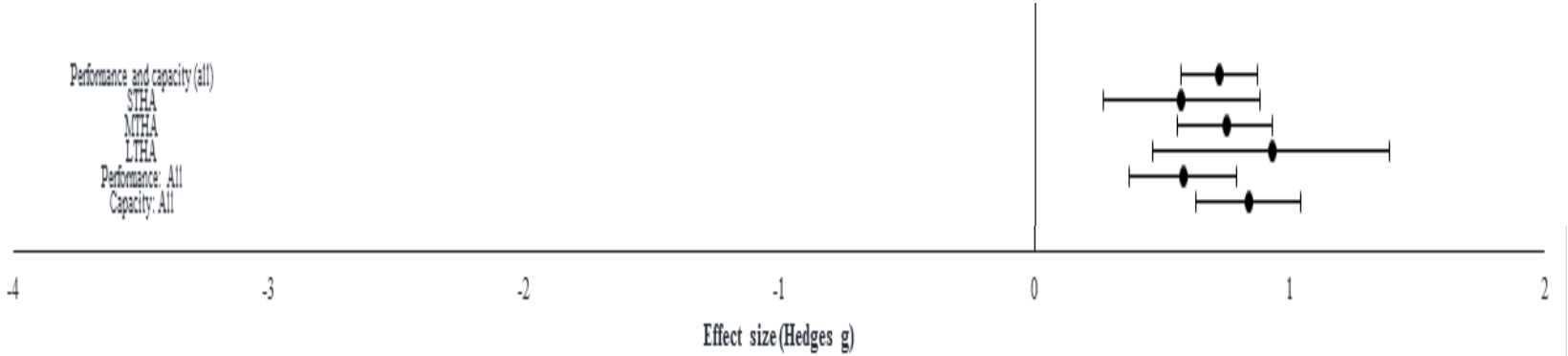
- Adaptation type
  - Controlled (n = 60)
  - Isothermal (n = 9)
  - Self-paced (n = 6)
- Duration
  - STHA: <7 d (n = 26/274)
  - MTHA: 8-14 d (n = 59/520)
  - LTHA: >14 d (n = 9/102)
- 976 total participants
  - 8% female

- Effect size (*g* statistic)
  - <0.19 = trivial/negligible
  - 0.20-0.49 = small
  - 0.50-0.79 = moderate
  - >0.8 = large

Limitations
Lack of blinding
Minimal control groups

Tyler et al. 2016

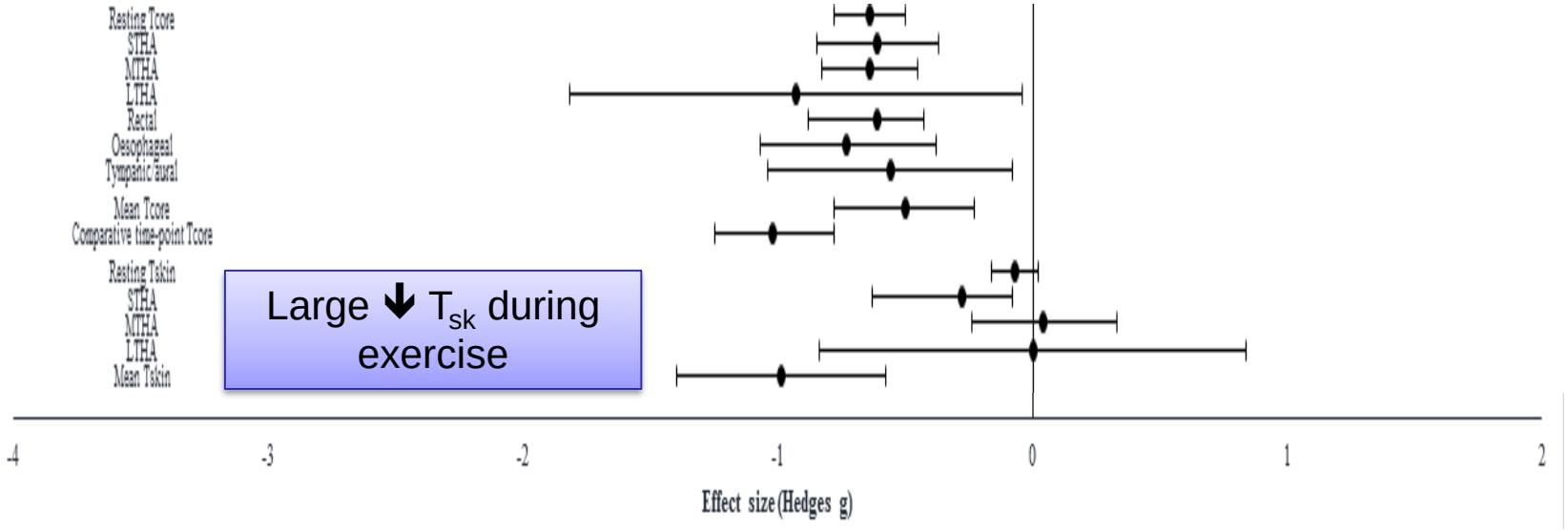
Performance Effects (48 datasets)



- 43/48 >1% improvement
  - Mean +16%, median +8%
- ↑ with frequency & duration
  - STHA & MTHA still moderate – large effect
- Isothermal & controlled moderate benefit
  - Self-paced larger benefit
  - Little data passive HA
- NS temperature, age, fitness

Tyler et al. 2016

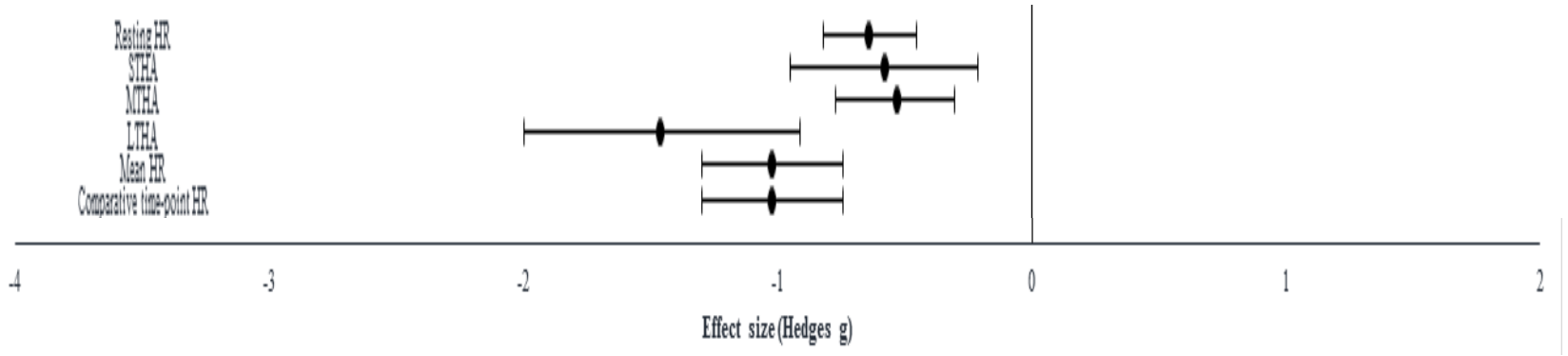
Core Temperature



- Moderate to large benefit
  - Resting (-0.16±0.13°C)
  - Mean (-0.35±0.32°C)
  - Iso-time (-0.35±0.24°C)
- Duration effect?
  - STHA~MTHA (-0.16°C)
  - LTHA (-0.32°C) 1 dataset
- NS age, fitness, sex

Tyler et al. 2016

Cardiovascular



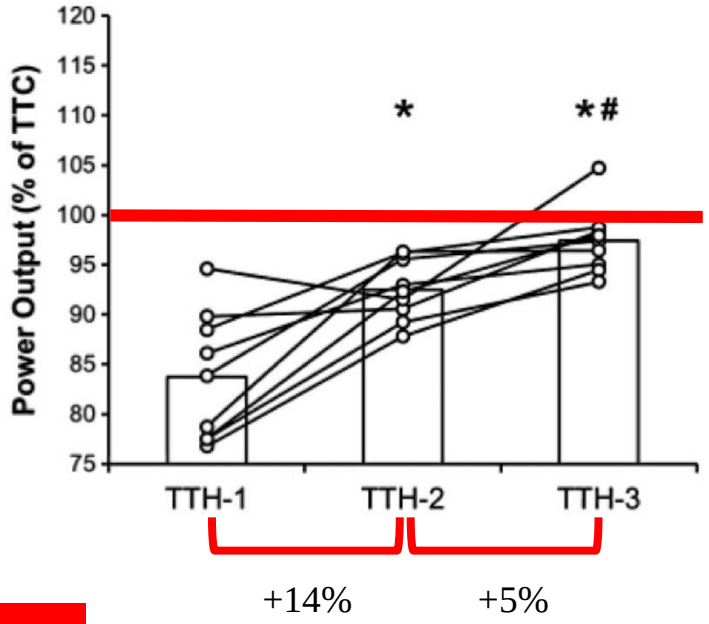
- Significant cardiovascular benefit
  - Moderate resting HR (-5±4 bpm)
  - Large mean (-12±10 bpm) and iso-time (-16±6 bpm) HR
- LTHA > STHA & MTHA
- Neglible BP, SV, Q effect

Tyler et al. 2016

Heat Adaptation Timecourse

- Trained Danish cyclists
  - 43.4 km outdoor TT in Denmark
- 2 week Qatar training camp (30-36°C)
- 43.4 km outdoor TT
  - Days 1 (TTH-1)
  - 6 (TTH-2)
  - 13 (TTH-3)

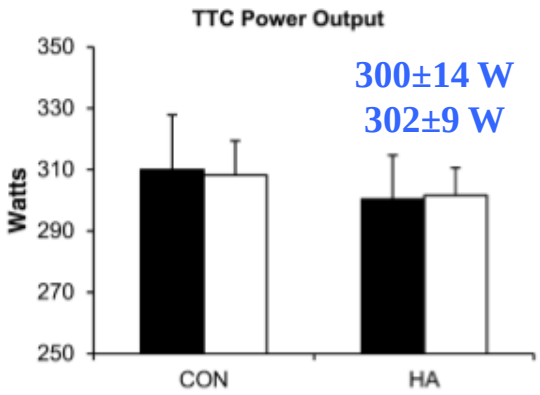
TTC (5°C, 300±14 W)

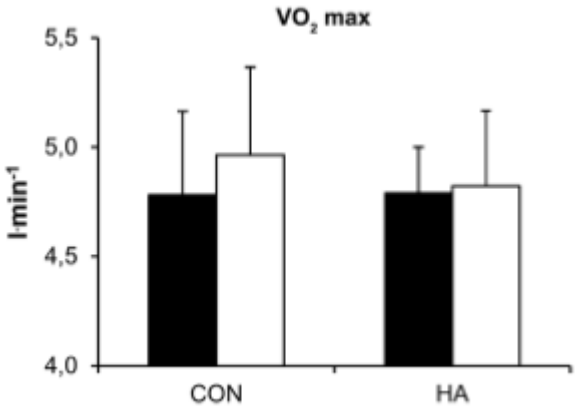


Heat remains a factor!

Karlsen et al. 2015a

HA as Ergogenic Aid in Cool Envt?





Return to Denmark: Repeat 43.4 km TT (13°C)

Heat adaptation is specific to heat performance!

Karlsen et al. 2015b

Clear hyperthermia impairments

Adaptation is possible

Physiological

Performance

Dose dependent response

STHA remains beneficial

HA ≠ Neutral benefit

Heat Adaptation Hacks

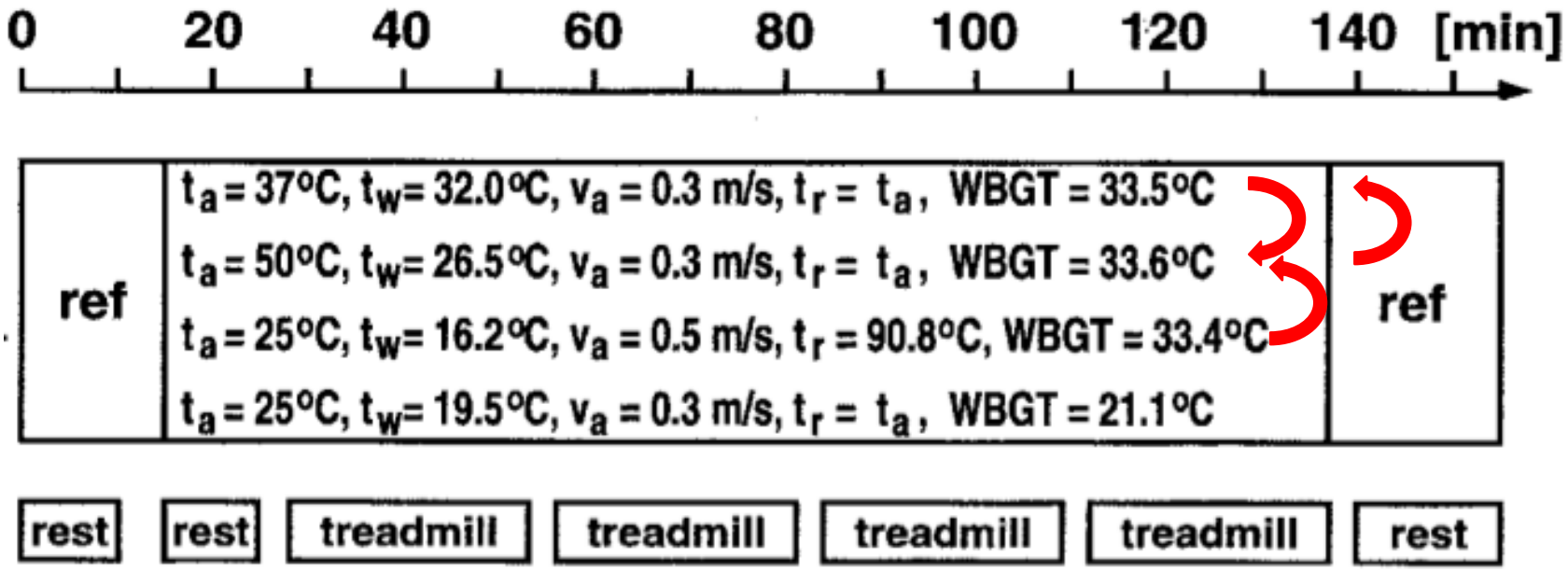
Passive HA?

- Limited performance data
- Multiple modalities
  - Sauna
  - Hot water immersion
- Timing
  - Before
  - After exercise

Likely similar mechanisms as active HA?

Careful monitoring required post-exercise

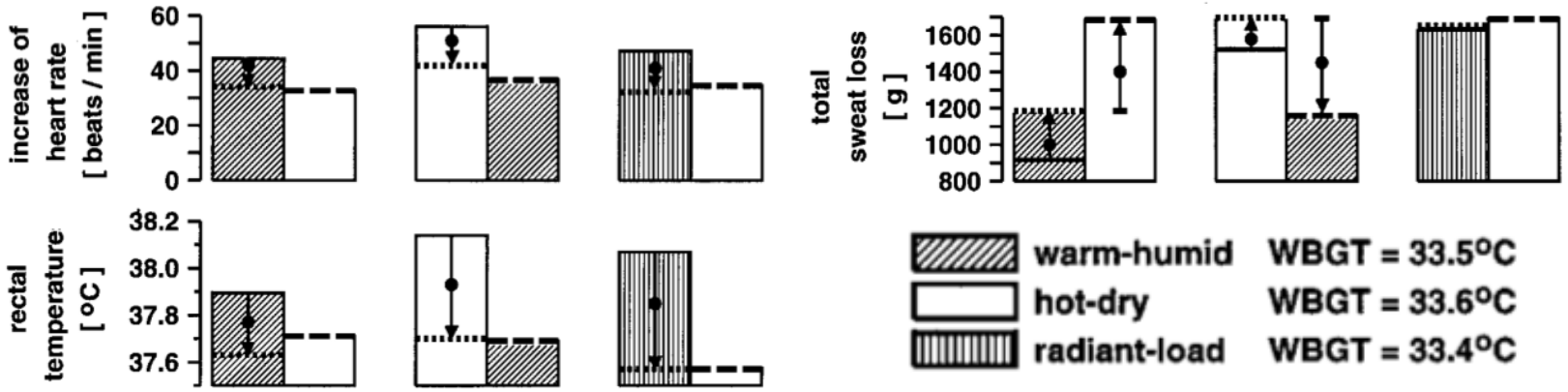
Does “hot” = “hot” = “hot?”



Does heat adaptation occur similarly across environments?

Can heat adaptation transfer across environments?

Griefahn 1997



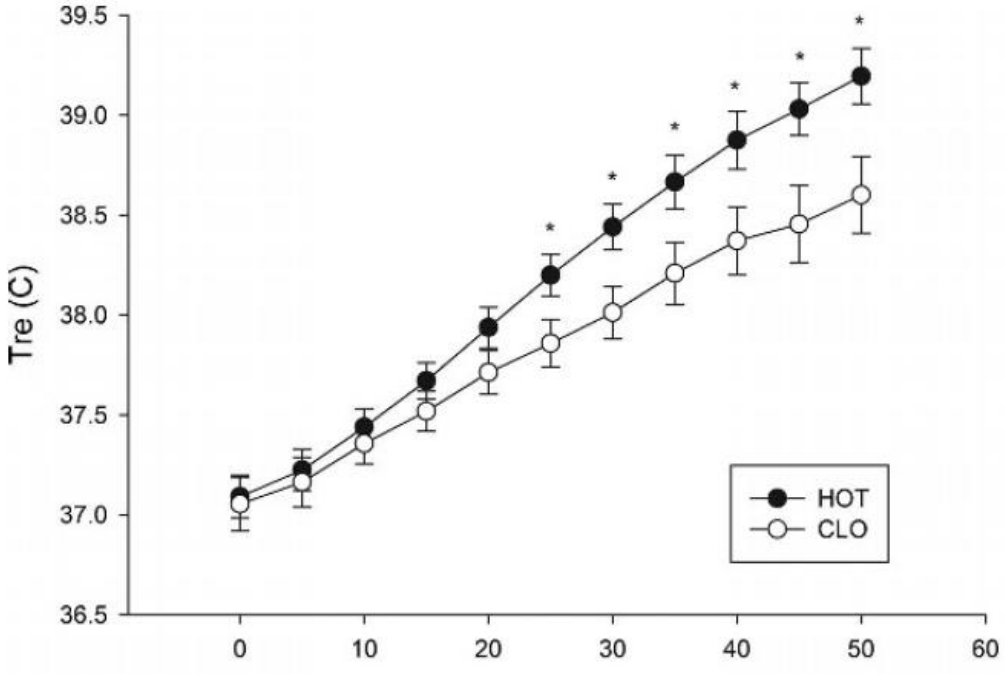
Time course of HA similar warm/humid, hot/dry, radiant

Heat adaptation is transferable across environments*

****Only existing study!***

Griefahn 1997

Clothing for HA?

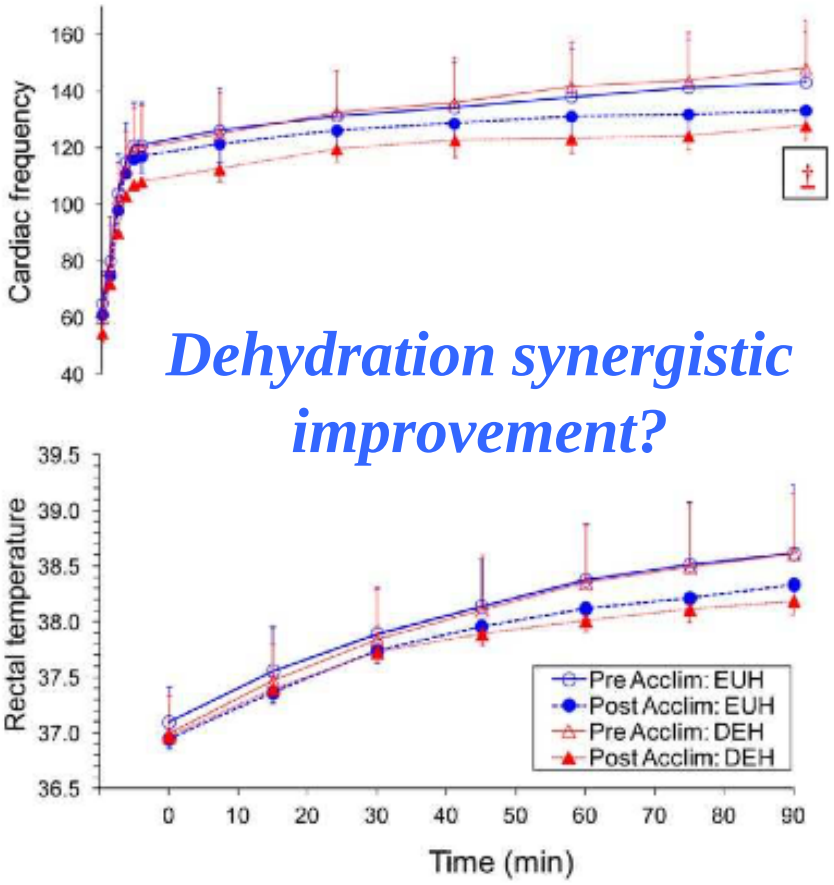


- Running study
  - "Winter/rain gear"
  - +1.7°C vs summer gear
- Hot
  - 40°C, 30% RH
- CLO
  - 15°C, 50% RH
  - 1.89 Clo

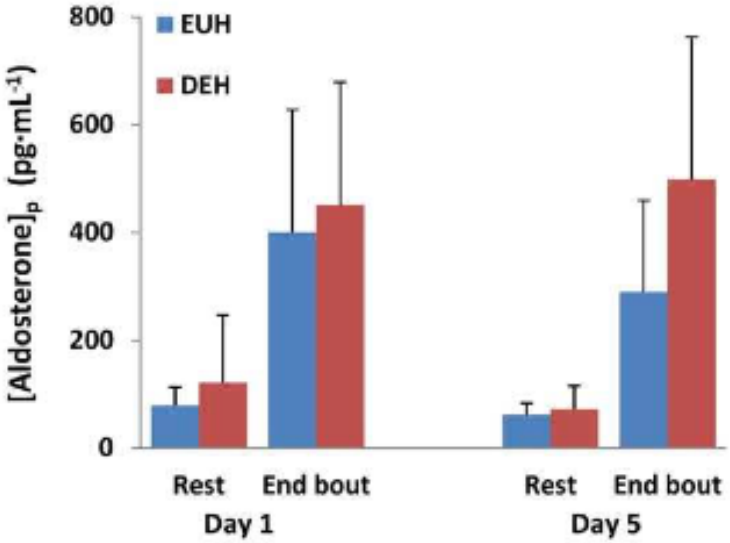
Some but incomplete stimulus!

Ely et al. 2018

Dehydration Stimulus?



Dehydration synergistic improvement?



- 5 days Isothermal (38.5°C) 90 min HA
  - EU (0.1-0.4% BM loss)
  - DH (-1.7-2.0% BM loss)

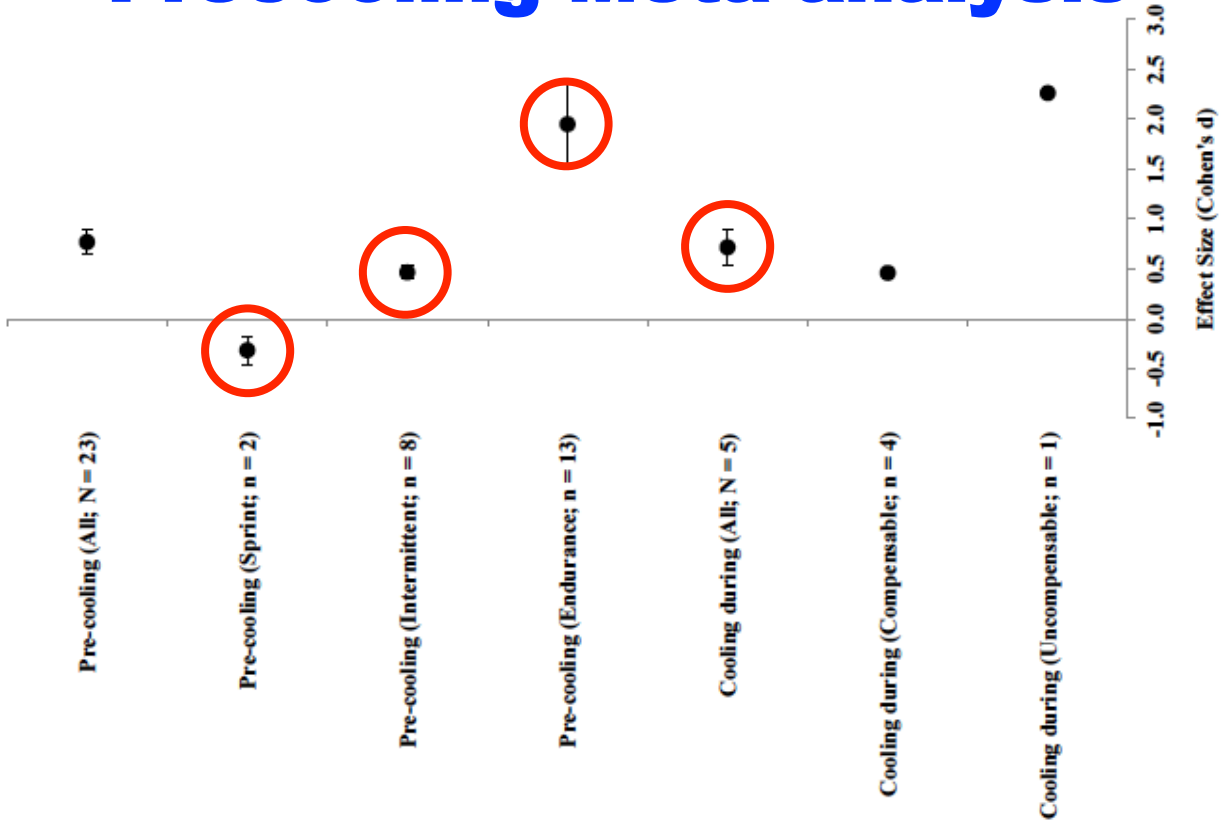
Garrett et al. 2014

Other Countermeasures

Pre-Cooling

- Theory
  - Metabolic/muscle warmup without T_{core} rise
  - ↑Thermal window
  - ↓Perceptual discomfort = ↑higher pacing
- Multiple modalities
  - Ice vests
  - Cooling hoods
  - Baths
  - Ice slurries

Precooling Meta-analysis

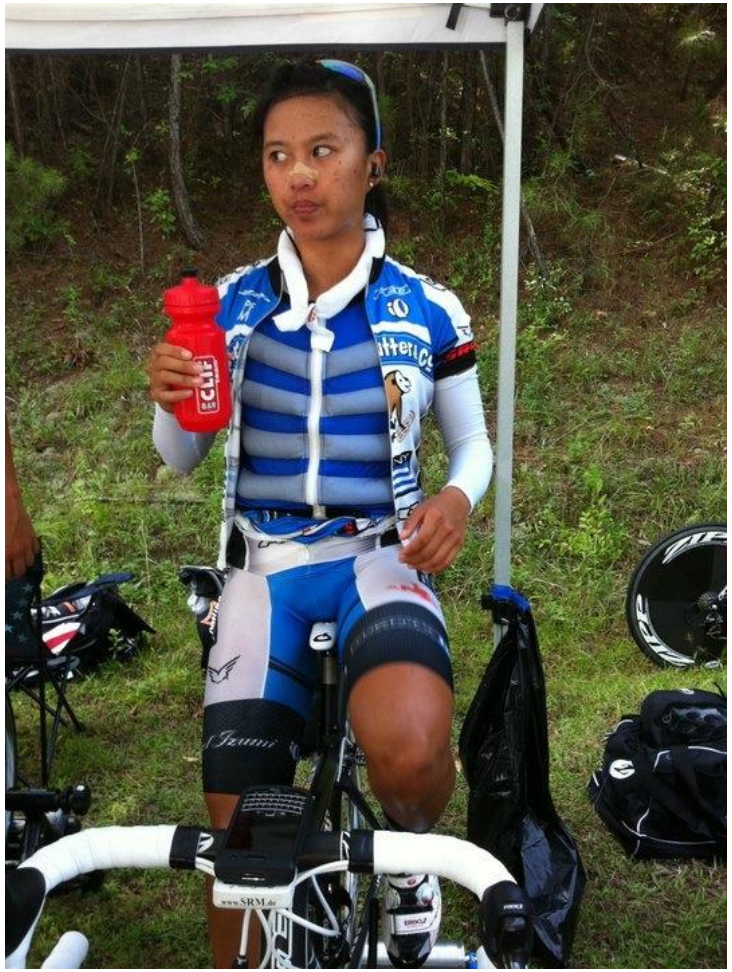


- Small negative effect with sprinting
- Moderate benefit with intermittent; high with endurance
- Moderate benefit during exercise

Tyler et al. 2015

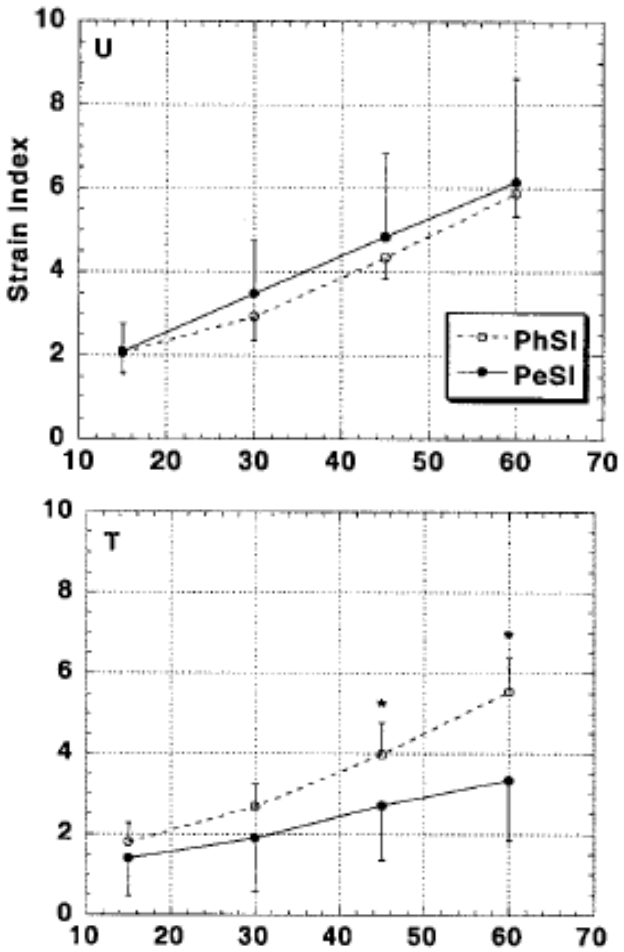
Precooling - do it properly!

Compare the coverage!



Wegman et al. 2013
Tyler et al. 2015

Effect of Fitness on Thermal Perception

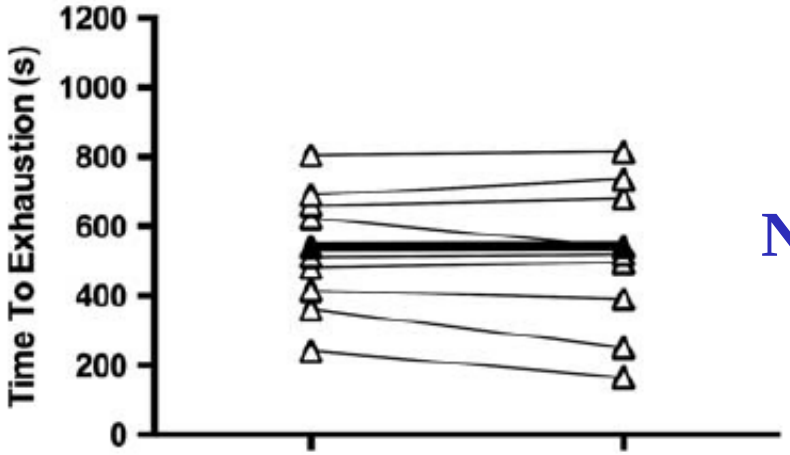


PhSI ∝ HR & T_{re}
PeSI ∝ RPE & TCV

- Untrained (U: 43.6mL) vs Trained (T: 59.0mL) in UHS
  - 40°C, 30%RH, 3.5 km/h
- Close matching in U
- Attenuated PeSI in T
  - NS HR/RPE
  - ↓ T_c/TS
  - = endpoint PeSI
  - ↑ endpoint PhSI
- Experience & habituation?

Tikuisis et al. 2002

Motivational Skills Training



NS pre/post

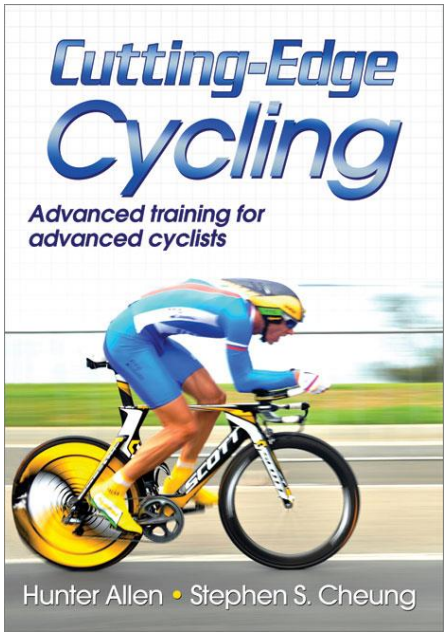
- 30 min pre-load
- TTE @80% PPO
- Cognitive testing
- 2 weeks MST / CON

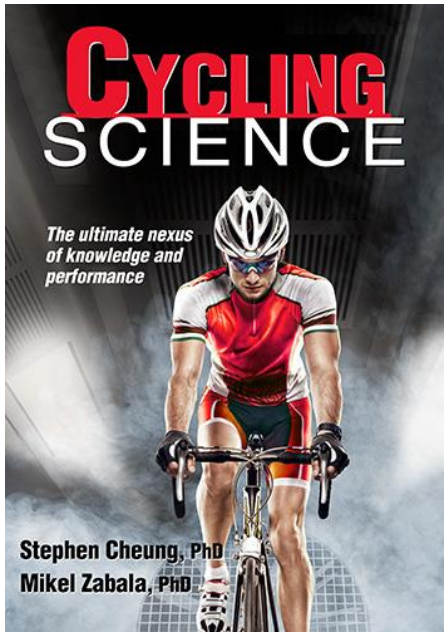
↑ executive function
↑ 26% TTE

Wallace et al 2017

Summary

- Clear hyperthermia impairments
- Adaptation is possible
  - Dose dependent response
  - Dehydration ↑ stimulus?
  - Different modalities effective
- Pre-cooling effective
- Psychological / Perceptual benefits





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