Korkealta kuumaan ja kosteaan

– case Tokio 2020

Kestävyysseminaari, Pajulahti, 26.11.2019

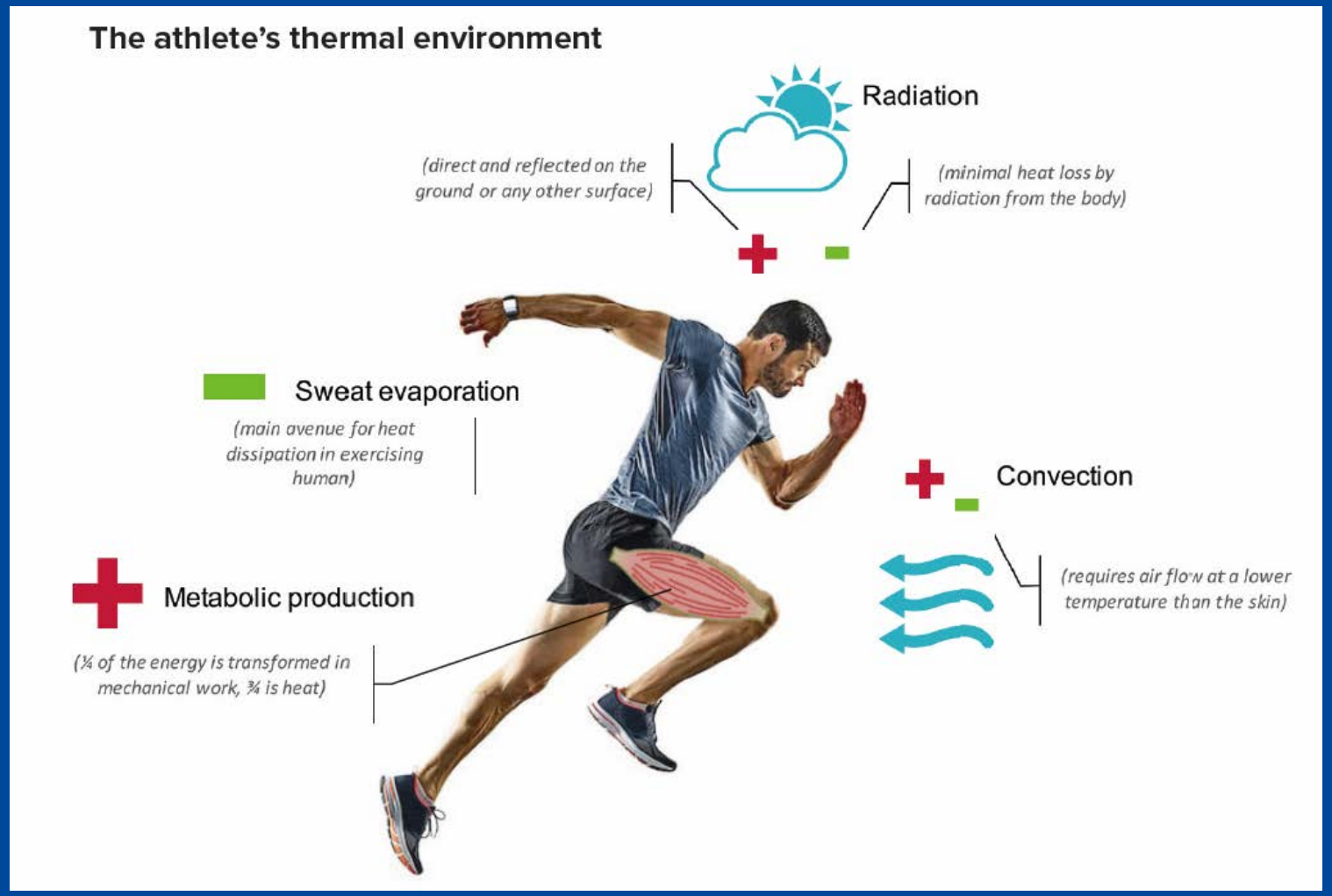
Esa Hynynen

Cross-adaptation

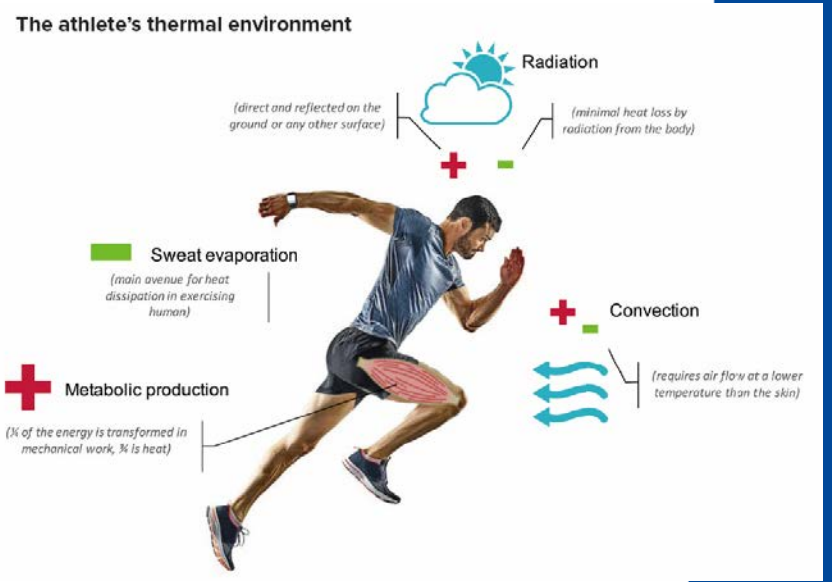
(cross-acclimation & cross-tolerance)

- Suorituskyvyn kannalta erityisolosuhteisiin on syytä sopeutua
- ”Yhteen stressiin sopeutuminen voi auttaa sopeutumaan ja sietämään toistakin”
- => Lämpöön sopeutuminen ja korkeus?
  - Löytyykö yhtäläisyyksiä?

Kuumassa urheileminen



Kuumaan sopeutuminen



- Parantunut lämmön poisto kehosta => parempi kehon lämpötilan ylläpito
  - Verenkierron ohjaus / verenpaineen säätely autonomisen säätelyn kautta
  - Kehon nestemäärän nousu
  - Lämmön poisto aktivoituu aiemmin
- Etenkin kehon nestemäärän muutokset hyödyllisiä myös korkealla

Kaikki tiet vievät Roomaan?

- Kuumassa urheillessa verenkierto ohjataan
  1. Työskenteleville lihaksille
  2. Kehon jäähdytykseen (pintaverenkiertoon)

  ⇒ samassa työssä pumpattava enemmän verta

- Korkealla veren happikylläisyys laskee

  ⇒ samassa työssä pumpattava enemmän verta

Kuumasta korkealle

Sports Med (2017) 47:1751–1768
DOI 10.1007/s40279-017-0717-z

REVIEW ARTICLE

Cross-Adaptation: Heat and Cold Adaptation to Improve Physiological and Cellular Responses to Hypoxia

Oliver R. Gibson[1,2] · Lee Taylor[3,4] · Peter W. Watt[2] · Neil S. Maxwell[2]

Table 1 Heat to hypoxia cross-acclimation experimental data

Study, year	Heat acclimation protocol	Adaptations to heat acclimation	Hypoxic protocol	Improved responses to hypoxia
Heled et al. [23], 2012	12 days 120 min day^{-1} 40 °C 40% RH [Fixed] Walking @ 30% $\dot{V}O_{2peak}$	Peak HR = ↓ 12 b min^{-1} Peak T_{rec} = ↓ 0.24 °C	OBLA test (FiO_2 = 0.15; ~2500 m)	HR @ OBLA = ↓ 10 b min^{-1} SpO_2 @ 7 km h^{-1} = ↑ 1.5%
Lee et al. [66], 2014	3 days 75 min day^{-1} (including 15 min preliminary rest) 40 °C 20% RH [Fixed] Cycling @ 50% $\dot{V}O_{2peak}$	Heat tolerance = ↑ 3 min Sweat rate = ↑ 23% Plasma volume = ↑ 4.6%	15 min @ rest 60 min @ 50% $\dot{V}O_{2peak}$ (FiO_2 = 0.14; ~3300 m)	Peak HR = ↓ 9 b min^{-1} Mean HR = ↓ 9 b.min^{-1} Peak T_{rec} = ↓ 0.3 °C Mean T_{rec} = ↓ 0.2 °C Peak T_{skin} = ↑ 0.6 °C Mean T_{skin} = ↑ 0.9 °C
Gibson et al. [20], 2015	10 days 90 min day^{-1} 40 °C 40% RH [ISO] Cycling @ 65% $\dot{V}O_{2peak}$	Resting HR = ↓ 18 b min^{-1} Resting T_{rec} = ↓ 0.49 °C Sweat rate = ↑ 48% Plasma volume = ↑ 14.7%	10 min rest 10 min cycling @ 40% $\dot{V}O_{2peak}$ 10 min cycling @ 65% $\dot{V}O_{2peak}$ (FiO_2 = 0.12; ~4500 m)	HR @ 65% $\dot{V}O_{2peak}$ = ↓ 12 b min^{-1} SpO_2 @ 65% $\dot{V}O_{2peak}$ = ↑ 3% $\dot{V}O_2$/HR @ rest = ↑ 0.5 mL bt^{-1} $\dot{V}O_2$/HR @ 65% $\dot{V}O_{2peak}$ = ↑ 1.3 mL bt^{-1} RER @ rest = ↓ 0.06
White et al. [22], 2016	10 days 2 × 50 min day^{-1} (10 min rest interval) 40 °C 55% RH (1600 m altitude) [Fixed] Cycling @ 50% $\dot{V}O_{2peak}$	Exercise HR = ↓ 21 b min^{-1} Exercise T_{rec} = ↓ 0.5 °C Plasma volume = ↑ 1.9% RPE = ↓ 3 TS = ↓ 1.0	16.1 km cycling TT (FiO_2 ≈0.12; 4350 m)	TT time = ↓ 1.6% (p = 0.07)
Lee et al. [21], 2016	10 days 75 min day^{-1} (including 15 min rest) 40 °C 25% RH [Fixed] Cycling @ 50% $\dot{V}O_{2peak}$	Mean HR = ↓ 14 b min^{-1} Resting T_{rec} = ↓ 0.26 °C Exercise T_{rec} = ↓ 0.54 °C Plasma volume = ↑ 3.5% Sweat rate = ↑ 88% TS = ↓ 0.9	40 min @ 50% $\dot{V}O_{2peak}$, then 16.1 km cycling TT (FiO_2 = 0.14; ~3300 m)	Mean HR = ↓ 9 b min^{-1} Mean SpO_2 = ↑ 2% $\dot{V}O_2$/HR = ↑ 0.7 mL bt^{-1} Mean T_{rec} = ↓ 0.15 °C TT time = ↓ 4.7%

[Fixed] denotes fixed-intensity protocol, *[ISO]* denotes isothermic/controlled hyperthermia protocol, FiO_2 = fractional inspired oxygen content, *HR* heart rate, *OBLA* onset of blood lactate accumulation, *RH* relative humidity, *RER* respiratory exchange ratio, *RPE* rating of perceived exertion, SpO_2 peripheral oxygen saturation, T_{rec} rectal temperature, *TS* thermal sensation, T_{skin} skin temperature, *TT* time trial, $\dot{V}O_{2peak}$ peak oxygen uptake, ↑ indicates increase, ↓ indicates decrease

Huom! Tutkittavat asuivat normaalisti 1500-1600 m mpy, ei kontrolliryhmää (White et al 2016)

Hypoksiaharjoittelulla vastaavia muutoksia, TT time parani 6,9 % (Lee et al 2016)

Gibson et al 2017

Solutason selitys

2.2.1 *Mechanisms by Which Heat to Hypoxia Cross-Tolerance May Occur*

Cross-tolerance experimental work has identified heat shock proteins (HSP) as key components of the cross-stressor response. At the current time, experimental evidence dictates that of greatest interest for cross-tolerance are HSP72 [17, 85] and HSP90α [18], both of which demonstrate increases in basal levels following HA [21, 86] and in response to various hypoxic exposures with [21, 67] and without exercise [87–89].

Table 2 Heat to hypoxia cross-tolerance experimental data

Study, year	Heat acclimation protocol	Adaptations to heat acclimation	Hypoxic protocol	Improved responses to hypoxia
Lee et al. [66], 2014	3 days 75 min day^{-1} (including 15 min preliminary rest) 40 °C 20% RH [Fixed] Cycling @ 50% $\dot{V}O_{2peak}$	↑ Basal monocyte HSP72 ↑ e*Hsp*72 pre/post session	15 min @ rest 60 min @ 50% $\dot{V}O_{2peak}$ ($FiO_2 = 0.14$; ~3300 m)	Monocyte HSP72 increase attenuated after heat acclimation ↑ eHSP72 maintained after heat acclimation
Gibson et al. [20], 2015	10 days 90 min day^{-1} 40 °C 40% RH [ISO] Cycling @ 65% $\dot{V}O_{2peak}$	↑ *Hsp*72 mRNA pre/post session ↑ *Hsp*90α mRNA pre/post session	10 min rest 10 min cycling @ 40% $\dot{V}O_{2peak}$ 10 min cycling @ 65% $\dot{V}O_{2peak}$ ($FiO_2 = 0.12$; ~4500 m)	Attenuated *Hsp*72 mRNA increase after heat acclimation ↑ *Hsp*90α mRNA maintained after heat acclimation
Lee et al. [21], 2016	10 days 75 min day^{-1} (including 15 min rest) 40 °C 25% RH [Fixed] Cycling @ 50% $\dot{V}O_{2peak}$	↑ Basal monocyte HSP72 (comparable magnitude to equivalent training in hypoxia)	40 min @ 50% $\dot{V}O_{2peak}$ then 16.1 km cycling TT ($FiO_2 = 0.14$; ~3300 m)	Monocyte HSP72 increase attenuated after heat acclimation

[Fixed] denotes fixed-intensity protocol, *[ISO]* denotes isothermic/controlled hyperthermia protocol, FiO_2 fractional inspired oxygen content, *HSP72/Hsp72* heat shock protein-72 (*eHSP* extracellular protein, *HSP* intracellular protein, *Hsp* gene). *Hsp*90α heat shock protein-90α, *mRNA* messenger RNA, *RH* relative humidity, *TT* time trial, $\dot{V}O_{2peak}$ peak oxygen uptake, ↑ indicates increase

Gibson et al 2017

Cross Acclimation between Heat and Hypoxia: Heat Acclimation Improves Cellular Tolerance and Exercise Performance in Acute Normobaric Hypoxia

Ben J. Lee[1,2], Amanda Miller[2], Rob S. James[2] and Charles D. Thake[2]*

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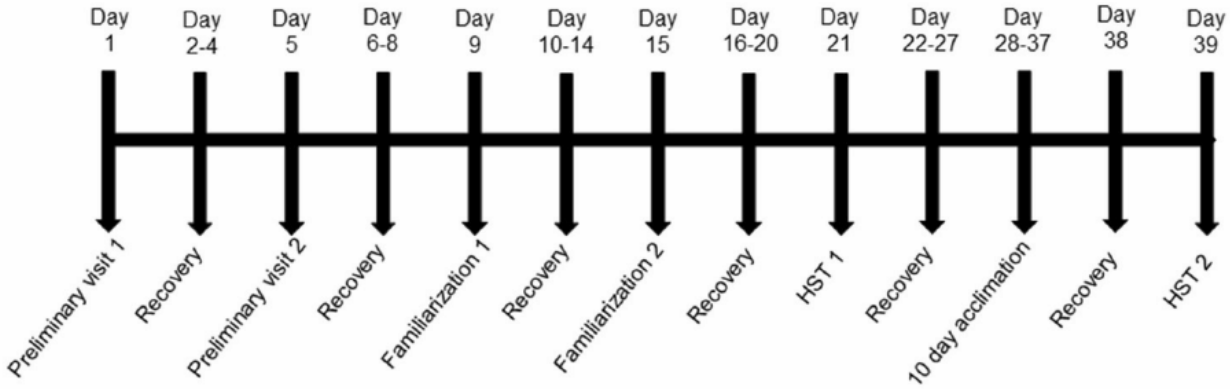
Front. Physiol. 7:78.
doi: 10.3389/fphys.2016.00078

- Mitä kymmenen päivän sopeutumisjakso kuumaan tai korkeaan vaikuttaa suorituskykyyn korkealla?
- Normoksia, hypoksia ja kuumuus, jokaisessa 7 hyväkuntoista miestä (ei urheilijoita)



Group	Age (years)	Height (m)	Body mass (kg)	N VO_2peak ($mL.kg.min^{-1}$)	H VO_2peak ($mL.kg.min^{-1}$)	Weekly training (hours)
CON	22 ± 3	1.74 ± 0.08	72.5 ± 11.4	51.4 ± 10.0	41.7 ± 9.8	8.5 ± 3.3
HYP	22 ± 5	1.75 ± 0.06	71.2 ± 2.8	52.3 ± 7.1	40.3 ± 7.1	8.8 ± 3.6
HOT	25 ± 6	1.78 ± 0.08	71.7 ± 9.2	50.7 ± 4.7	41.9 ± 5.7	8.5 ± 3.1

FIGURE 1 | Schematic of the experimental design, anthropometric and physiological characteristics of participants, indicating the typical days on which specific tests were undertaken.

- Sopeutumisjaksolla (10 pv) päivittäin 60 min 50 % normoksian VO_{2max} tehosta
  - Kontrolli (18 ˚C, 35 % RH)
  - Kuuma (40 ˚C, 25 % RH)
  - Hypoksia (18 ˚C, 35 % RH, F_IO_2 = 14 % ~ 3500 m mpy)

Lee et al 2016

Kymmenen päivän sopeutumisjakson vaikutuksia

- Plasmavolyymi (levossa)
  - Hypoksiassa ↓
  - Kuumassa ↑
- Syke vakiokuormalla
  - Hypoksiassa ↓
  - Kuumassa ↓
- Painon lasku harjoituksen aikana
  - Hypoksiassa ↔
  - Kuumassa ↑

Lee et al 2016

Aika-ajo hypoksiassa (16,1 km)

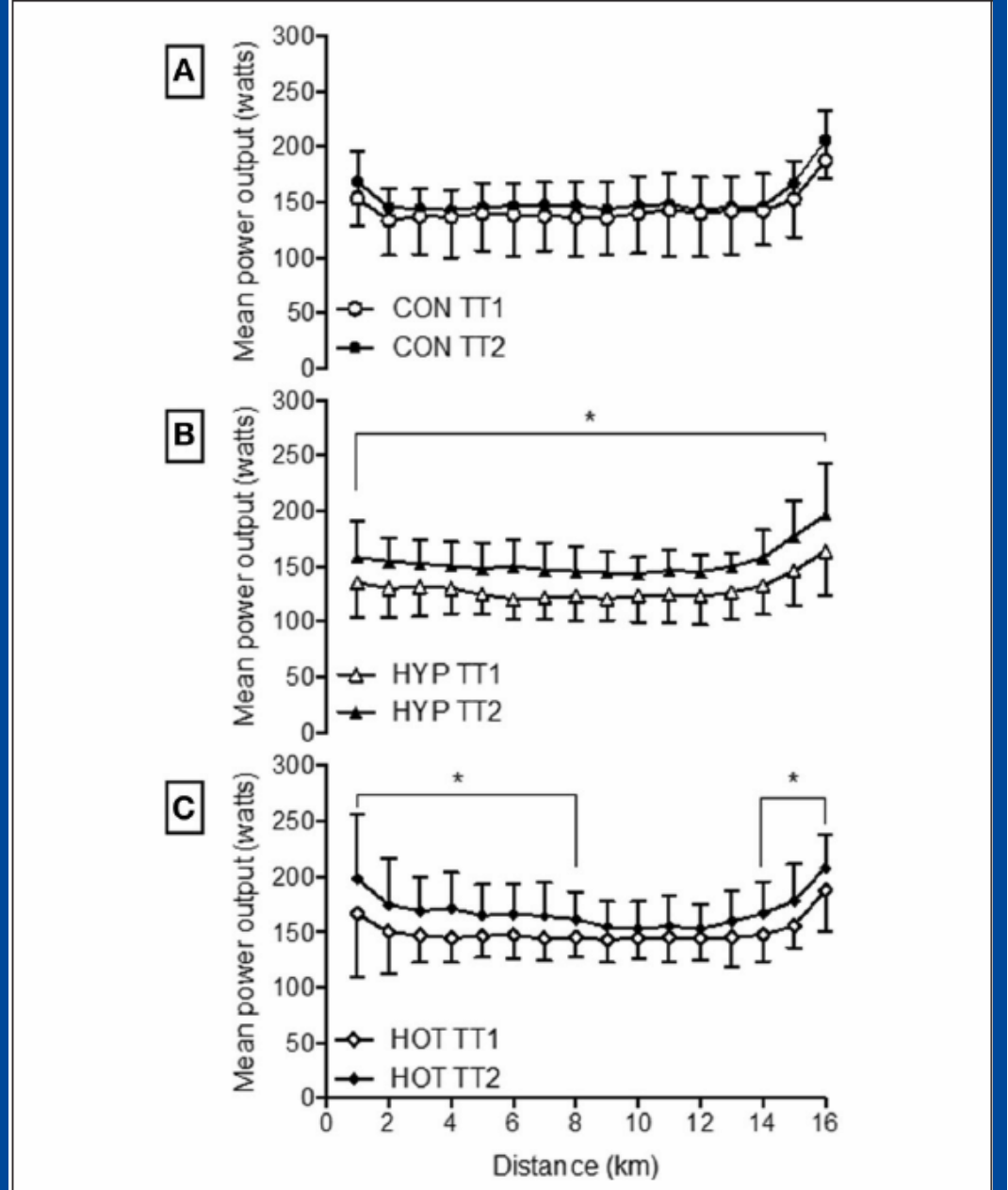


FIGURE 6 | Mean power output during each kilometer of the 16.1 km time trial for CON (A), HYP (B) and HOT (C). *Difference from TT1 ($p < 0.05$).

Lee et al 2016

Maksimaalinen aerobinen kapasiteetti ja kuumuus

DOI: 10.1113/EP087268

RESEARCH PAPER

WILEY EP Experimental Physiology

Heat acclimation does not affect maximal aerobic power in thermoneutral normoxic or hypoxic conditions

Alexandros Sotiridis[1,2] | Tadej Debevec[1,3] | Urša Ciuha[1] | Ola Eiken[4] | Igor B. Mekjavic[1,5]

- Päivittäin 90 min pyöräily 10 päivän ajan tavoite(rektaali)lämpönä 38,5 ˚C

Kuuman treenijakson vaikutuksia

- Submax tasolla matalammat sykkeet vakiokuormalla olosuhteesta riippumatta
- Lämpötila alempi
- Hikoilu suurempaa
- Maksimitehossa vain pientä vaihtelua, ei olennaista muutosta normoksiassa tai hypoksiassa (termoneutraalissa oloissa)

Sotiridis et al 2019

Korkeus ja kuumuus yhdessä

International Journal of Sports Physiology and Performance, 2019, 14, 635-643
https://doi.org/10.1123/ijspp.2018-0399

Human Kinetics
ORIGINAL INVESTIGATION

Impaired Heat Adaptation From Combined Heat Training and "Live High, Train Low" Hypoxia

Erin L. McCleave, Katie M. Slattery, Rob Duffield, Philo U. Saunders, Avish P. Sharma, Stephen Crowcroft, and Aaron J. Coutts

- Asuminen alppimajassa (n. 3000 m mpy)
- Kuumatreenejä kolme kertaa viikossa ja kolmen viikon ajan
- Kilpailevia juoksijoita, treenasivat 10-20 tuntia viikossa

Table 1 Physical Characteristics of Participants in H+H, HOT, and CONT Training Groups at Baseline

	H+H n = 9 m = 5, f = 4	HOT n = 9 m = 6, f = 3	CONT n = 7 m = 5, f = 2
Age, y	29.5 (7.8)	29.8 (5.2)	30.7 (5.1)
Body mass, kg	64.2 (8.3)	71.5 (11.9)	69.9 (10.6)
Height, cm	173.7 (8.2)	176.7 (9.4)	179.1 (9.3)
VO_2peak, L·min^{-1}	4.0 (0.8)	4.7 (1.2)	4.5 (1.1)
VO_2peak, mL·min^{-1}·kg^{-1}	62.5 (8.5)	65.1 (7.2)	64.9 (9.3)
vVO_2peak, km·h^{-1}	17.5 (1.9)	18.6 (1.8)	19.0 (3.4)

Abbreviations: CONT, temperate training; f, females; H+H, heat and hypoxia training; HOT, heat training; m, males; VO_2peak, peak oxygen consumption; vVO_2peak, velocity corresponding to VO_2peak. Note: Data are presented as group mean (SD) of the raw values.

Group	Heat training 3x 90 min·week^{-1}	Hypoxic exposure
H+H (n = 9)	32.7°C (31.2°C–34.6°C), 59.1% RH (46.6%–72.2%)	F_iO_2 = 14.4% (3000 m) 13.9 ± 0.7 h·day^{-1}
HOT (n = 9)	32.7°C (30.5°C–34.0°C) 58.9% RH (50.0%–61%)	< 600 m
CONT (n = 7)	13.9°C (9.0°C–18.0°C) 52.3% RH (41%–80%)	< 600 m

	Session description	Pace
1	45-min heat run	65% vVO_2peak
2	4 × 5 min (90 s recovery)	80% vVO_2peak
3	8 × 90 s @ 6% gradient (90 s recovery)	80% vVO_2peak
4	6 × 3 min (60 s recovery)	85% vVO_2peak
5	45-min continuous	65% vVO_2peak
6	12 × 1 min (60 s recovery)	100% vVO_2peak
7	2 × 10 min (3 min recovery)	80% vVO_2peak
8	1/2/3/4/3/2/1 min (60 s recovery)	90% vVO_2peak
9	45-min heat run	65% vVO_2peak

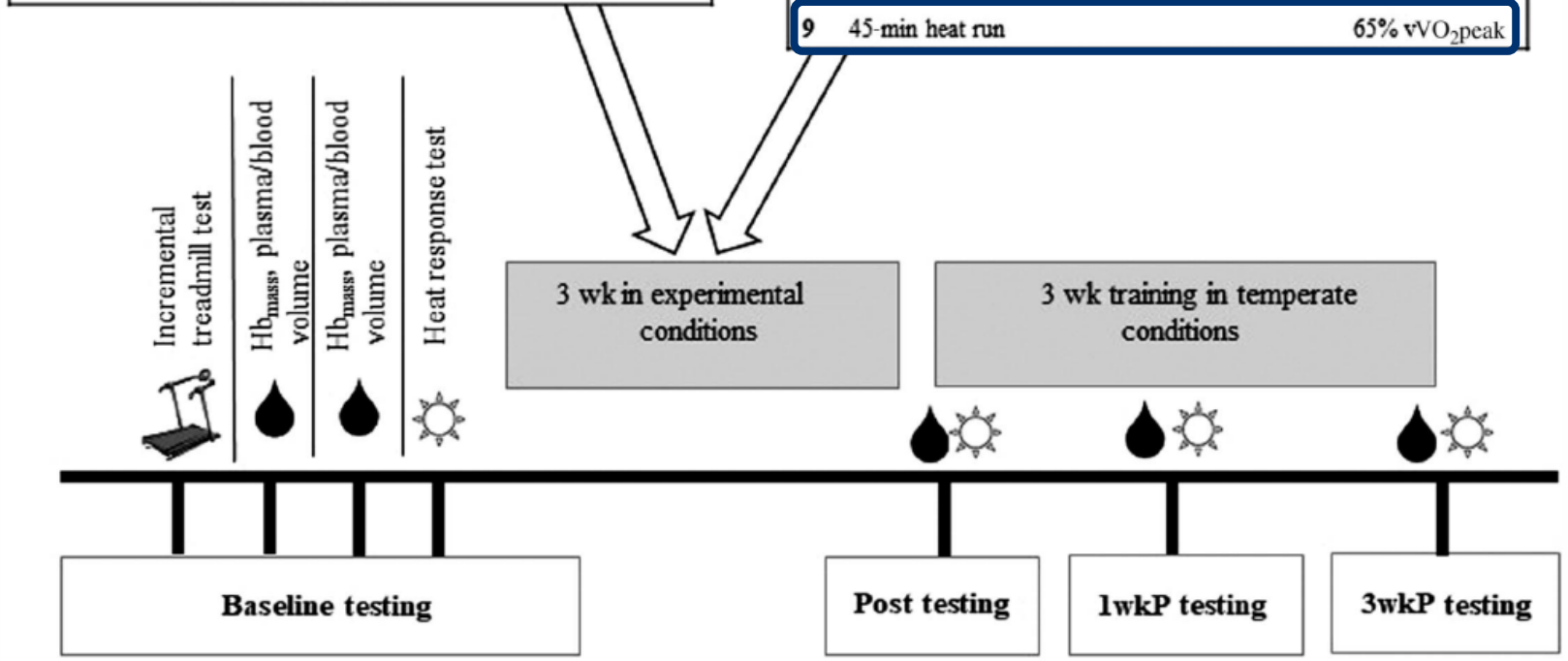


Figure 1 — Experimental design. CONT indicates temperate training; H+H, heat and hypoxia training; HOT, heat training; 1wkp, 1 week postexposure; 3wkP, 3 weeks postexposure.

McCleave et al 2019

- Pelkkä kuuma-altistus aiheutti selkeimmät kuumaan sopeutumisvasteet, siinäkin vaimea vaste (+ 6 % plasmaa)
- Lisästressi korkeasta ei tuottanut isompaa vastetta
- Vaikuttiko kuntotaso (vs. aiemmat tutkimukset)?
- 3 krt/vko kuuma-altistus liian vähän?
- Hypoksiassa verenkierron säätelyssä ”isompi kisa” pintaverenkierron ja sisäelinten välillä

McCleave et al 2019

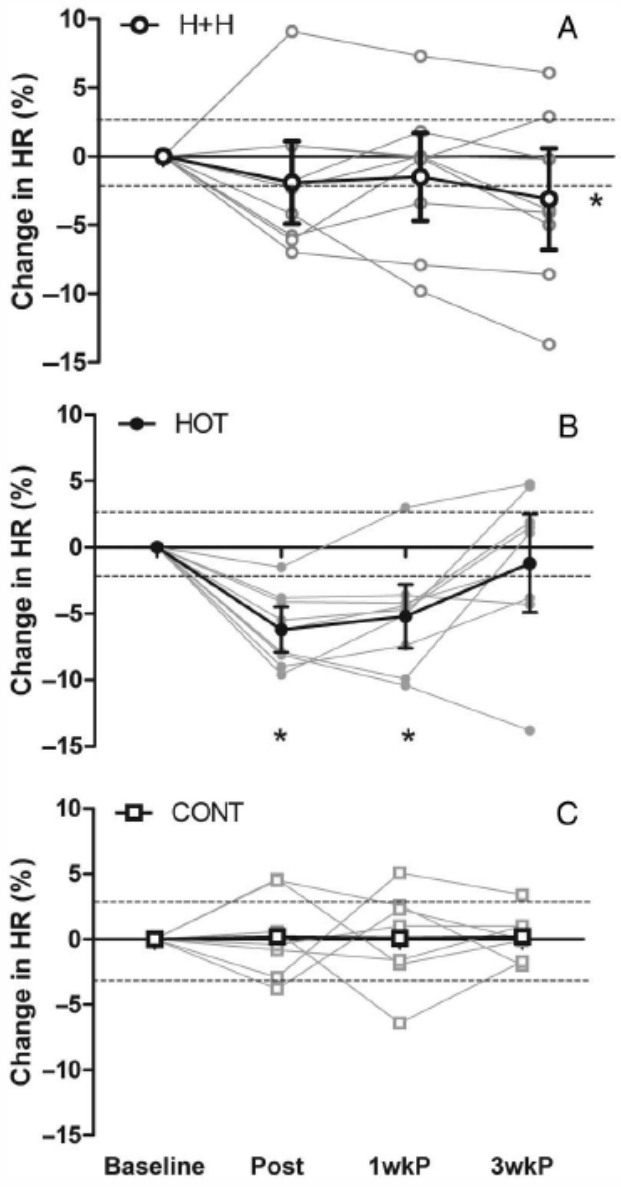


Figure 2 — Changes in average heart rate during the heat-response test, expressed as a percentage change from baseline ±90% confidence limits for (A) H+H, (B) HOT, and (C) CONT. CONT indicates temperate training; H+H, heat and hypoxia training; HOT, heat training. *Likely within-group difference from baseline.

Korkealta kuumaan

J Appl Physiol 125: 1284–1295, 2018.
First published July 26, 2018; doi:10.1152/japplphysiol.01114.2017.

RESEARCH ARTICLE

Exercise cardiorespiratory and thermoregulatory responses in normoxic, hypoxic, and hot environment following 10-day continuous hypoxic exposure

Alexandros Sotiridis,[1,2] Tadej Debevec,[1,3] Adam C. McDonnell,[1] Urša Ciuha,[1] Ola Eiken,[4] and Igor B. Mekjavic[1,5]

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- Tutkimustietoa tästä heikosti tarjolla

Kymmenen päivää heikossa hapessa

PRE			Hypoxic Acclimatization									POST		
D-3	D-2	D-1	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D+1	D+2	D+3
· 3 SSTs · 3 VO_{2max} tests: 1.normoxia 2.hypoxia 3.heat			· 240 hours, F_iO_2 = 13.65 ± 0.35 % · Daily exercise Training for 1h at 50% hypoxic W_{peak}									· 3 SSTs · 3 VO_{2max} tests: 1.normoxia 2.hypoxia 3.heat		

SST : Steady State Test that comprises 30min cycling in normoxic 40% W_{peak}

- Kaksitoista fyysisesti aktiivista miestä
- Simuloitu vuoristo ~ 4000 m mpy

Sotiridis et al 2018

Vakiokuorma ennen ja jälkeen 10 päivän hypoksia-altistuksen

Sopeutuminen

- Hypoksiaan ↑
- Kuumaan ↔

Table 2. *Cardiorespiratory responses and RPE in the last 10 min of the constant-workrate cycling before and after the hypoxic acclimatization for the normoxic, hypoxic, and heat trials*

	Pre-Hypoxic Acclimatization			Post-Hypoxic Acclimatization		
	NOR	HYP	HE	NOR	HYP	HE
HR, beats/min	136 (13)	154 (13)†	148 (15)†	125 (9)*	141 (11)*†	148 (14)†
$\dot{V}O_2$, ml/min	2,175 (194)	2,208 (262)	2,065 (207)†‡	2,101 (189)	2,013 (208)*	2,101 (204)
$P_{ET}CO_2$, mmHg	43.3 (2.3)	38.1 (3.5)†	37.5 (2.5)†	39.5 (1.0)*	33.3 (2.4)*†	33.5 (1.8)*†
$\dot{V}E$, l/min	49.8 (5.7)	62.8 (8.8)†	54.6 (7.5)†‡	52.9 (5.8)	66 (6.9)†	60.4 (7.9)*†‡
S_pO_2, %	95.0 (1.3)‡	76.8 (4.8)	94.6 (1.0)‡	95.8 (0.8)	84.8 (3.7)*†	95.6 (0.8)‡
% of W_{peak}	41.9 (1.6)	49.4 (3.2)†	44.5 (2.9)†‡	40.7 (1.4)	47.6 (2.7)†	44.9 (3.0)†‡
RPE	12 (9–15)	13 (11–15)	12 (10–15)	11 (7–12)*	12 (10–14)*†	11 (8–13)*†

Values are mean (SD), except RPE values are median (range); $n = 12$ participants. HE, heat trial; HYP, hypoxic trial; NOR, normoxic trial; $P_{ET}CO_2$, partial pressure of end-tidal carbon dioxide; RPE, rating of perceived exertion; S_pO_2, capillary oxyhemoglobin saturation; $\dot{V}E$, minute ventilation; $\dot{V}O_2$, oxygen intake; W_{peak}, peak power output. *Significant difference to values before the hypoxic acclimatization; †Significant difference to normoxic values; ‡Significant difference to hypoxic values, $P < 0.05$.

Sotiridis et al 2018

Lämmönsäätelyssä ei juuri muutoksia hypoksiajakson myötä

Table 3. *Thermoregulatory responses at rest and during the last 10 min of the constant-workrate cycling before and after the hypoxic acclimatization for the normoxic, hypoxic, and heat trials*

	Pre-Hypoxic Acclimatization			Post-Hypoxic Acclimatization		
	NOR	HYP	HE	NOR	HYP	HE
$T_{re\ rest}$, °C	37.6 (0.3)	37.5 (0.2)	37.4 (0.6)	37.3 (0.4)	37.2 (0.3)	37.3 (0.3)
$T_{re\ exer}$, °C	38.1 (0.2)	38.0 (0.3)	38.0 (0.3)	37.8 (0.4)	37.9 (0.3)	37.8 (0.3)
T_{sk}, °C	33.5 (0.7)	32.9 (0.7)†	36.6 (0.3)†‡	32.6 (0.8)*	32.6 (0.6)	36.3 (0.4)†‡
$\Delta T_{f\text{-}f}$, °C	0.88 (−2.22 to +10.59)	0.32 (−2.07 to +10.60)	0.26 (−0.73 to +0.78)†	−0.54 (−1.81 to +4.64)	0.07 (−2.1 to +5.99)*	0.2 (−1.53 to +1.05)
$\dot{m}_{sw}$, $g \cdot m^{-2} \cdot min^{-1}$	7.0 (2.8)	7.3 (2.2)	9.6 (2.6)	5.9 (3.1)	6.6 (1.8)	10.5 (2.6)†‡
$\dot{m}_{sw}$ gain, $g \cdot m^{-2} \cdot min^{-1} \cdot °C^{-1}$	27.1 (10.3)	19.3 (8.2)	19.4 (7.0)	20.3 (6.1)	22.7 (15.6)	21.5 (12.6)
Threshold T_{re} for sweating, °C	37.6 (0.2)	37.5 (0.2)	37.4 (0.3)	37.4 (0.4)	37.3 (0.3)	37.3 (0.3)
Δmass, %	−0.65 (0.25)	−0.61 (0.39)	−0.96 (0.14)†‡	−0.65 (0.12)	−0.65 (0.11)	−0.94 (0.19)†‡

Values are mean (SD), except $\Delta T_{f\text{-}f}$ values are median (range); $n = 12$ participants. Δmass, difference in body mass; $\Delta T_{f\text{-}f}$, difference between forearm and fingertip skin temperatures; HE, heat trial; HYP, hypoxic trial; $\dot{m}_{sw}$, sweating rate; NOR, normoxic trial; T_{re}, rectal temperature; T_{sk}, mean weighted skin temperature from four sites. Sweat rate production values ($\dot{m}_{sw}$) are averages of the 30 min of exercise. *Significant difference to values before the hypoxic acclimatization; †Significant difference to normoxic values; ‡Significant difference to hypoxic values, $P < 0.05$.

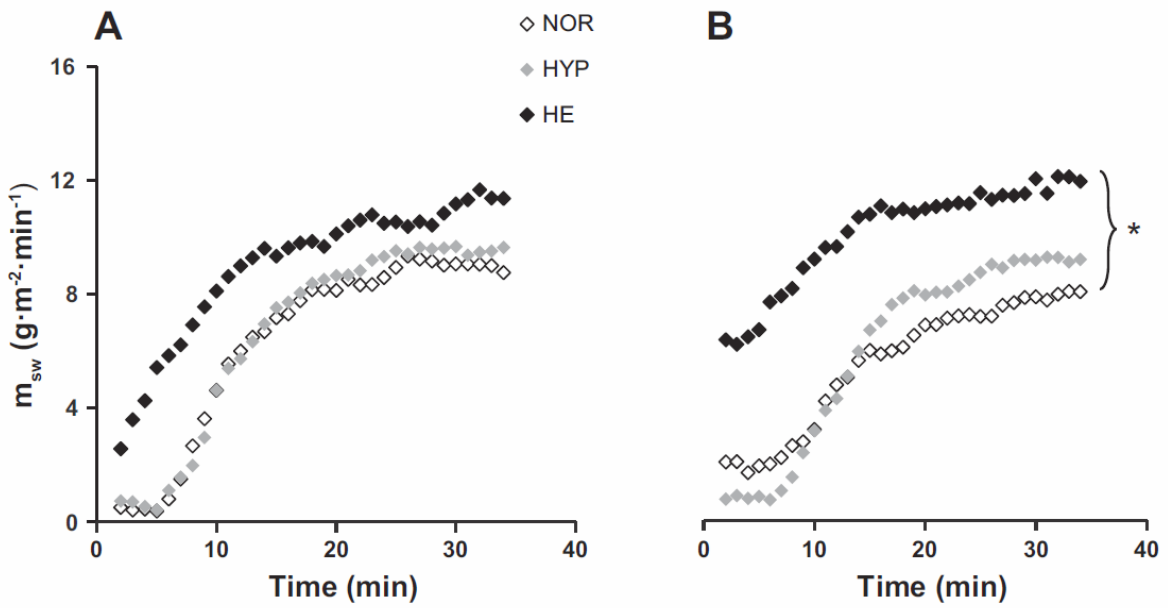

Fig. 2. Temporal response of the mean forehead sweating rate ($\dot{m}_{sw}$, $g \cdot m^{-2} \cdot min^{-1}$) during exercise in the normoxic (NOR), hypoxic (HYP), and heat (HE) trials before (*A*) and after (*B*) the hypoxic acclimatization ($n = 12$ participants). *$P < 0.05$. SD bars are omitted for clarity.

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Suorituskyky

Treeni (10 päivän jakso) puree hieman, mutta eipä juuri eroa eri olosuhteiden välillä

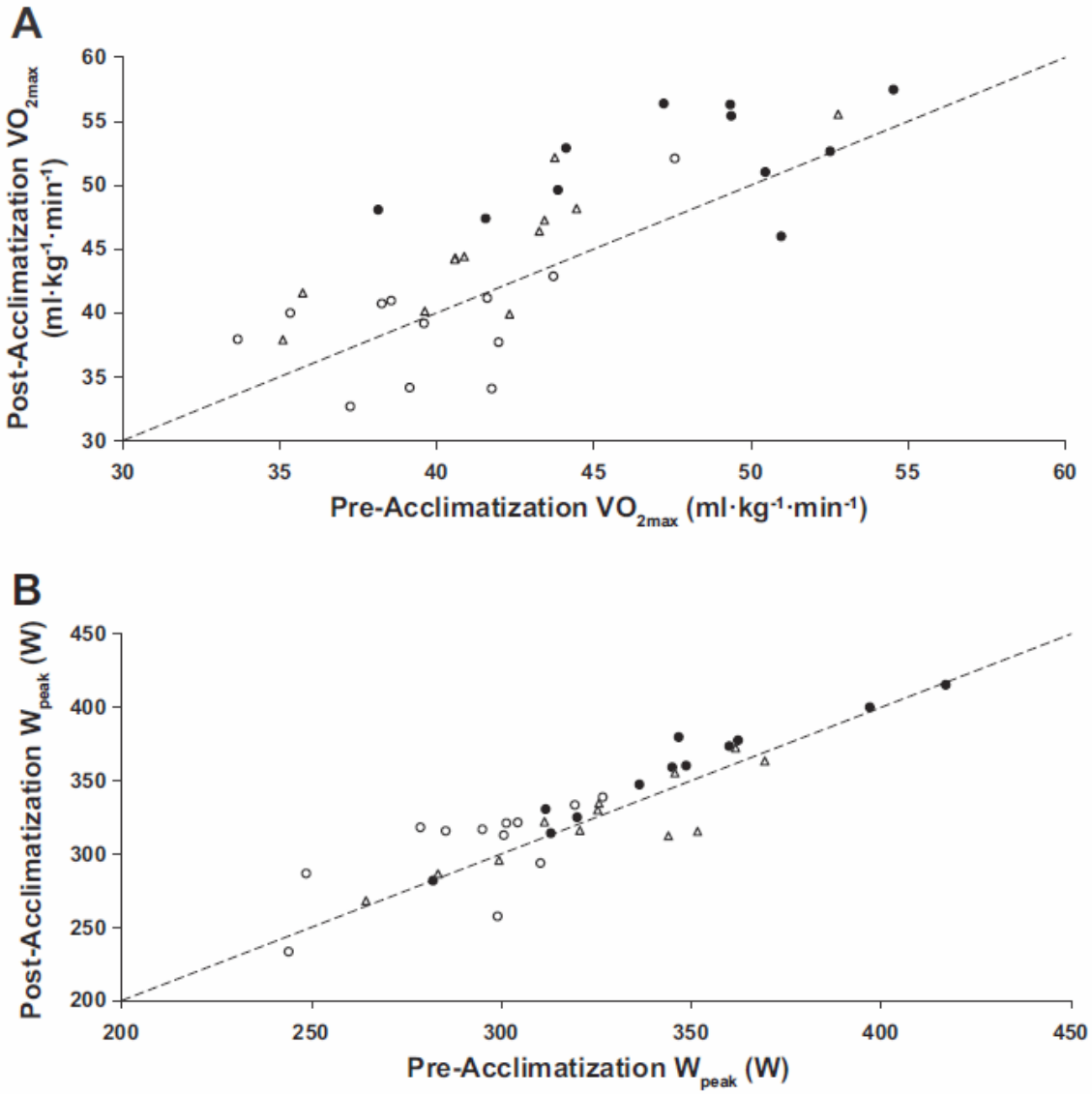


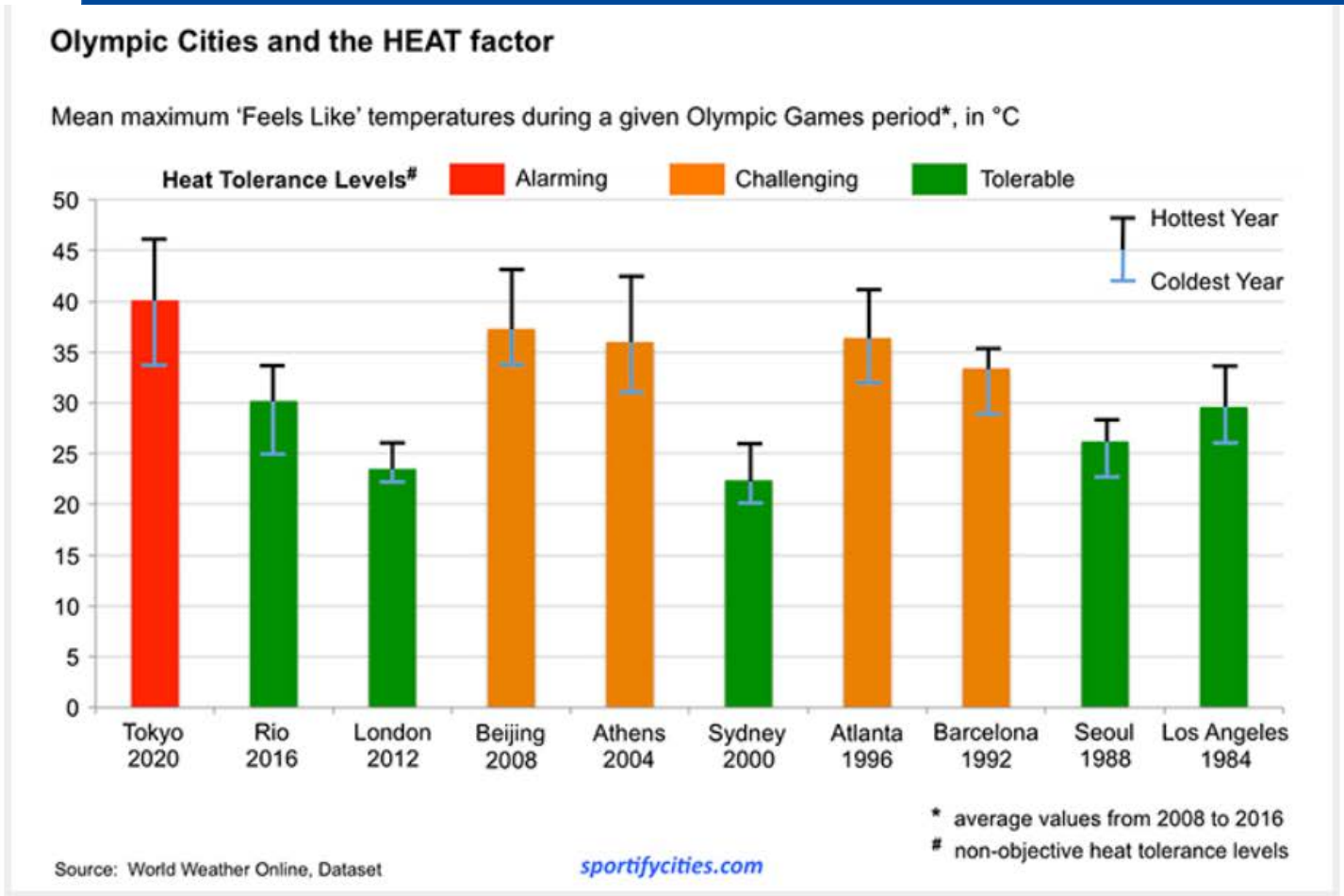
Fig. 5. Pre- and post-acclimatization individual data for maximal oxygen uptake ($\dot{V}O_{2max}$, $ml \cdot kg^{-1} \cdot min^{-1}$; *A*) and peak power output (W_{peak}, W; *B*) in normoxia (closed circles), hypoxia (open circles), and heat (triangles).

Sotiridis et al 2019

Entäs kun kisat on kuumassa, ei korkealla?

- Sopeutuminen kuumaan keskeistä
- Korkean leiriä edeltävä kuumaan sopeutuminen voi auttaa korkealle sopeutumista
- Kuuma-altistuksista korkealla ei ehkä lisäefektiä korkean vaikutuksiin, mutta entä kuumasopeutumisen ylläpito?
- Ennen kisoja viimeiset kaksi viikkoa kannattaa oleskella kisaolosuhteissa

Case Tokio 2020



Athletes competing at the 2020 Tokyo Olympics are likely to be exposed to the hottest perceived temperatures ever experienced during the modern Summer Olympic Games.

Case Sapporo 2020

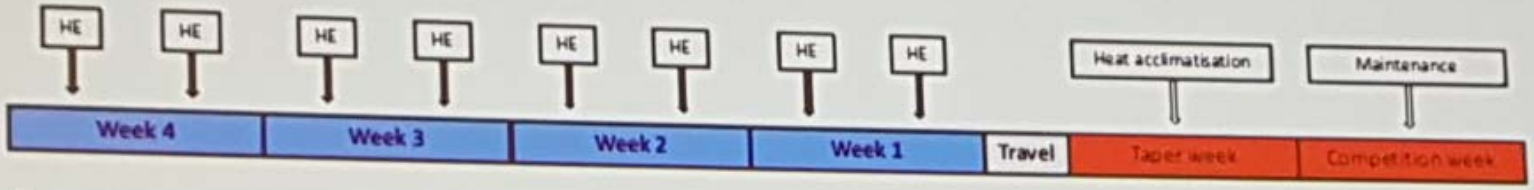
Sapporo Weather August 2019

Sapporo weather Thursday August 1, 2019	Sapporo weather Friday August 2, 2019	Sapporo weather Saturday August 3, 2019	Sapporo weather Sunday August 4, 2019	Sapporo weather Monday August 5, 2019	Sapporo weather Tuesday August 6, 2019
					
30°C	30°C	30°C	30°C	28°C	29°C
light rain	light rain	light rain	sky is clear	scattered clouds	overcast clouds
min: 19°C max: 30°C	min: 19°C max: 30°C	min: 16°C max: 30°C	min: 18°C max: 30°C	min: 18°C max: 28°C	min: 19°C max: 29°C
Night: 19°C Evening: 24°C Morning: 28°C	Night: 19°C Evening: 23°C Morning: 28°C	Night: 16°C Evening: 22°C Morning: 29°C	Night: 18°C Evening: 22°C Morning: 28°C	Night: 18°C Evening: 22°C Morning: 25°C	Night: 19°C Evening: 23°C Morning: 27°C
Cloud cover: 48% **Rain:** 1.87	**Cloud cover:** 96% **Rain:** 0.5	**Cloud cover:** 27%		**Cloud cover:** 28%	**Cloud cover:** 99%
36°C	33°C	33°C	31°C	29°C	31°C
Real feel temperature	Real feel temperature	Real feel temperature	Real feel temperature	Real feel temperature	Real feel temperature

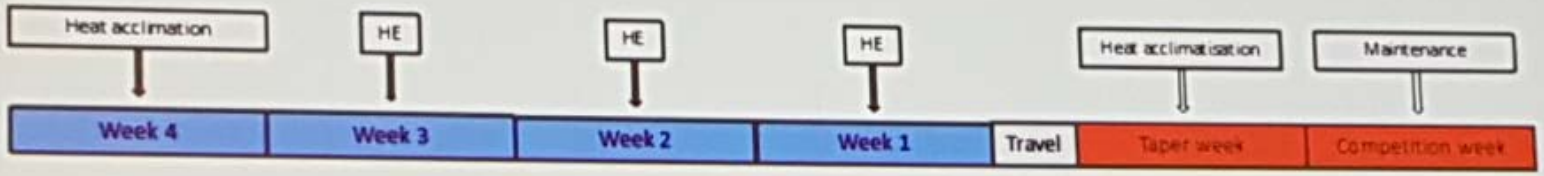
Case Tokio (Sapporo) 2020

Arriving early to competition

A



B



HE (heat exposure)
Unique exposure conducting non-key workout (e.g. ≥60 min, 40ºC & 40% RH), or clamped heat rate protocol (e.g. 85% HR_{max}, ≥60 min, 40ºC & 40% RH), or passive heating post-workout in the cool (e.g. 20 to 45 min, sauna ~80ºC or hot bath 40ºC)

Heat acclimatisation
Training outdoors at the competition venue in the heat, avoiding the hottest part of the day when doing key workouts.

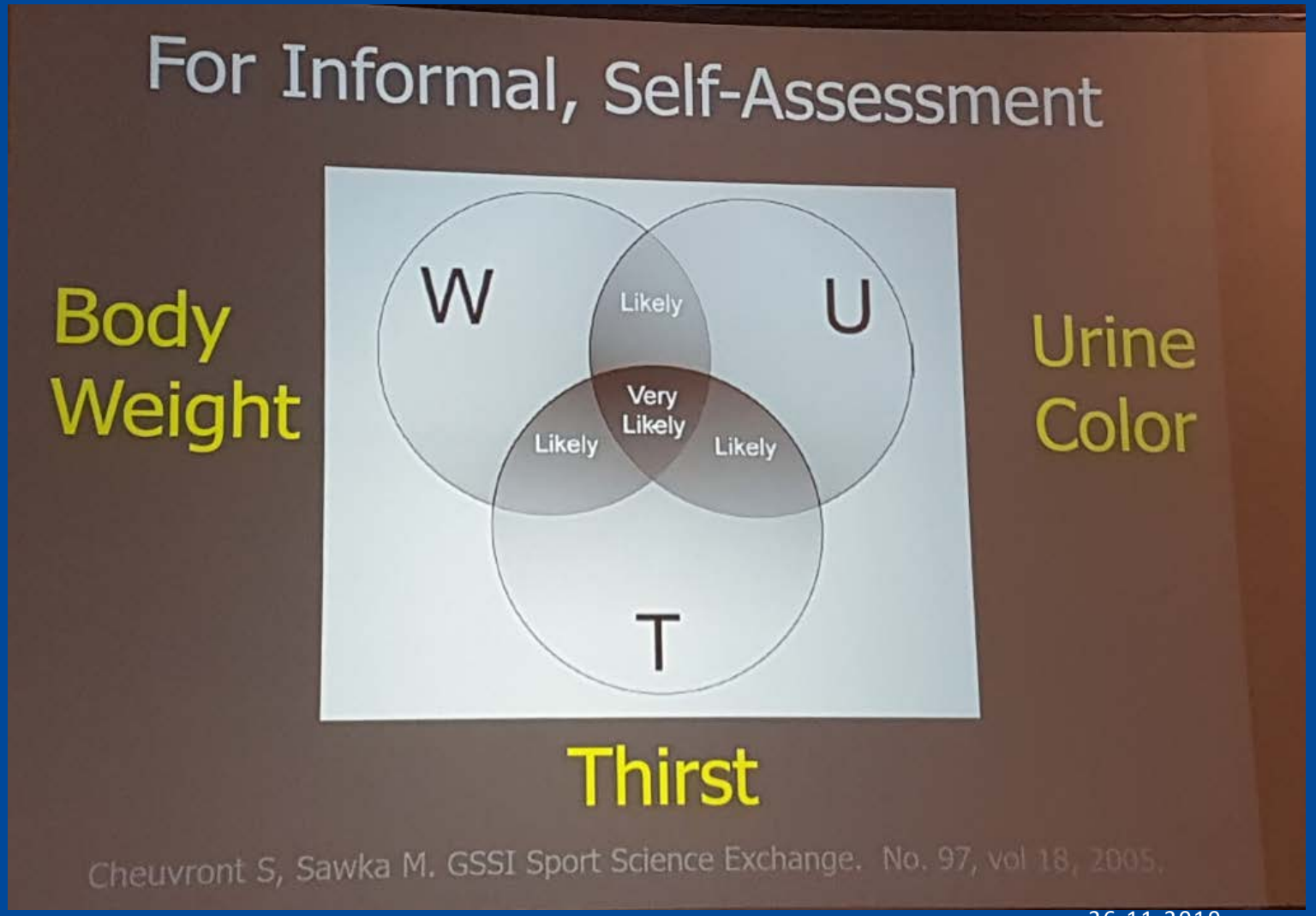
Heat acclimation
Daily exposures for 7 to 14 days of clamped heat rate protocol (e.g. 85% HR_{max}, ≥60 min, 40ºC & 40% RH), or non-key workouts (e.g. ≥60 min, 40ºC & 40% RH), or passive heating post-workout in the cool (e.g. 20 to 45 min, sauna ~80ºC or hot bath 40ºC)

Maintenance
Heat acclimation/acclimatisation adaptations maintained through competing and conducting training sessions in the outdoor heat.

Saunders et al. (2019) *Int J Sport Nutr Exerc Metab*

Nestetasapainon seuranta

1		Jos virtsasi väri vastaa värejä 1–3, sinulla on hyvä nestetasapaino. Juo suositusten mukaisesti.
2		
3		
4		Jos virtsasi väri vastaa punaisen alapuolella olevia 4–6 värejä, sinulla on nestehukka. Juo enemmän vettä/nestettä!
5		
6		
7		
8		Terveurheilija.fi



Hikoilkaa ja hengästykää, hyvät ystävät!

24.7.-9.8.

25.8.-6.9.