Presteren in hitte en koude

Prof. Dr. Hein Daanen

Faculteit der Gedrags- en Bewegingswetenschappen

Vrije Universiteit Amsterdam

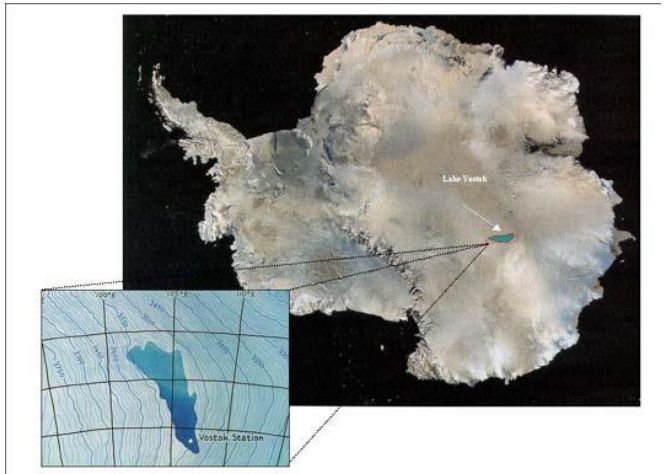
Achtergrond

- Hoogleraar Thermofysiologie VU vanaf 2003
- Onderzoeker TNO 1991 – 2013

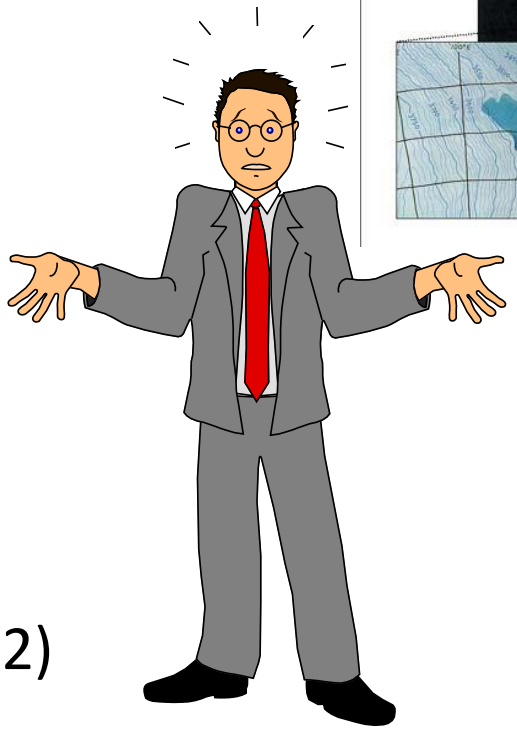
VU VRIJE UNIVERSITEIT AMSTERDAM

Faculty of Behavioural and Movement Sciences

Onze uitdaging



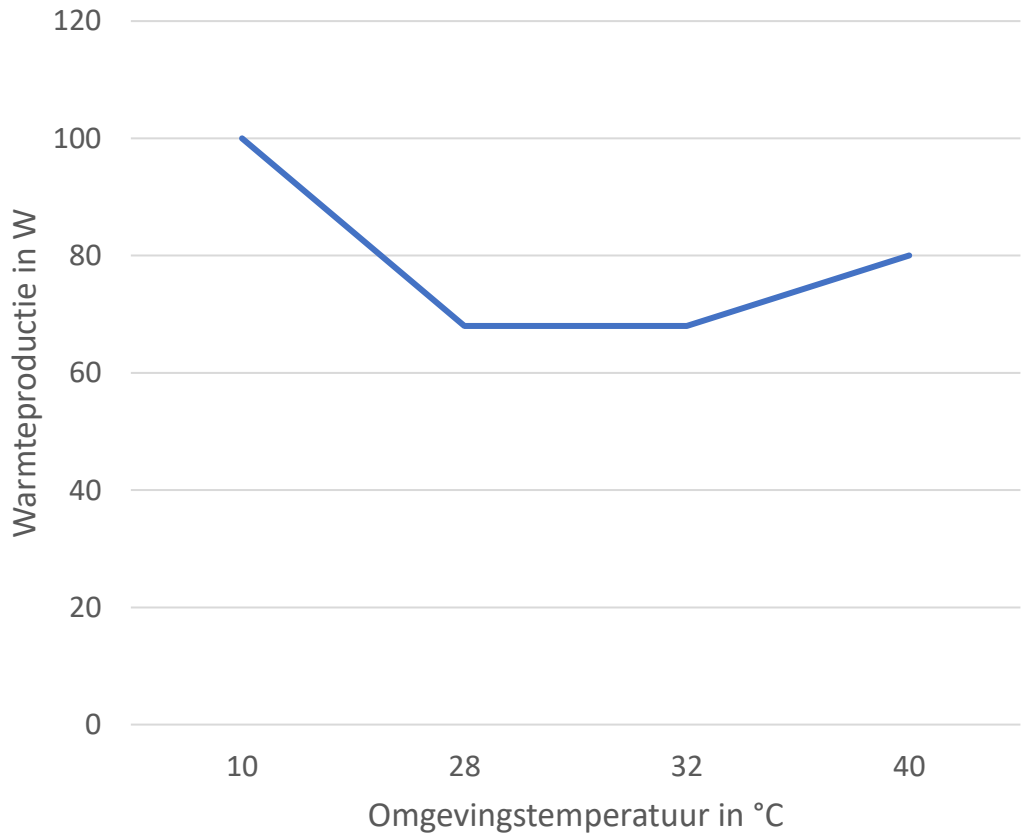
57.8°C (september 1922)



-89.5°C (juli 1983)

Comfort-zone

Koude

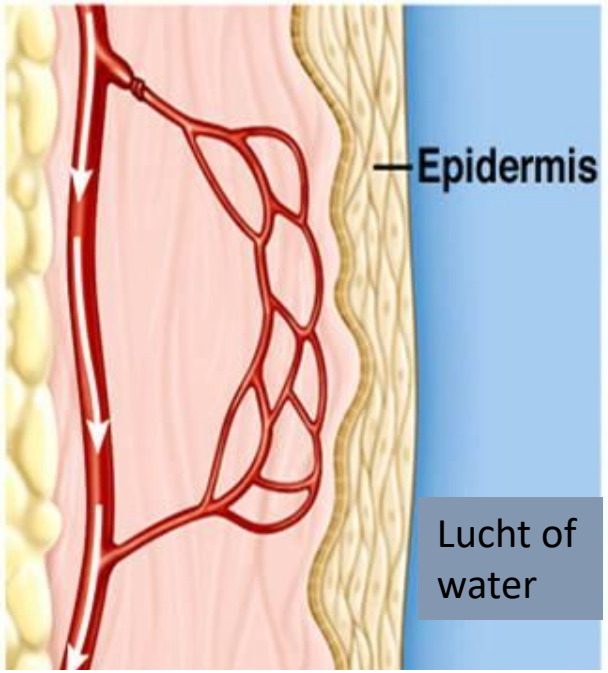


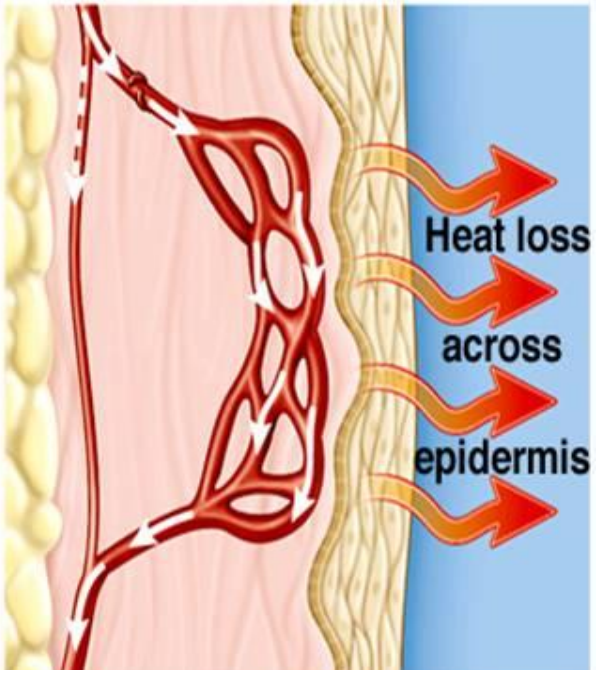
Hitte

Reactie op hitte en koude

Koude

Hitte





Bloedvatvernauwing

Bloedvatverwijding

Rillen en Zweten

Met rillen kun je tot ongeveer 300 W aan warmte maken, zonder rillen 15 W (bruin vet verbranden)

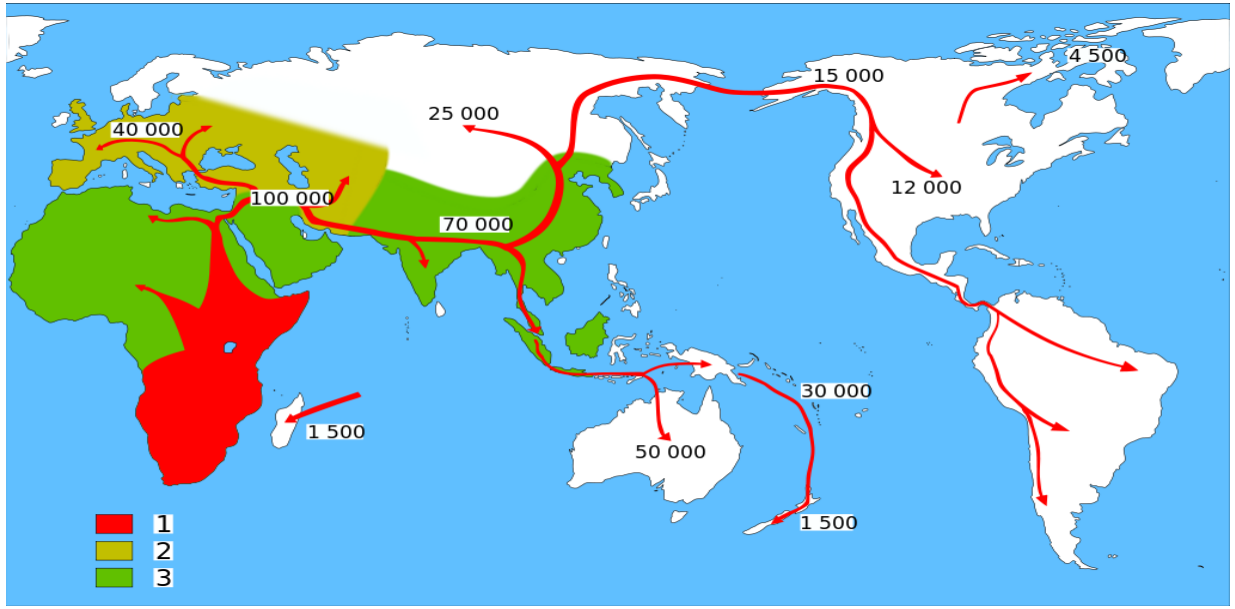
Zweten: alleen verdamping koelt!
Max. 3 L/uur
> 2000 W koeling!

We zijn tropische dieren..

We koelen geweldig in de hitte

We kunnen maar een beetje warmte maken in de kou

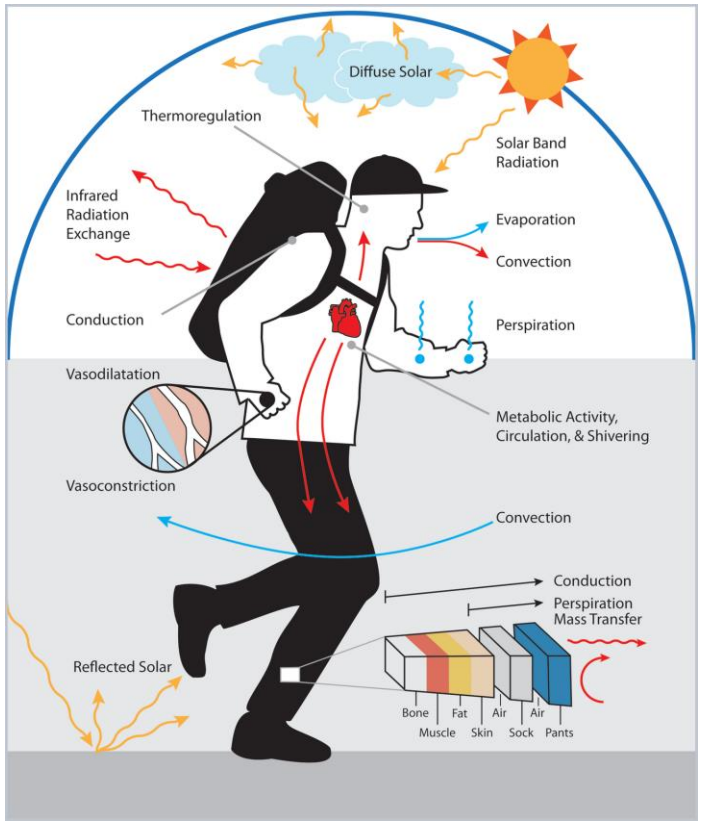
We passen ons wel aan hitte aan, maar niet aan kou…

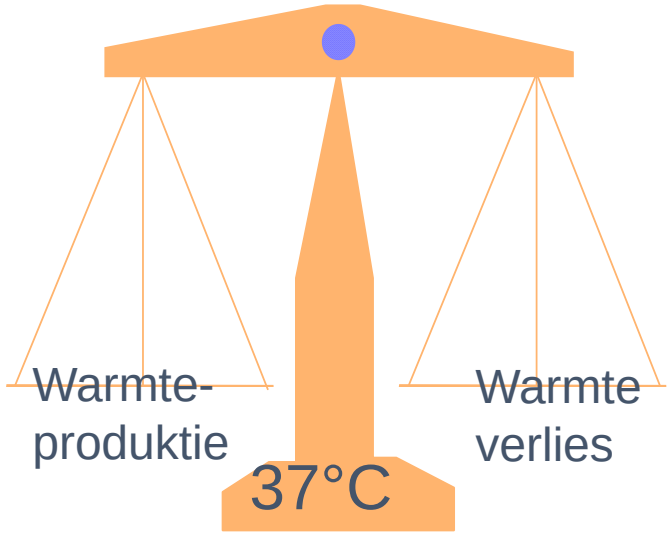


We komen dan ook pas recent uit Afrika (40000 jaar..)

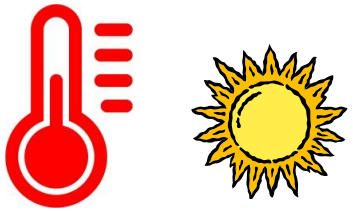
De warmtebalans

warmteproduktie ± droog warmteverlies – nat warmteverlies = opslag





Invloeden op de warmtebalans

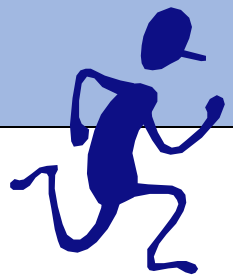


Lichaamsbouw
Acclimatisatie
Getraindheid

Temperatuur
Zon
Vochtigheid
Wind

Warmtebalans

Inspanning



Kledingisolatie
Waterdampweerstand

Meten van hittebelasting

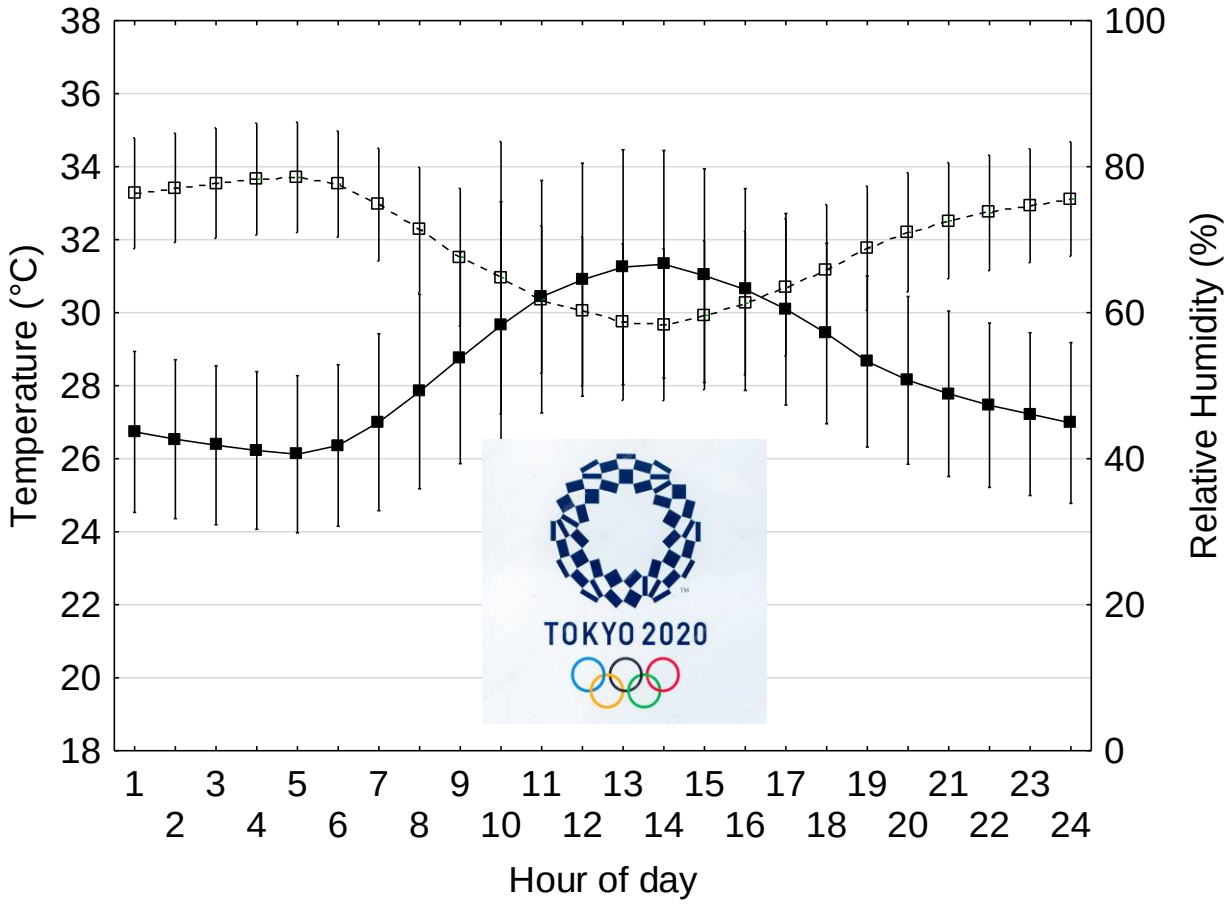
Wet Bulb Globe Temperature (WBGT)=
0,7 x natte bol temperatuur +
0,2 x zwarte bol temperatuur +
0,1 x droge bol temperatuur

Ambient conditions prior to Tokyo 2020 Olympic and Paralympic games. Considerations for acclimation or acclimatization

Gerrett, N., Kingma, B., Sluijter, R.& Daanen, H.A.M.

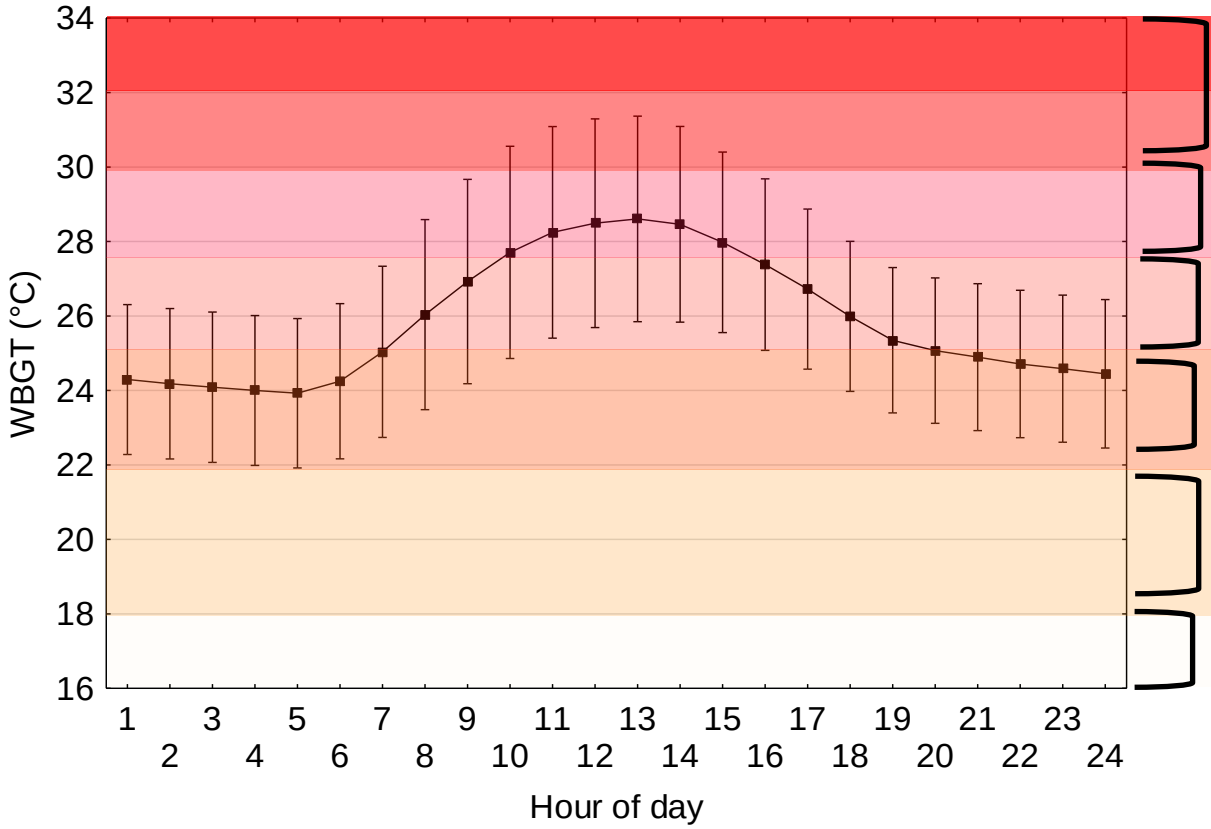
Frontiers in Physiology (2019)

A



- Gegevens van 29 jaar (1990-2018)
- Olympische periode 2020 (24 juli – 9 augustus)

WBGT tijdens de **OS**: 27.0 ± 2.8 ˚C



Cancel all exercise

Cancel practice and competition

Cancel level for exertional heat stroke risk

Risk for unfit, non-acclimatized individuals is high

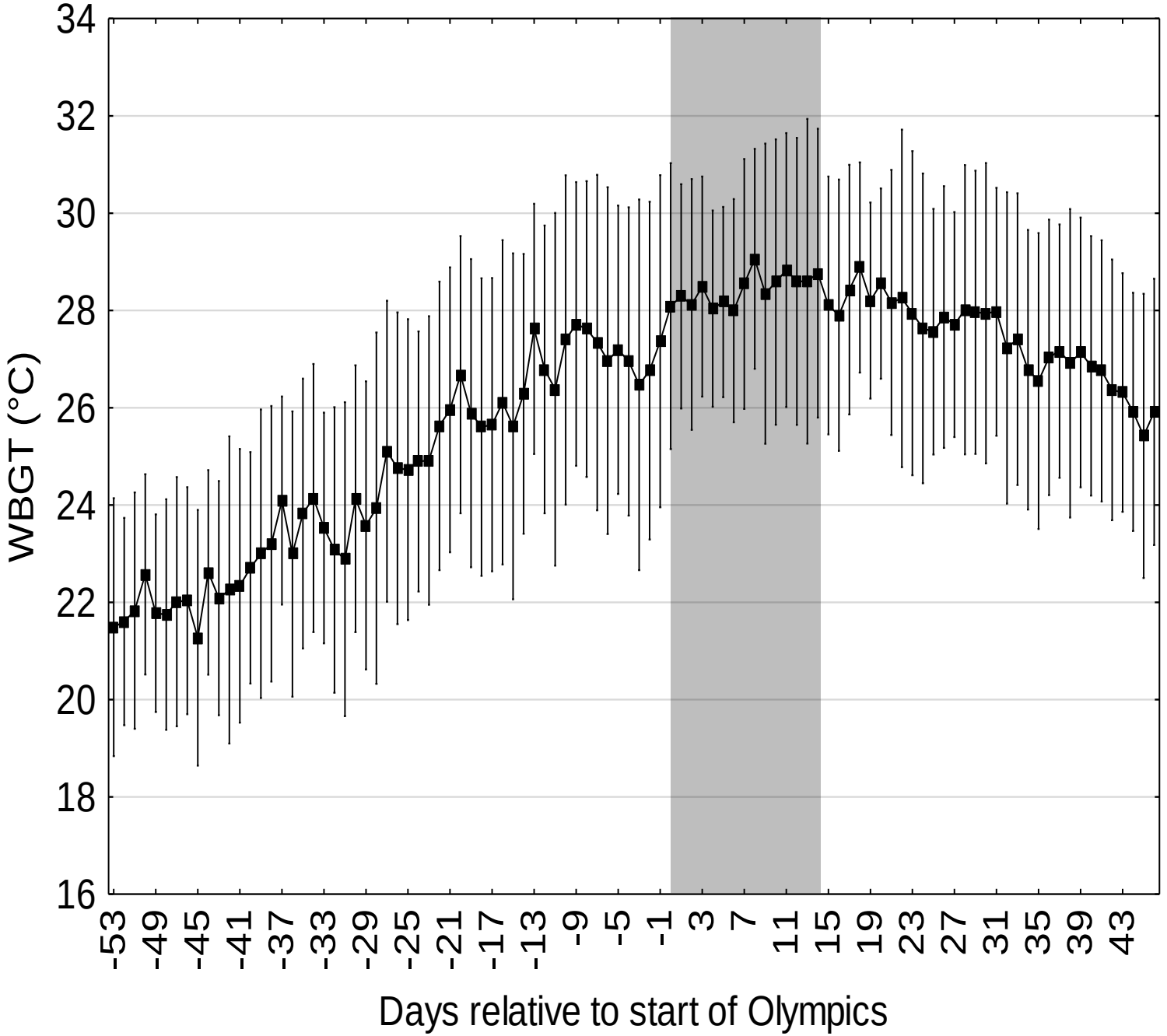
Risk for all competitors increases

Risk of exertional heat stroke and heat illness; high risk individuals should be monitored or not compete

Generally safe for normal activity

Based on ACSM position stand (Armstrong et al. 2007)

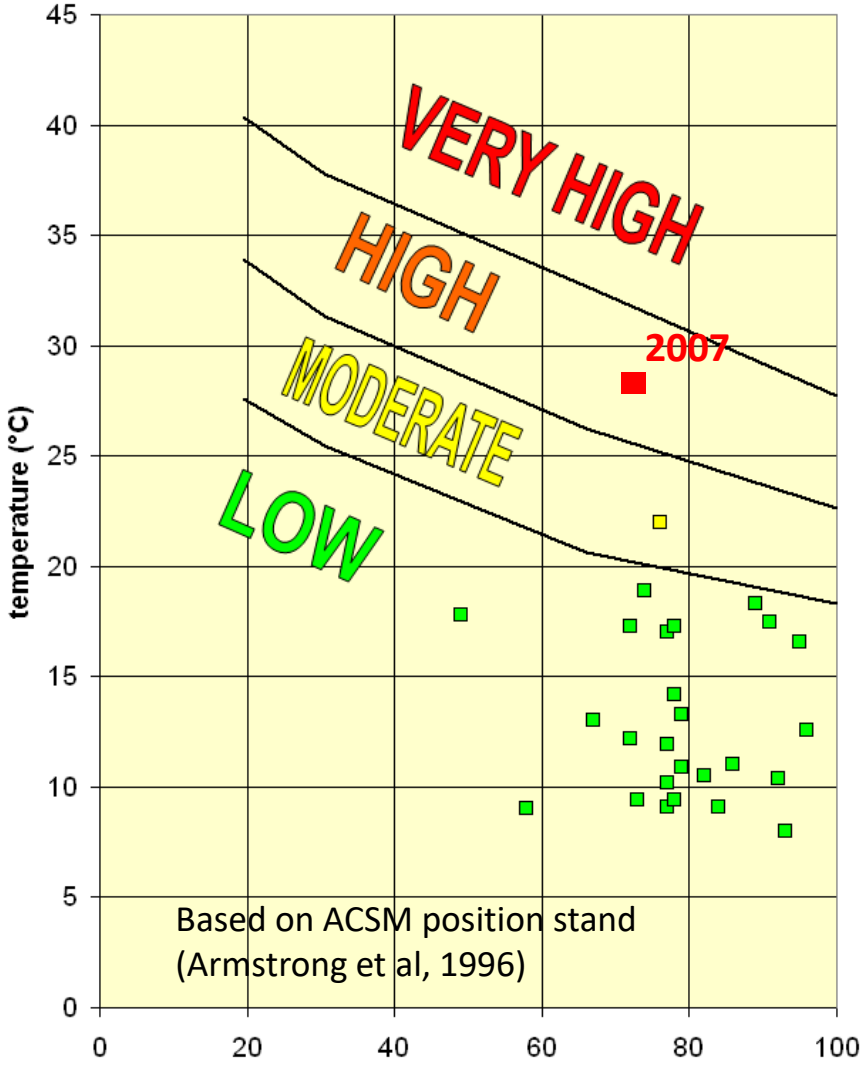
VU VRIJE UNIVERSITEIT AMSTERDAM
Faculty of Behavioural and Movement Sciences



WBGT (van 12:00 – 15:00) gerelateerd aan de startdag van de OS (dag 0) (Garrett et al. 2019)

VU VRIJE UNIVERSITEIT AMSTERDAM
Faculty of Behavioural and Movement Sciences

Kans op hitteproblemen tijdens Marathon van Rotterdam tot en met 2007



VU VRIJE UNIVERSITEIT AMSTERDAM

Faculty of Behavioural and Movement Sciences

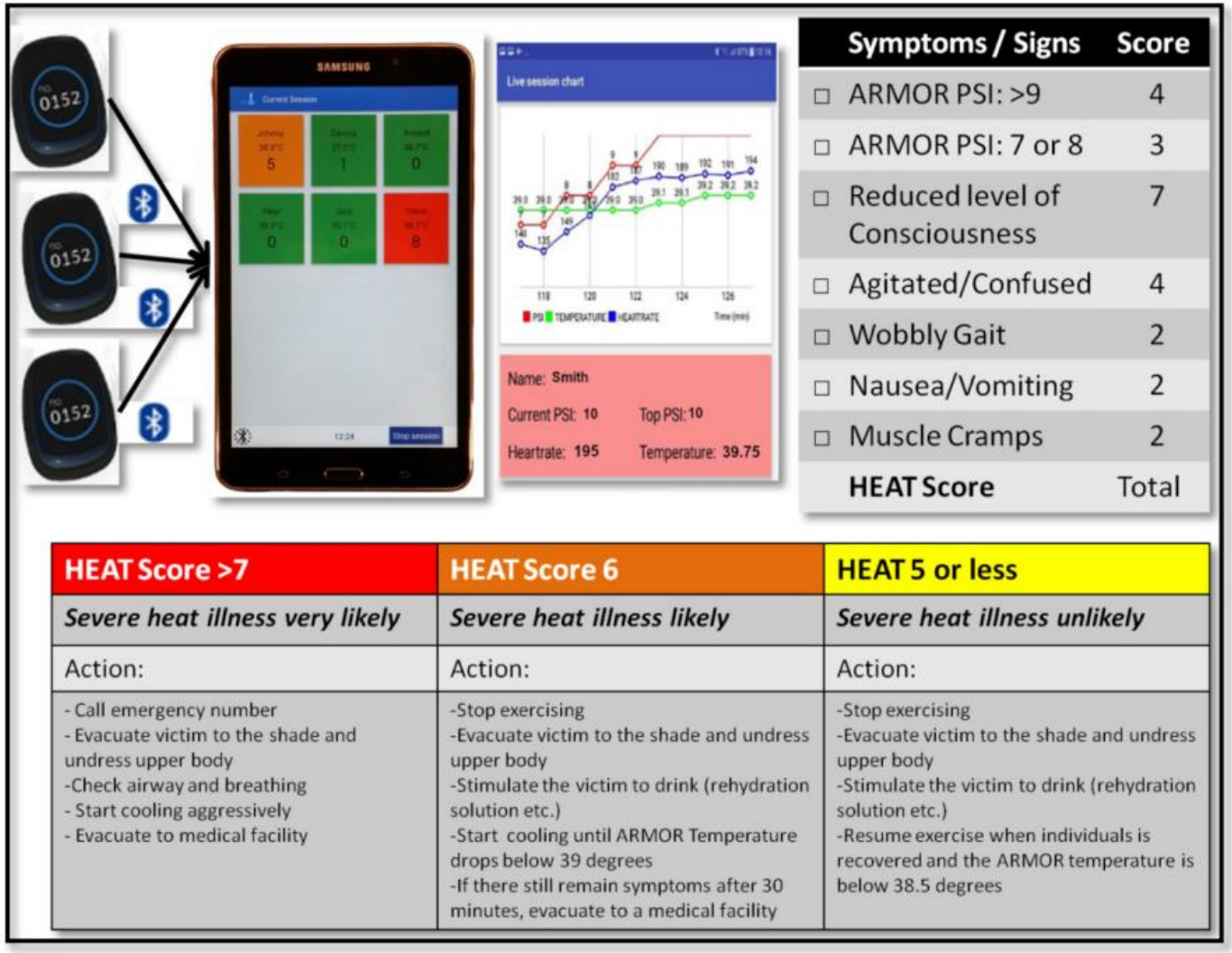
Hitteziekten

- Hitte-uitslag
- Hitte-kramp
- Hitte-uitputting
- Heat syncope - flauwvallen
- Heat stroke - hitteberoerte

Kerntemperatuur > 40°C

Aandoeningen van CNS (bewegen, overgeven, hoofdpijn, ..)

Wobbling (zwalken) als indicatie hitteberoerte?



Symptoms / Signs	Score
☐ ARMOR PSI: >9	4
☐ ARMOR PSI: 7 or 8	3
☐ Reduced level of Consciousness	7
☐ Agitated/Confused	4
☐ Wobbly Gait	2
☐ Nausea/Vomiting	2
☐ Muscle Cramps	2
HEAT Score	Total

HEAT Score >7	HEAT Score 6	HEAT 5 or less
Severe heat illness very likely	***Severe heat illness likely***	***Severe heat illness unlikely***
Action:	Action:	Action:
- Call emergency number - Evacuate victim to the shade and undress upper body -Check airway and breathing - Start cooling aggressively - Evacuate to medical facility	-Stop exercising -Evacuate victim to the shade and undress upper body -Stimulate the victim to drink (rehydration solution etc.) -Start cooling until ARMOR Temperature drops below 39 degrees -If there still remain symptoms after 30 minutes, evacuate to a medical facility	-Stop exercising -Evacuate victim to the shade and undress upper body -Stimulate the victim to drink (rehydration solution etc.) -Resume exercise when individuals is recovered and the ARMOR temperature is below 38.5 degrees

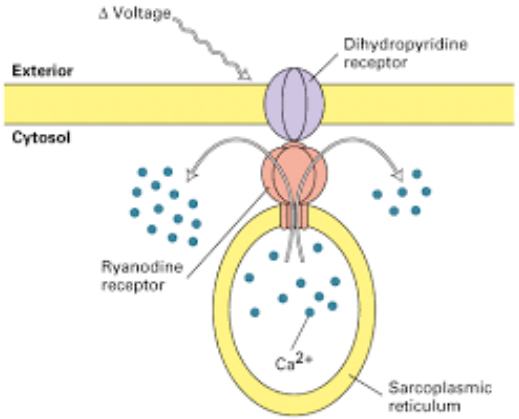
Cerebellum affected by high body core temperatures. Investigate walking pattern:

Buller, M.J., Delves, S.K., Fogarty, A.L., Veenstra, B.J.

On the real-time prevention and monitoring of exertional heat illness in military personnel(2021) Journal of Science and Medicine in Sport.

VU VRIJE UNIVERSITEIT AMSTERDAM
Faculty of Behavioural and Movement Sciences

Pathologie - Hitte-intolerantie



Bron: Steemit.com

Plotselinge toename van warmteproductie (maligne hyperthermie)

Problemen met warmte-afgifte (moeite met zweten, slechte huiddoorbloeding)

Bron: Van Brakel

Thermoregulatie niet meer in orde (hypothalamus)

Hitte-intolerantie testen

Worden vooral in Israel gebruikt, maar ook in Nederland voor Return-to-duty.

Zijn nog niet echt betrouwbaar

Journal of Thermal Biology 38 (2013) 539–542

Contents lists available at ScienceDirect

Journal of Thermal Biology

journal homepage: www.elsevier.com/locate/jtherbio

Refining the distinction between heat tolerant and intolerant individuals during a Heat tolerance test

Druyan Amit[a,1], Ketko Itay[a,b], Yanovich Ran[a,b], Epstein Yoram[a,c], Heled Yuval[a,b,*]

[a] Heller Institute of Medical Research, Sheba Medical Center, Tel Hashomer 52621, Israel
[b] The IDF Institute of Military Physiology, Israel
[c] Sackler Faculty of Medicine, Tel Aviv University, Israel

Journal of Thermal Biology 78 (2018) 42–50

Contents lists available at ScienceDirect

Journal of Thermal Biology

journal homepage: www.elsevier.com/locate/jtherbio

A new occupational heat tolerance test: A feasibility study

Emily R. Watkins*, Jemma Gibbons, Yanoula Dellas, Mark Hayes, Peter Watt, Alan J. Richardson

Environmental Extremes Laboratory, Welkin Laboratories, University of Brighton, Eastbourne BN20 7SN, UK

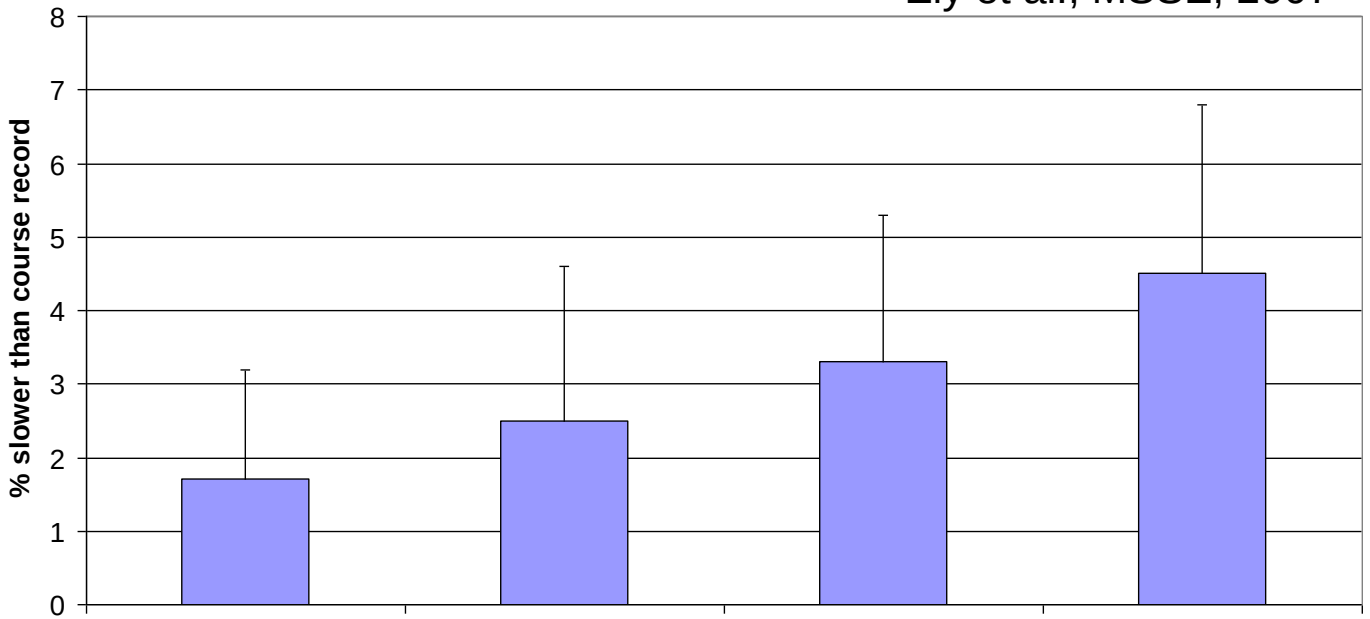
VU VRIJE UNIVERSITEIT AMSTERDAM

Faculty of Behavioural and Movement Sciences

Prestatieverlies in hitte

Prestatieverlies gerelateerd aan WBGT voor 7 marathons in US/Canada

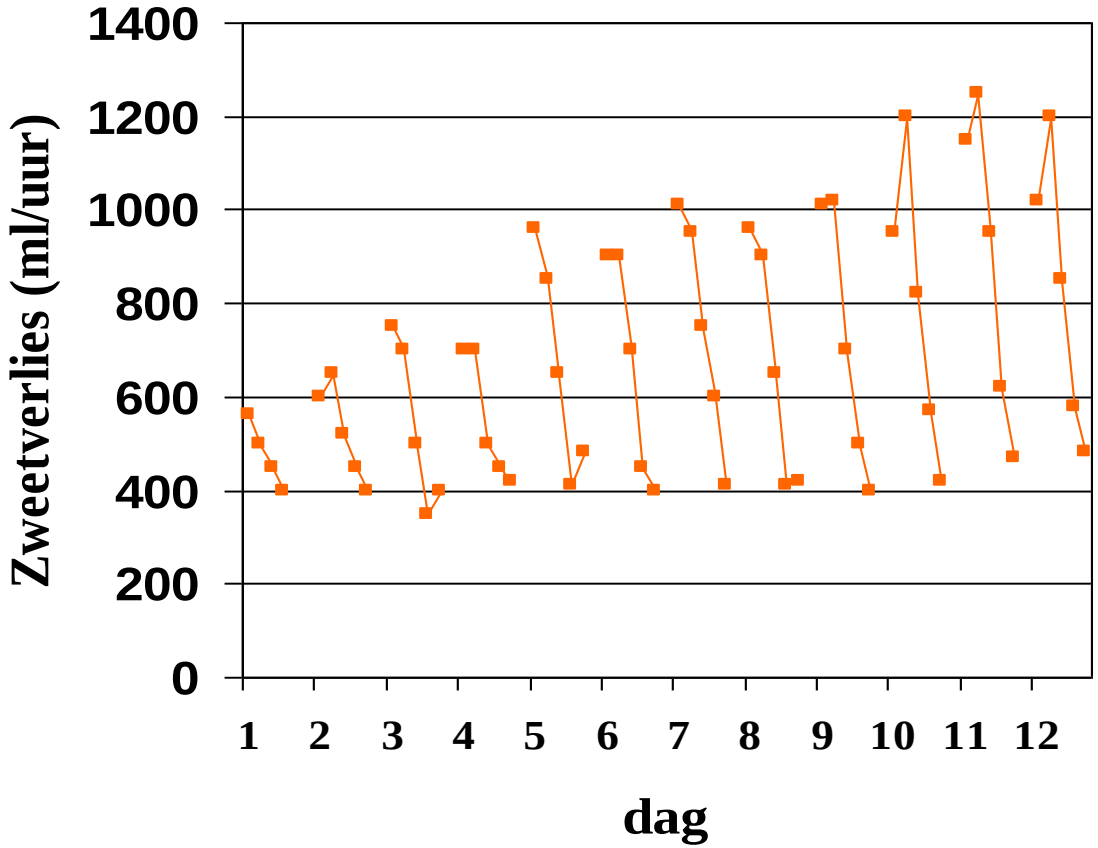
Ely et al., MSSE, 2007

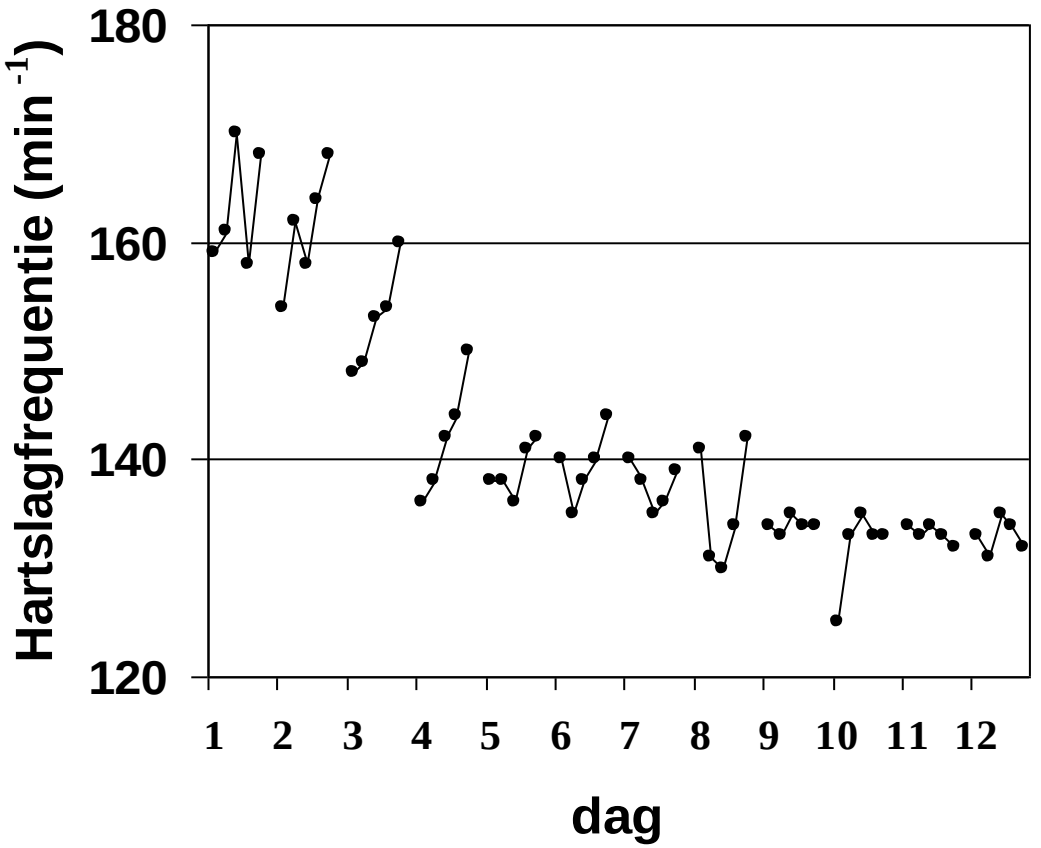


Hoe prestatieverlies in de hitte tegengaan?

- Selectie - magere kleine mensen hebben minder risico
- Pacing strategie – rustig beginnen in hitte
- **Acclimatisatie aan hitte**
- Fysieke training (cross acclimatisatie)
- **Koelen (voor, tijdens en na inspanning)**

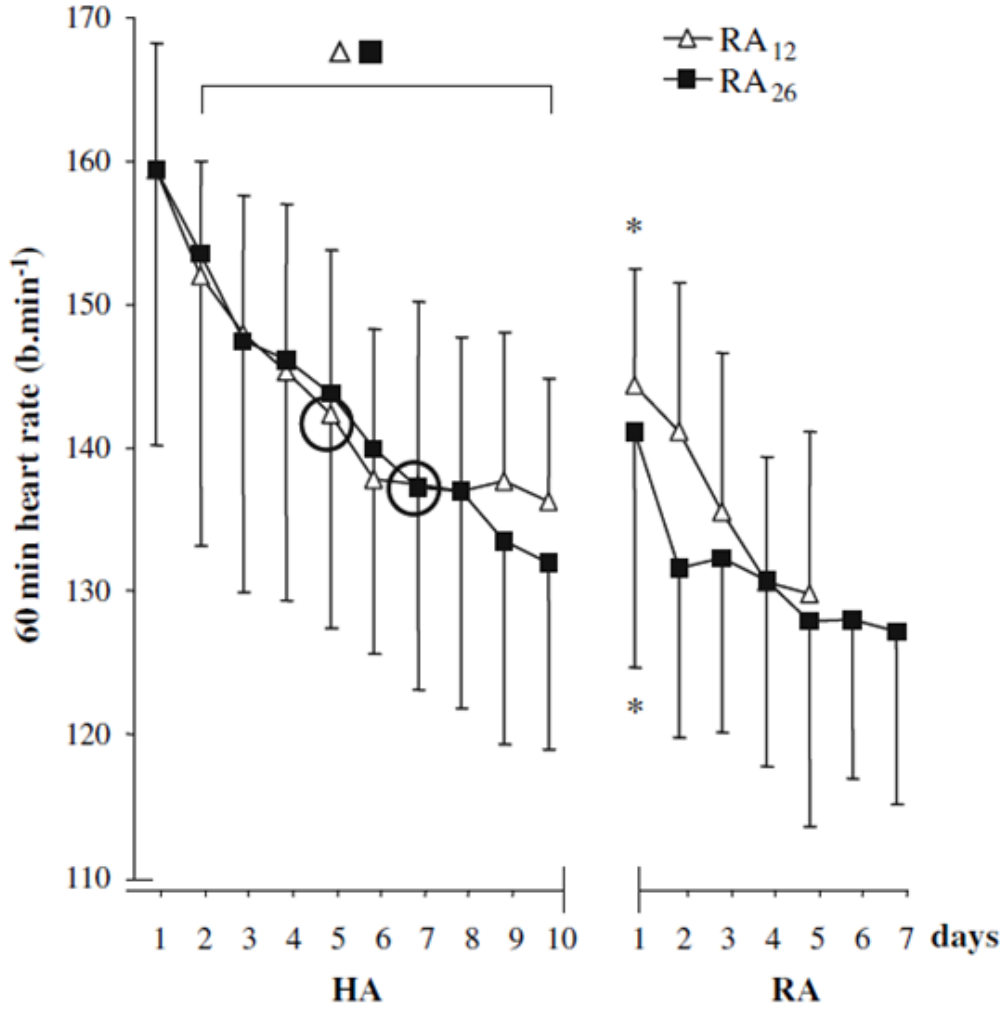
Hitte acclima(tisa)tie





Strydom et al., 1966

De- and Re-acclimatisatie



Hoe acclimatiseer je goed?

- Omgevingtemp > verwacht (bijv. 32°C)
- Vochtigheid > verwacht (bijv. 75%)
- Tijdsduur > verwacht (advies > 1 uur/dag)
- Controlled hyperthermia (kerntemp 38,5°C)
- Idealiter >10 dagen, maar kan worden geïndividualiseerd
- Koelte tijdens de nachten (nodig voor herstel)

Koelconcepten

- **Water in onderkleding**

- **Lucht**

  Buitenlucht in kledingspouw voor betere verdamping zweet

  Droging van lucht

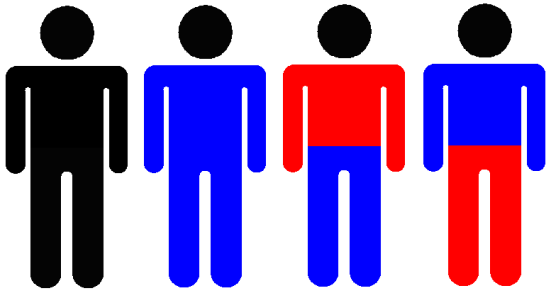
  Koeling van lucht

- **Faseverandering materialen**

  Overgang van vast naar vloeibaar onttrekt warmte aan de huid

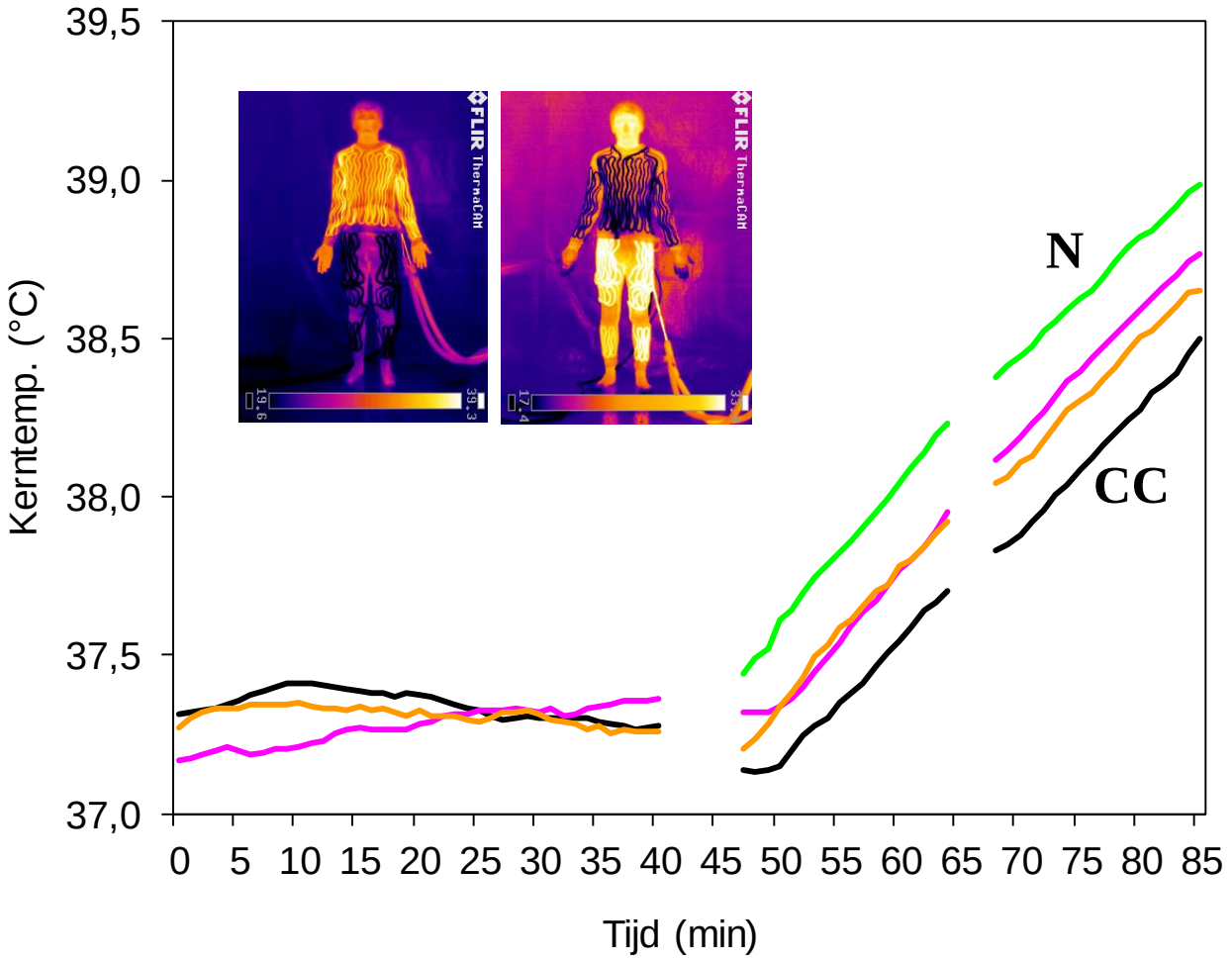
Voorkoelen

- **8 mannen**
- **Vier koelmethoden (40 min):**

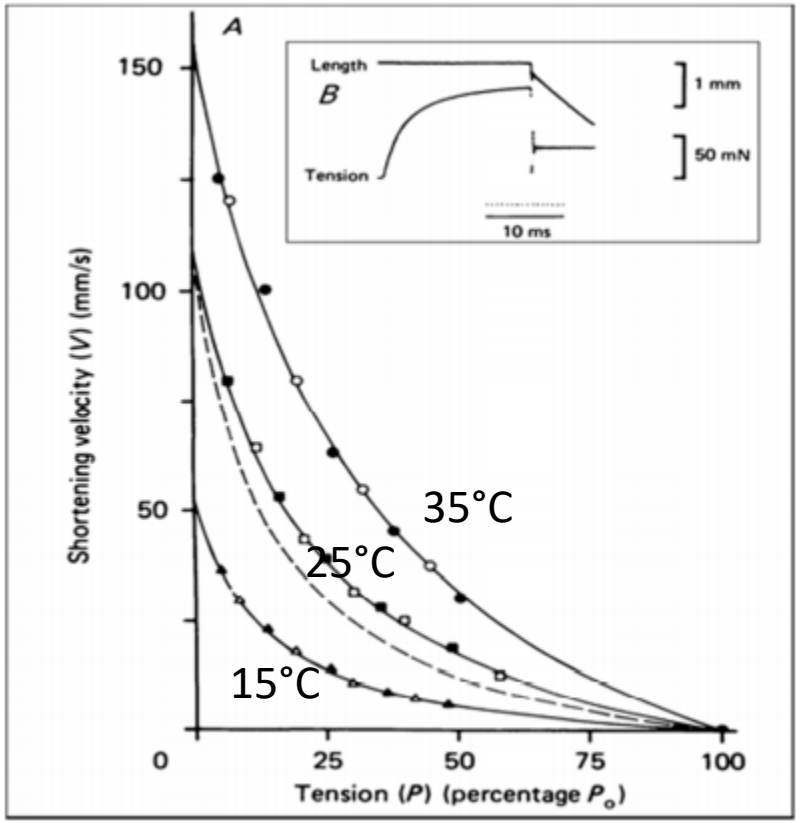


- **Gevolgd door 40 min inspanning op 60% VO_2max**

Temperatuurverloop na voorkoeling



Spierprestatie in kou



International Journal of *Molecular Sciences*

MDPI

Review

Temperature Effects on Force and Actin–Myosin Interaction in Muscle: A Look Back on Some Experimental Findings

K. W. Ranatunga

School of Physiology, Pharmacology & Neuroscience, University of Bristol, Bristol BS8 1TD, UK; K.W.Ranatunga@Bristol.ac.uk; Tel.: +44-117-931-1969

Received: 24 April 2018; Accepted: 16 May 2018; Published: 22 May 2018

check for updates

Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology • Open Access • Volume 231, Issue 2, Pages 91 - 101 • 1 June 2017

External heating garments used post-warm-up improve upper body power and elite sprint swimming performance

Wilkins E.L.[a, b], Havenith G.[a]

VU VRIJE UNIVERSITEIT AMSTERDAM

Faculty of Behavioural and Movement Sciences

Duurprestatie in de kou

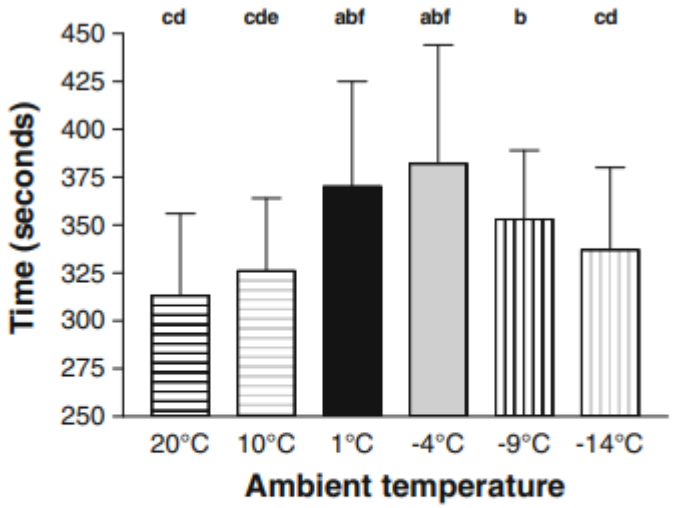


Fig. 3 Time to exhaustion (TTE, $n = 7$) at the six ambient conditions. The *letters a*, *b*, *c*, *d*, *e*, *f* indicate a significant difference in TTE between ambient conditions ($P < 0.05$) from corresponding values at 20, 10, 1, −4, −9 and −14 °C, respectively. Values are expressed as mean ± SD

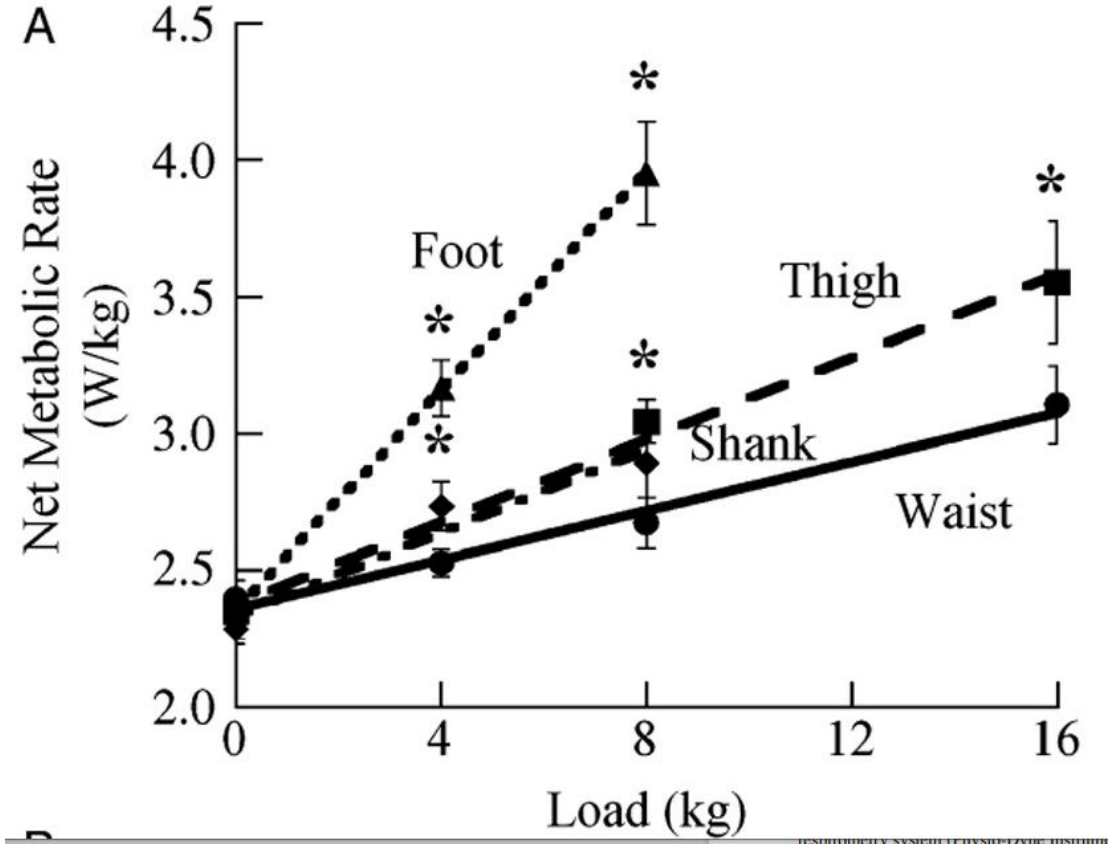
Eur J Appl Physiol (2012) 112:3939–3947
DOI 10.1007/s00421-012-2373-1

ORIGINAL ARTICLE

Effect of ambient temperature on endurance performance while wearing cross-country skiing clothing

Mariann Sandsund · Vegard Saursaunet · Øystein Wiggen · Julie Renberg · Hilde Færevik · Mireille C. P. van Beekvelt

Extra metabolisme door gewicht

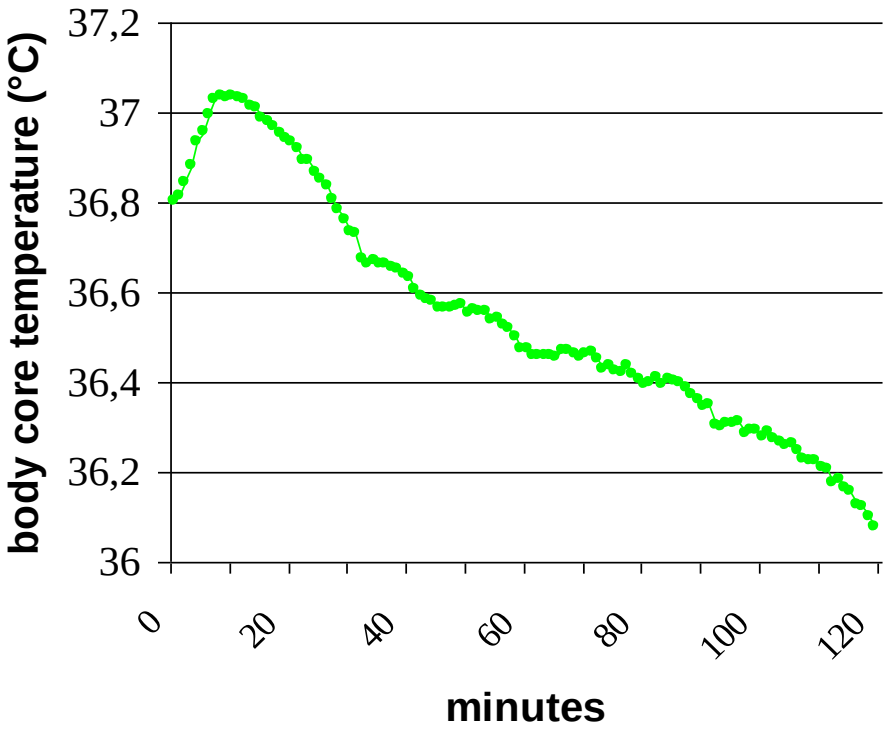


The Effects of Adding Mass to the Legs on the Energetics and Biomechanics of Walking

RAYMOND C. BROWNING[1], JESSE R. MODICA[1], RODGER KRAM[1], and AMBARISH GOSWAMI[2]

[1]Department of Integrative Physiology, University of Colorado, Boulder, CO; and [2]Honda Research Institute, Mountain View, CA

Koude - Onderkoeling



Onderkoeling

Resultaat van een langdurige negatieve warmtebalans

TREATMENT IN THE FIELD

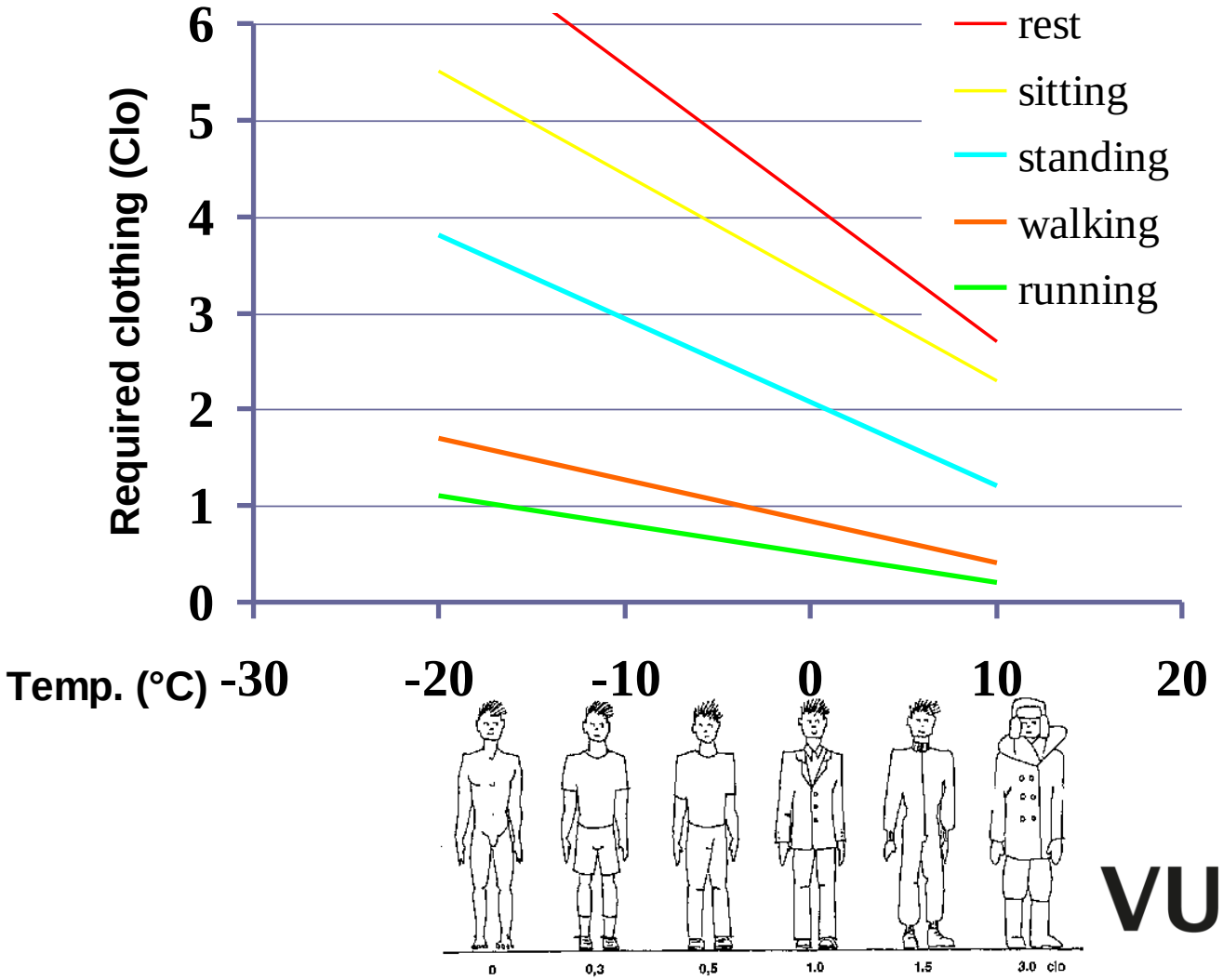
BODY SIGNS/SYMPTOMS TEMP. (rectal)	
37.5°C NORMAL	
36 FEEL COLD	Seek dry shelter, replace wet clothing with dry including socks, gloves, hat, cover neck, insulate whole body including HEAD from cold. Exercise but avoid sweating. External warmth (bath, fire) ONLY if CORE TEMP. above 35°C. Warm sweet drinks and food (high calories).
35 SHIVERING	
BODY CORE TEMPERATURE BELOW 35°C = HYPOTHERMIA = HOSPITAL	
	NO EXERCISE, HANDLE GENTLY, REST. **NO EXTERNAL WARMTH** (except to chest, trunk, eg. Hiebler Jacket).
CLUMSY 34 IRRATIONAL CONFUSED (may appear drunk)	Warm sweet drinks and calories. Internal warming via warm moist air (exhaled air, steam) or warm moist oxygen (40 - 42°C at mask).
33 MUSCLE STIFFNESS	Monitor pulse, breathing. Restrict all activity, lie down with feet slightly raised.
32 SHIVERING STOPS, COLLAPSE. TRANSFER TO HOSPITAL. URGENT.	
31 SEMI CONSCIOUS 30 UNCONSCIOUS No response to painful stimuli	Nothing by mouth. Check airway remains open. May tolerate plastic airway, put in recovery position, check airway, turn every 2 hours to protect skin, monitor pulse and breathing.
29 SLOW PULSE AND BREATHING	Slow mouth-to-mouth breathing, at victim's own rate (may be very slow).
28 CARDIAC ARREST No obvious pulse or breathing Pupils dilated	Check airway. CPR, with mouth-to-mouth breathing. Aim for normal CPR rates of 12-15 breaths/min. and 80-100 compressions/min. but slower rates of 6-12 breaths/min. and 40-60 compressions/min. may be adequate. Continue for as long as you can.
BELOW 28°C. NO VITAL SIGNS, COLD. DO NOT GIVE UP TREATMENT.	

NOTE: NOT DEAD UNTIL WARM AND DEAD!
Avoid rapid rewarming and **HANDLE GENTLY AT ALL TIMES.**
Core temperature may lag behind skin temperature and continue to drop, so keep monitoring.

Paradoxaal ontkleden

1st auteur	Hypothermie	Paradoxaal ontkleden (%)
Brandstrom	207	30
Lim	24	29
Oesterberg	68	69
Mizukami	164	21
Shimizu	36	31
Rotshield	69	25
Sivaloganathan	20	70
Albiin	51	50

Uitrekenen van kledingbehoefte – ISO 11079

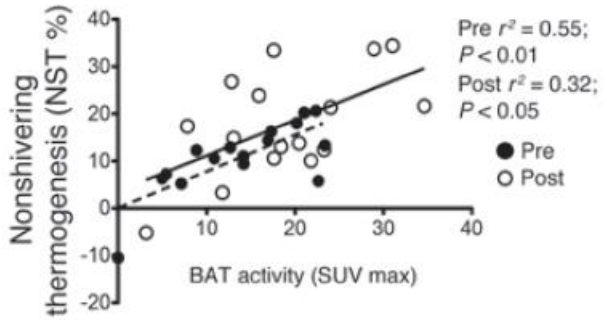


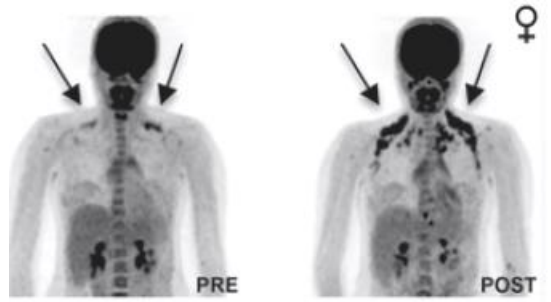
Aanpassing aan milde kou

Cold acclimation recruits human brown fat and increases nonshivering thermogenesis

Anouk A.J.J. van der Lans,[1] Joris Hoeks,[1] Boudewijn Brans,[2] Guy H.E.J. Vijgen,[1,3] Mariëlle G.W. Visser,[2] Maarten J. Vosselman,[1] Jan Hansen,[1] Johanna A. Jörgensen,[1] Jun Wu,[4] Felix M. Mottaghy,[2,5] Patrick Schrauwen,[1] and Wouter D. van Marken Lichtenbelt[1]

- 9 females, 10 males
- 10 days mild cold exposure (15 °C, 6 hr / day)
- 4% increase of NST
- equals < 1 W





Aanpassing aan strenge kou

- 14 males
- 14°C water immersion
- 35.5°C / 170 min

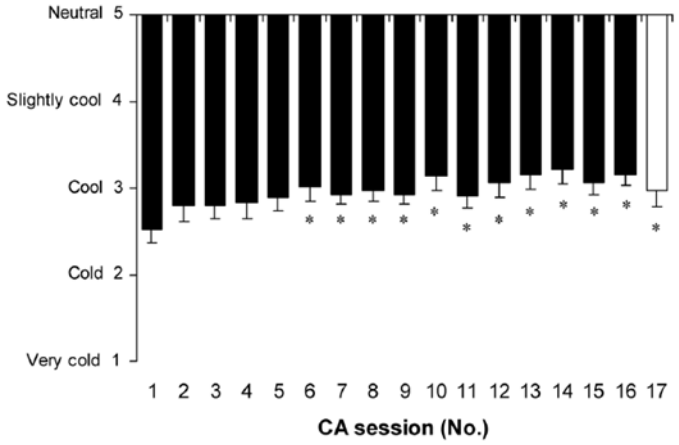
OPEN ACCESS Freely available online

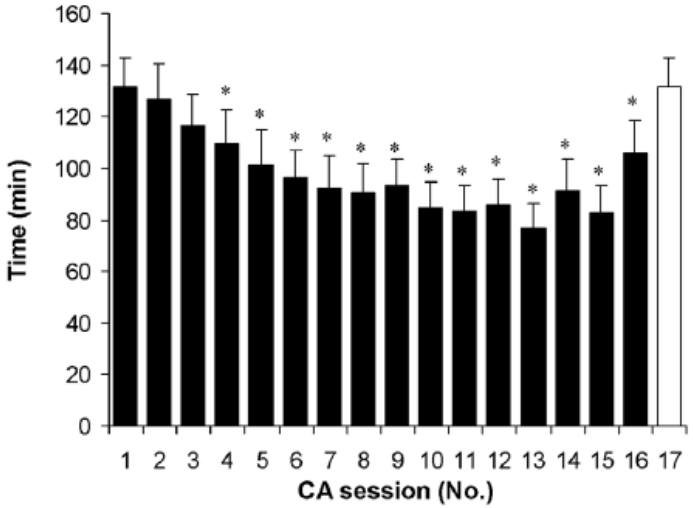
PLOS ONE

Time Course of Physiological and Psychological Responses in Humans during a 20-Day Severe-Cold–Acclimation Programme

Marius Brazaitis[1]*, Nerijus Eimantas[1], Laura Daniuseviciute[2], Neringa Baranauskiene[1], Erika Skrodeniene[3], Albertas Skurvydas[1]

1 Sports Science and Innovation Institute, Lithuanian Sports University, Kaunas, Lithuania, **2** Department of Educational Studies, Kaunas University of Technology, Kaunas, Lithuania, **3** Department of Laboratory Medicines, Medical Academy, Lithuanian University of Health Science, Kaunas, Lithuania





VU VRIJE UNIVERSITEIT AMSTERDAM
Faculty of Behavioural and Movement Sciences

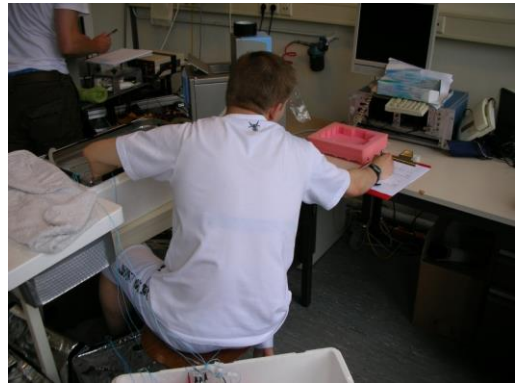
Aanpassing handdoorbloeding aan kou

Eur J Appl Physiol (2012) 112:2595–2601
DOI 10.1007/s00421-011-2233-4

ORIGINAL ARTICLE

Trainability of cold induced vasodilatation in fingers and toes

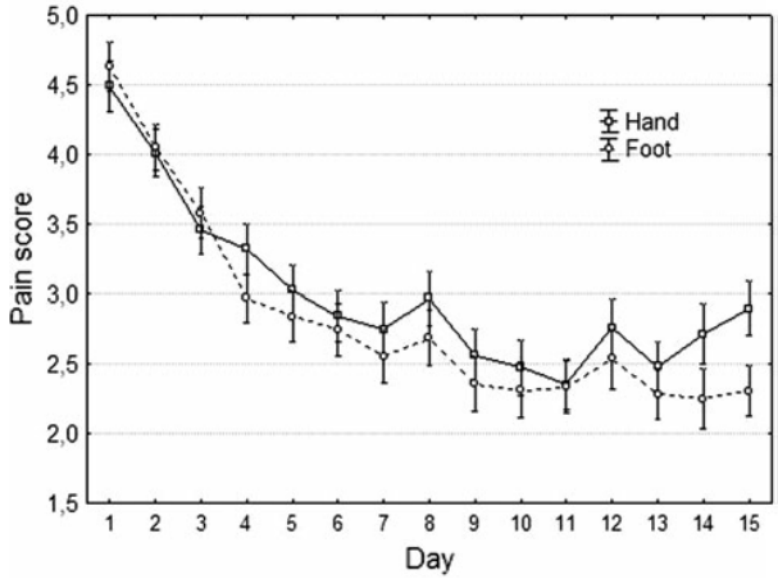
Hein A. M. Daanen · Jens Koedam · Stephen S. Cheung



16 studenten dompelden hun rechter (getrainde) hand en voet gelijktijdig in 8ºC water; 30 min per dag; 15 dagen lang.

Op dag 1 en 5 dompelden ze hun linker hand en voet (ongetraind) eveneens in het koude water.

Geen effect op doorbloeding handen/voeten.



VU VRIJE UNIVERSITEIT AMSTERDAM
Faculty of Behavioural and Movement Sciences

The Ice-man

PNAS

Voluntary activation of the sympathetic nervous system and attenuation of the innate immune response in humans

2014

Matthijs Kox[a,b,c,1], Lucas T. van Eijk[a,c], Jelle Zwaag[a,c], Joanne van den Wildenberg[a,c], Fred C. G. J. Sweep[d], Johannes G. van der Hoeven[a,c], and Peter Pickkers[a,c]

[a]Intensive Care Medicine, [b]Anesthesiology, [c]Nijmegen Institute for Infection, Inflammation and Immunity, and [d]Laboratory Medicine, Radbou Medical Centre, Geert Grooteplein 10, 6500 HB, Nijmegen, The Netherlands

The Effects of Cold Exposure Training and a Breathing Exercise on the Inflammatory Response in Humans: A Pilot Study

2022

Jelle Zwaag, MD, Rick Naaktgeboren, MD, Antonius E. van Herwaarden, PhD, Peter Pickkers, MD, PhD, and Matthijs Kox, PhD

Cold exposure training alone did not relevantly modulate the LPS-induced inflammatory response.

VU VRIJE UNIVERSITEIT AMSTERDAM
Faculty of Behavioural and Movement Sciences

The Ice-man

OPEN ACCESS Freely available online

PLOS ONE

Frequent Extreme Cold Exposure and Brown Fat and Cold-Induced Thermogenesis: A Study in a Monozygotic Twin

Maarten J. Vosselman[1], Guy H. E. J. Vijgen[3], Boris R. M. Kingma[1], Boudewijn Brans[2], Wouter D. van Marken Lichtenbelt[1]*

1 Department of Human Biology, School for Nutrition, Toxicology and Metabolism – NUTRIM, Maastricht, the Netherlands, 2 Department of Nuclear Medicine, Maastricht University Medical Center+, Maastricht, the Netherlands, 3 Department of Surgery (G.V.), Erasmus Medical Center, Rotterdam, the Netherlands

Abstract

Introduction: Mild cold acclimation is known to increase brown adipose tissue (BAT) activity and cold-induced thermogenesis (CIT) in humans. We here tested the effect of a lifestyle with frequent exposure to extreme cold on BAT and CIT in a Dutch man known as 'the Iceman', who has multiple world records in withstanding extreme cold challenges. Furthermore, his monozygotic twin brother who has a 'normal' sedentary lifestyle without extreme cold exposures was measured.

Methods: The Iceman (subject A) and his brother (subject B) were studied during mild cold (13°C) and thermoneutral conditions (31°C). Measurements included BAT activity and respiratory muscle activity by [^{18}F]FDG-PET/CT imaging and energy expenditure through indirect calorimetry. In addition, body temperatures, cardiovascular parameters, skin perfusion, and thermal sensation and comfort were measured. Finally, we determined polymorphisms for uncoupling protein-1 and β3-adrenergic receptor.

Results: Subjects had comparable BAT activity (A: 1144 SUV_{total} and B: 1325 SUV_{total}), within the range previously observed in young adult men. They were genotyped with the polymorphism for uncoupling protein-1 (G/G). CIT was relatively high (A: 40.1% and B: 41.9%), but unlike during our previous cold exposure tests in young adult men, here both subjects practiced a g-Tummo like breathing technique, which involves vigorous respiratory muscle activity. This was confirmed by high [^{18}F]FDG-uptake in respiratory muscle.

Conclusion: No significant differences were found between the two subjects, indicating that a lifestyle with frequent exposures to extreme cold does not seem to affect BAT activity and CIT. In both subjects, BAT was not higher compared to earlier observations, whereas CIT was very high, suggesting that g-Tummo like breathing during cold exposure may cause additional heat production by vigorous isometric respiratory muscle contraction. The results must be interpreted with caution given the low subject number and the fact that both participants practised the g-Tummo like breathing technique.

Dank voor uw aandacht

- h.a.m.daanen@vu.nl

- Please visit
- www.heindaanen.nl

VU VRIJE UNIVERSITEIT AMSTERDAM

Faculty of Behavioural and Movement Sciences

Hot flashes

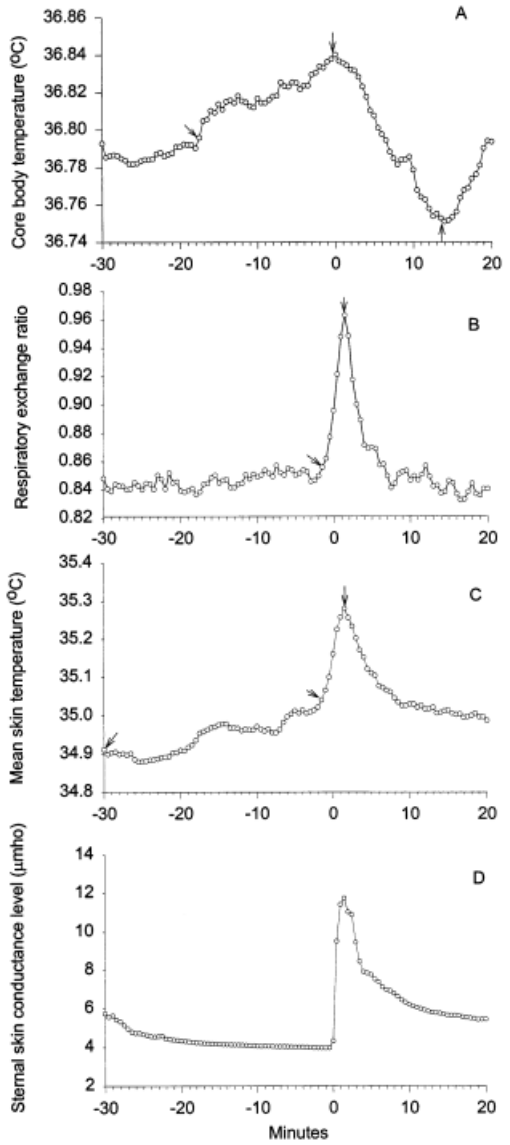
Hormonal changes that bring the onset of sweating and shivering to the same point.

Plasma levels of 3-methoxy-4-hydroxy-phenylglycol (MHPG) increase.

The thermoneutral zone is minimized.

FIGURE 1

(**A**), Core body temperature (means) during menopausal hot flashes. (**B**), Respiratory exchange ratio (means) during hot flashes. (**C**), Mean skin temperature (means) during hot flashes. (**D**), Sternal skin conductance (means) during hot flashes. Time 0 is the beginning of the sternal skin conductance response. Intervals between arrows are significantly different from each other at $P<.05$, Duncan's test.



Freedman, R.R. Biochemical, metabolic, and vascular mechanisms in menopausal hot flashes (1998) Fertility and Sterility, 70 (2), pp. 332-337.