Indoor temperature variations for energy efficient and healthy climate control

Building occupants' comfort, energy metabolism and physiological health

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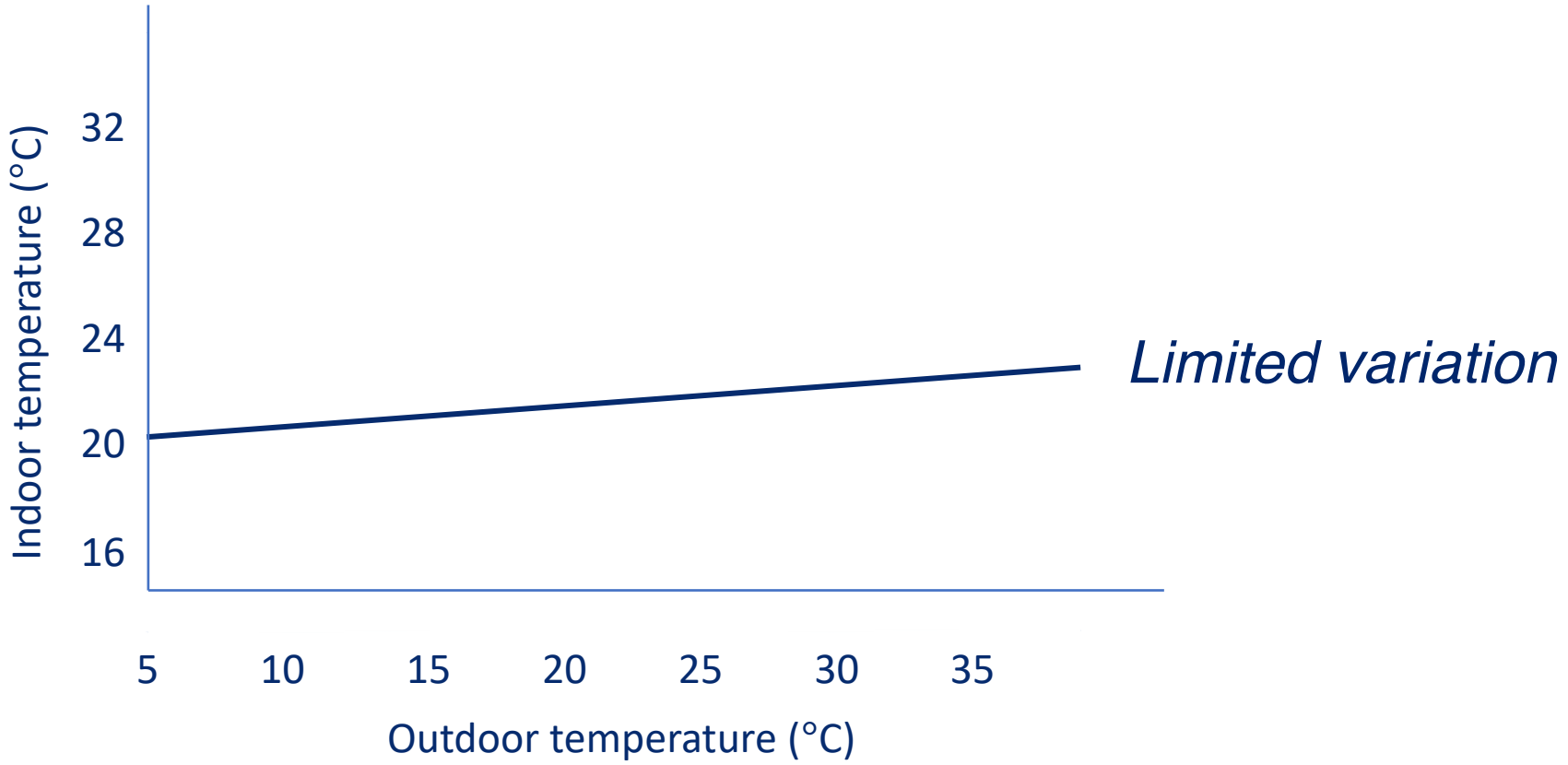
Conventional comfort model used in the built environment



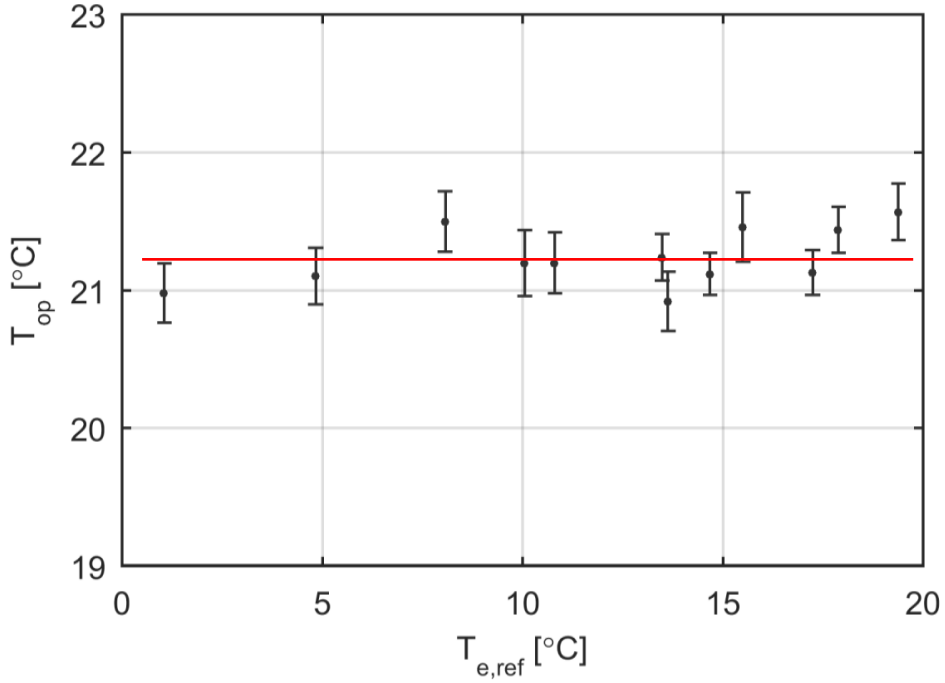
Problems

- Excessive energy consumption
- Environmental impact
- Comfort is assumed to be guaranteed
- Health effects?

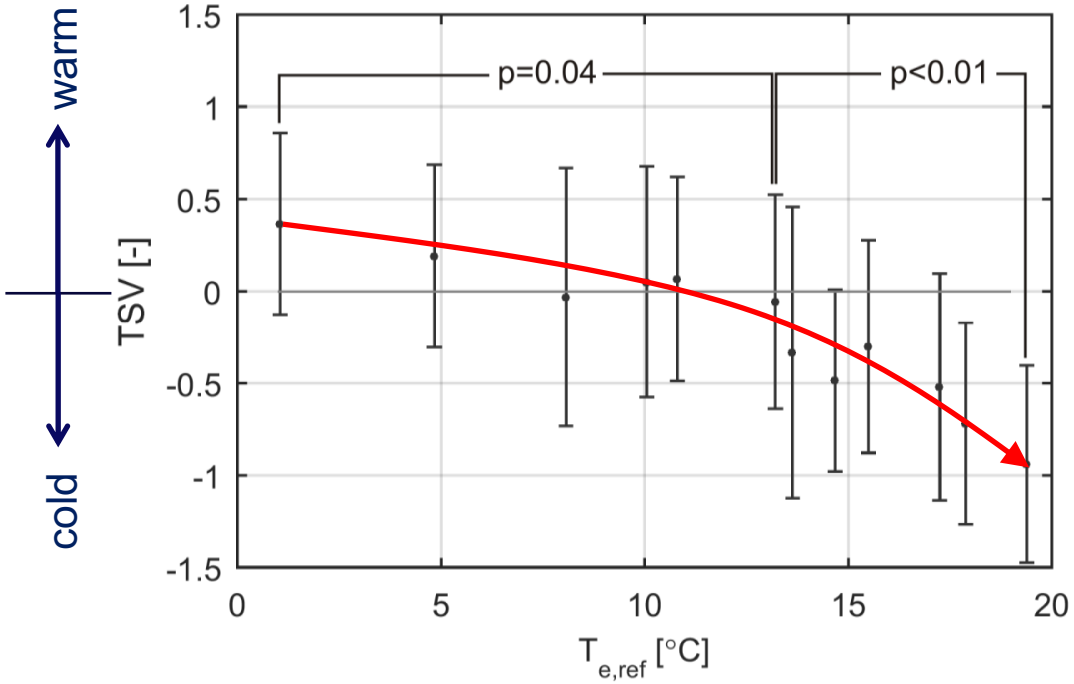
Case study – Hermitage Amsterdam Museum

Static climate: Thermal comfort not guaranteed

Temperature

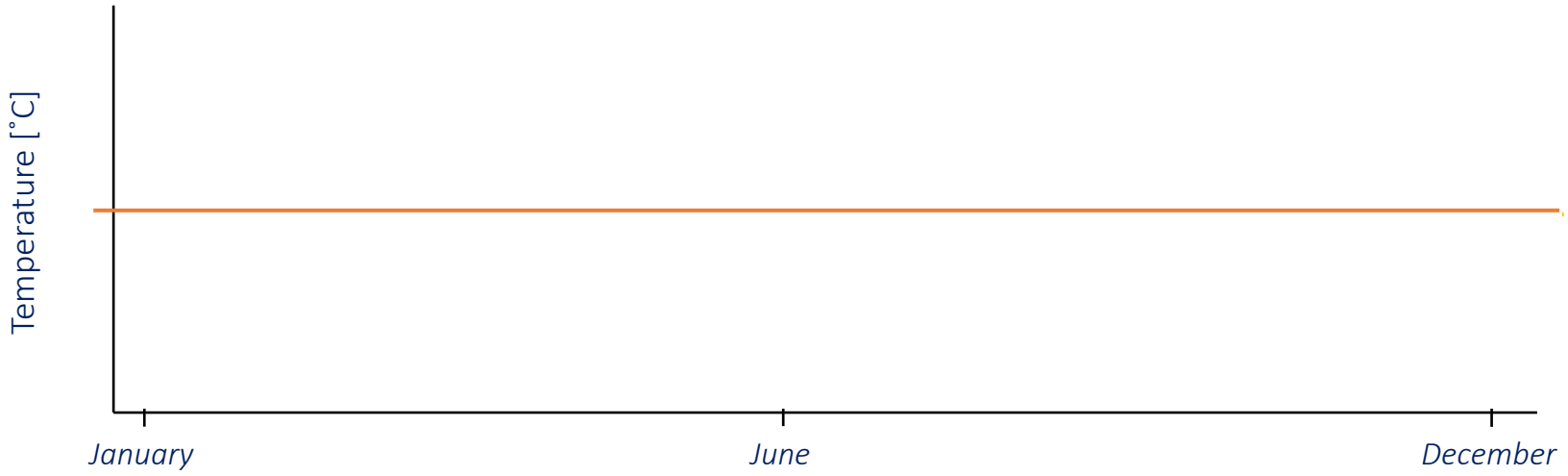


Thermal sensation

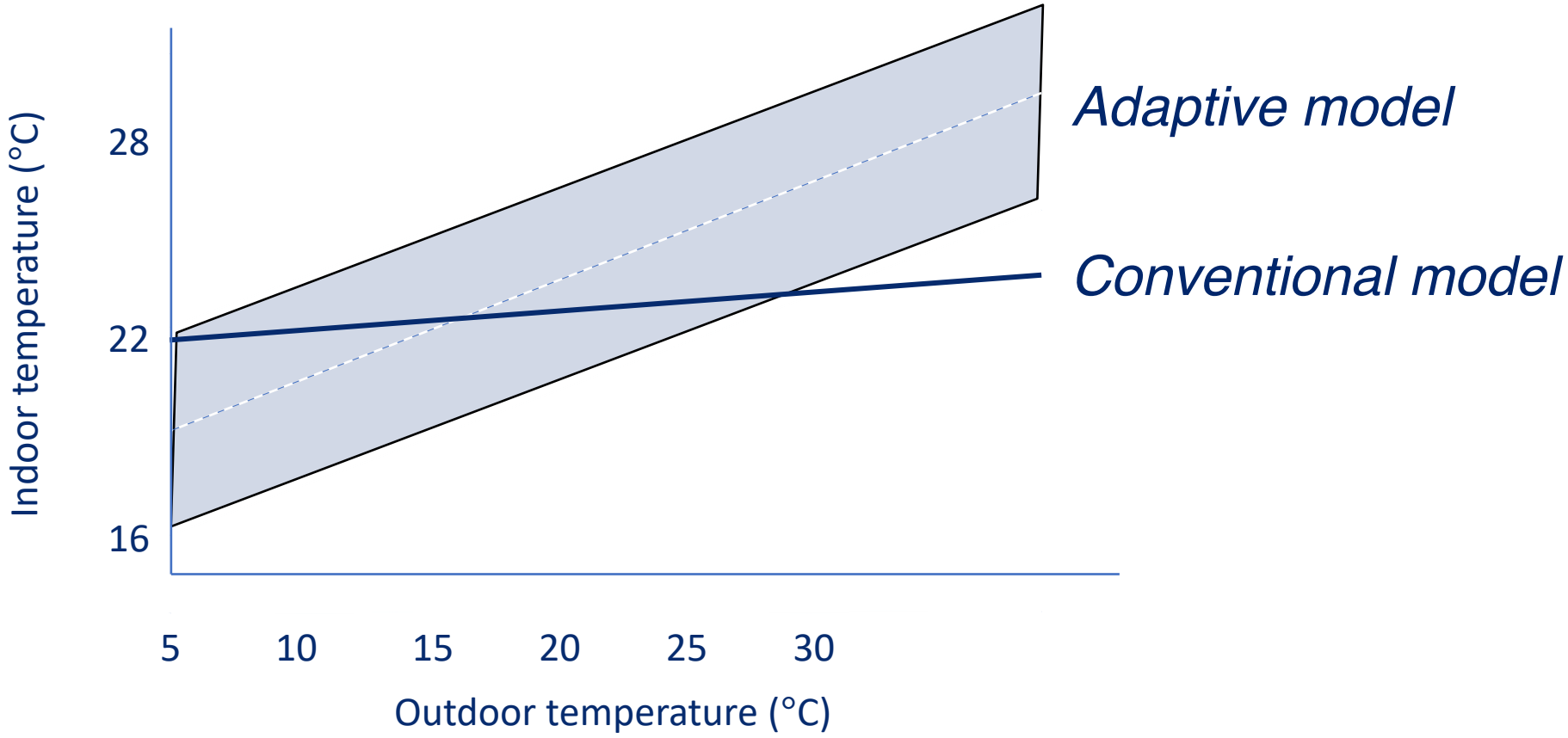


Clever Climate Control for Culture (2017). R.P. Kramer, PhD thesis, Eindhoven University of Technology, Eindhoven, The Netherlands

Paradigm shift: from static to dynamic

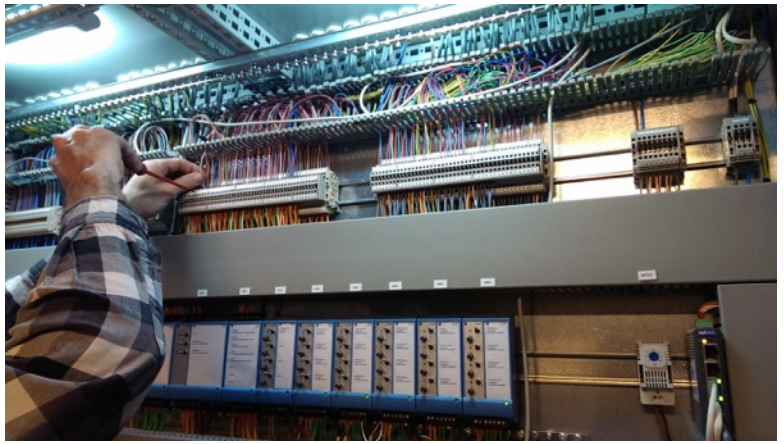


Adaptive comfort model



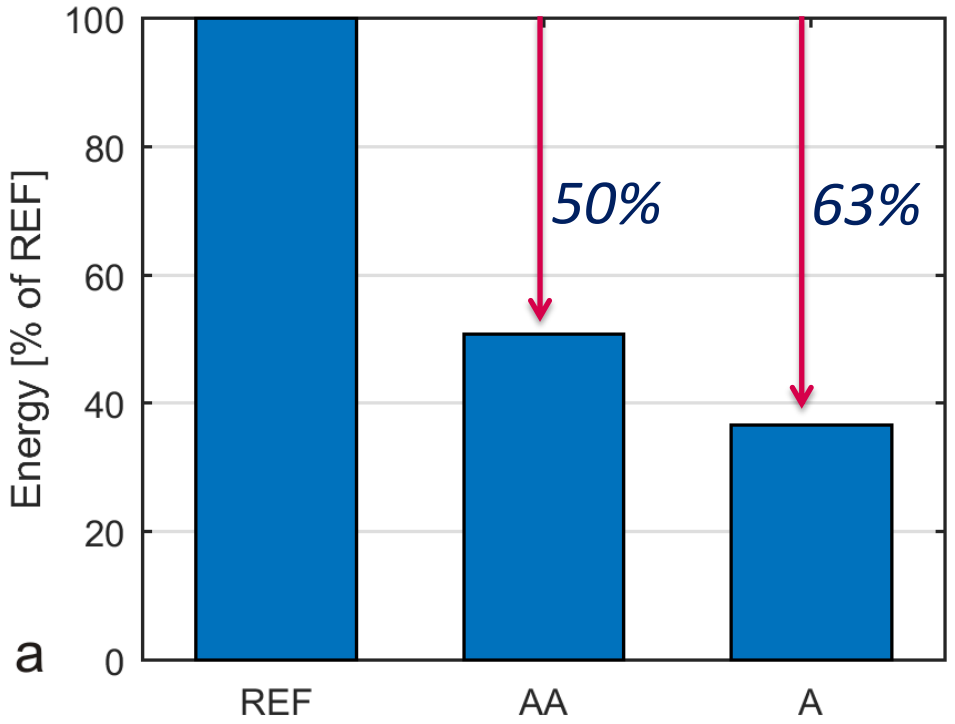
Humphreys et al., Energy & Buildings 2007
De Dear et al., Energy & Buildings 2001

Energy monitoring in Air Handling Units



Dynamic indoor climate: energy impact

- Reference: 21˚C / 50% RH
- ASHRAE class AA: 45 – 55 % RH / T from ATG
- ASHRAE class A: 40 – 60 % RH / T from ATG



Health effects?

Static vs Dynamic climate

Obesity: BMI > 25

NL

- 36% BMI 25 - 30
- 14% BMI ≥ 30

USA

- 33% BMI 25 - 30
- 36% BMI ≥ 30

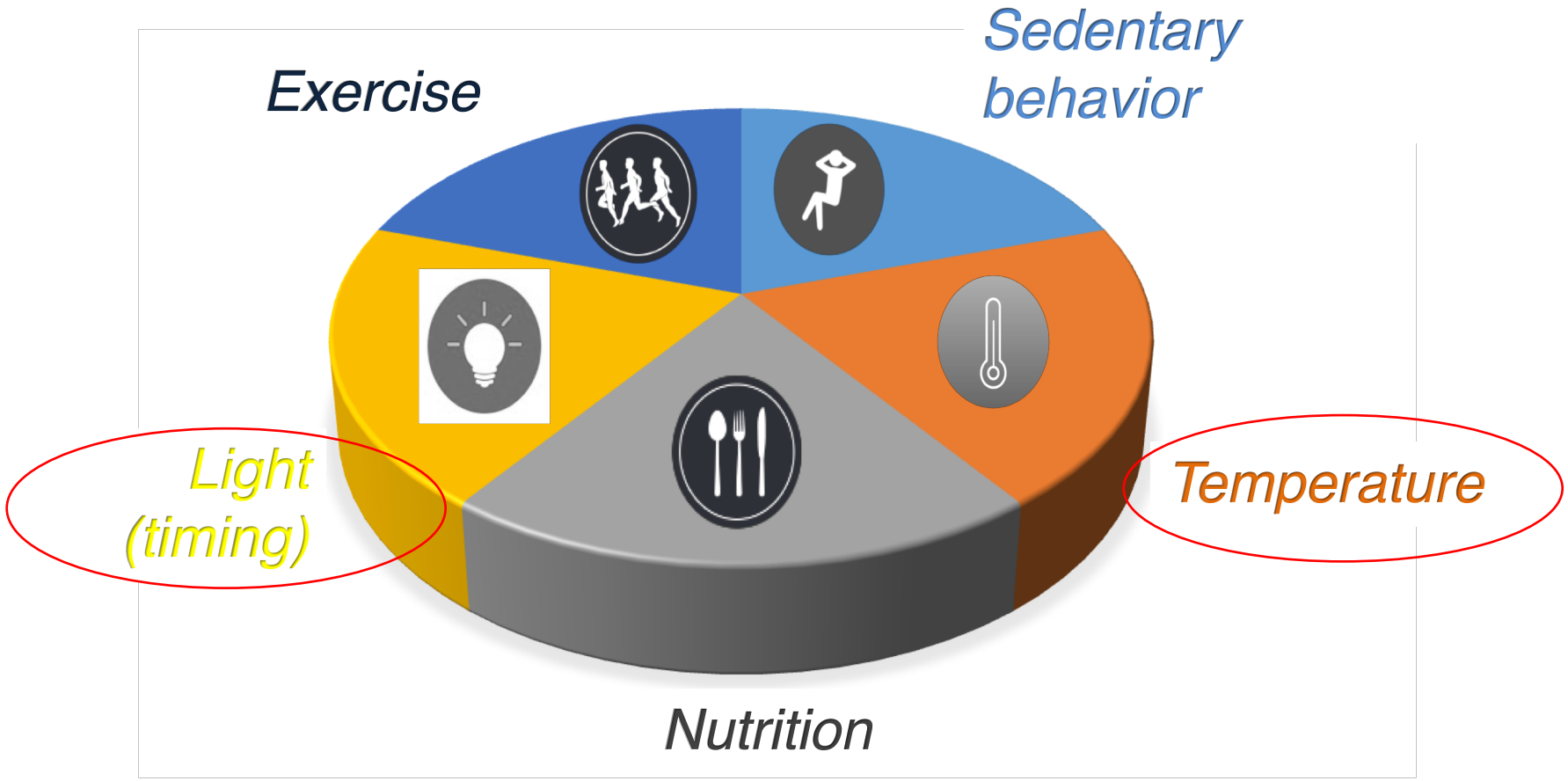
Consequences obesity

- Reduced insulin sensitivity → diabetes
- Coronary heart diseases
  - High blood pressure
  - Hart infarct
  - Stroke
- Disturbed lipid metabolism
- Sleep apnea
- Some types of cancer
- Cognitive ageing

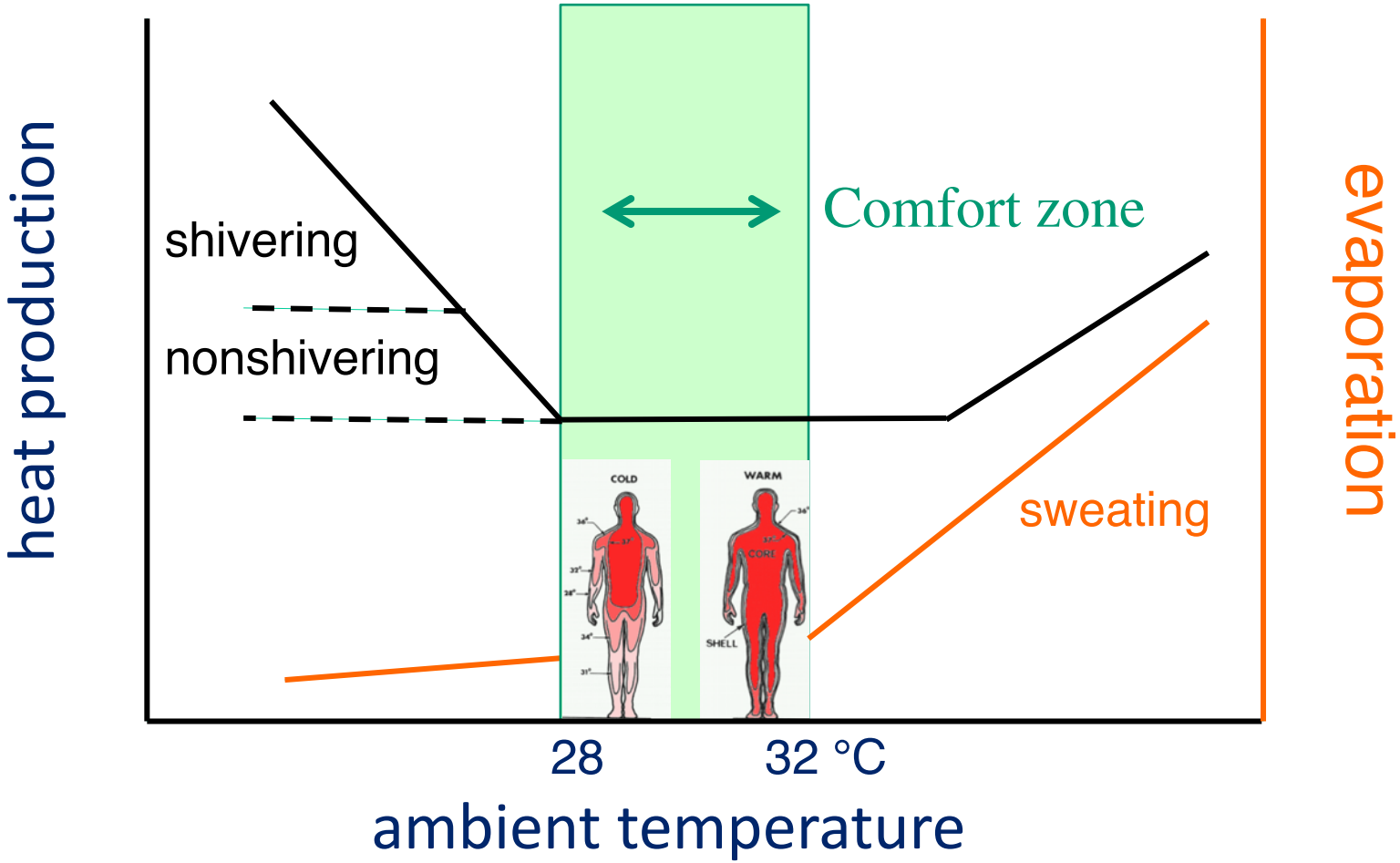
WHO 2000, report 894


STOP

Lifestyle

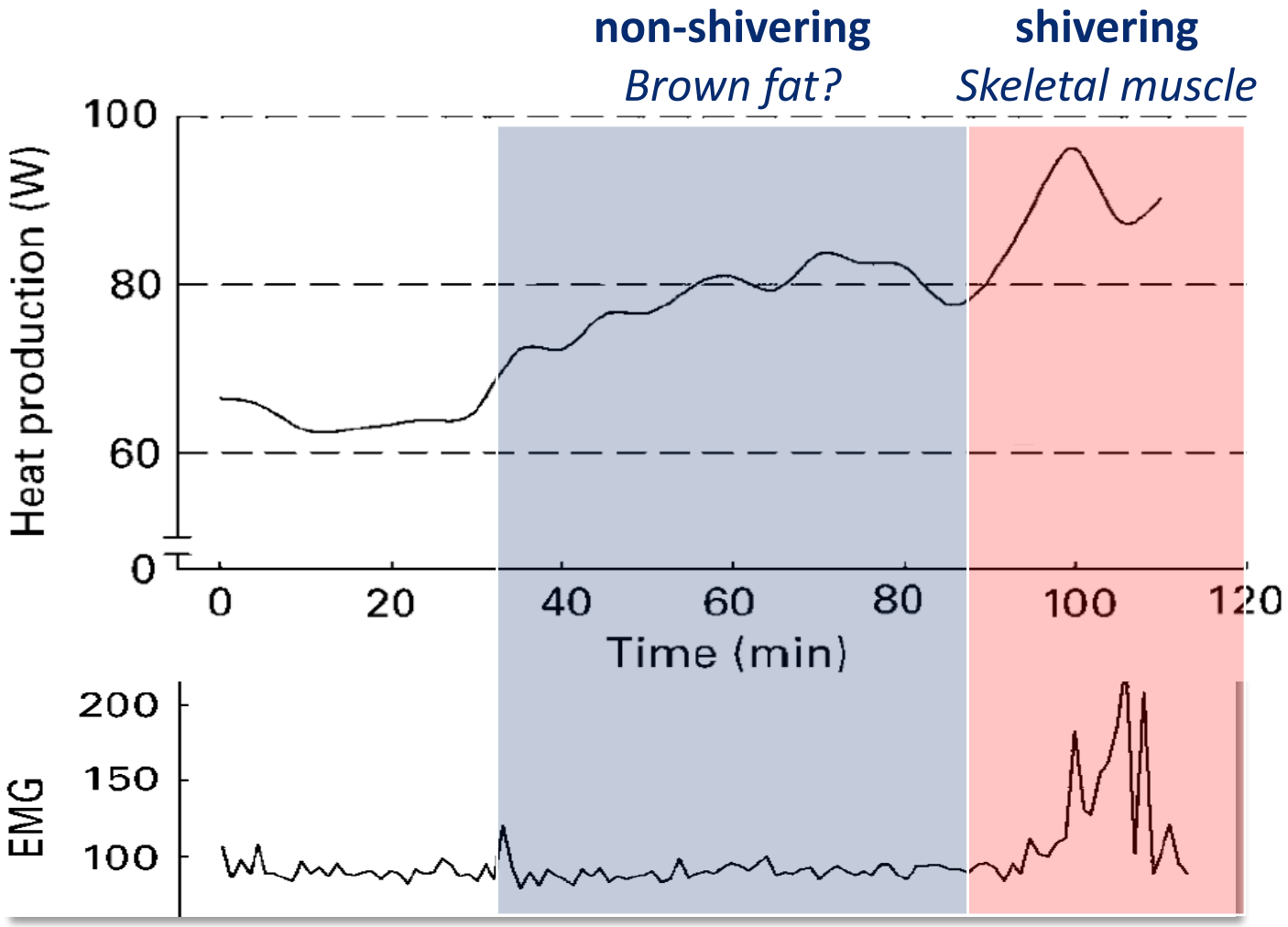

Exercise
Sedentary behavior
Light (timing)
Temperature
Nutrition

Thermo neutral zone



Metabolic Research Unit Maastricht (MRUM)

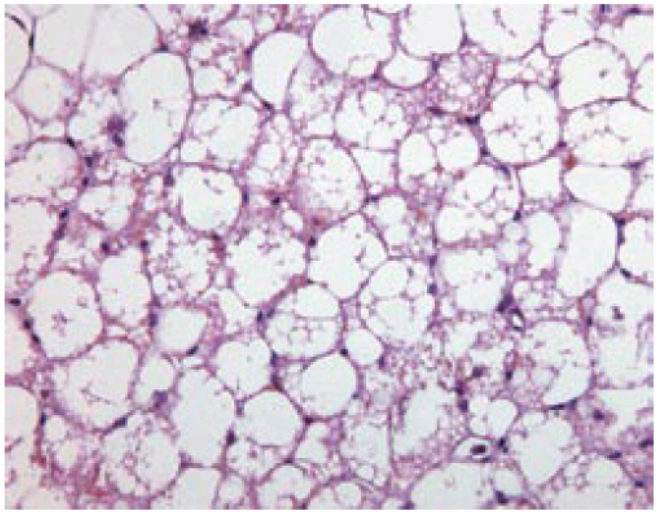
Mild cold: non-shivering thermogenesis

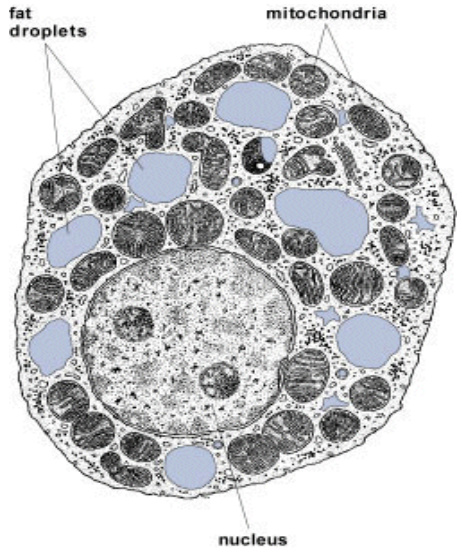


Van Ooijen et al. Br J Nutr 2005

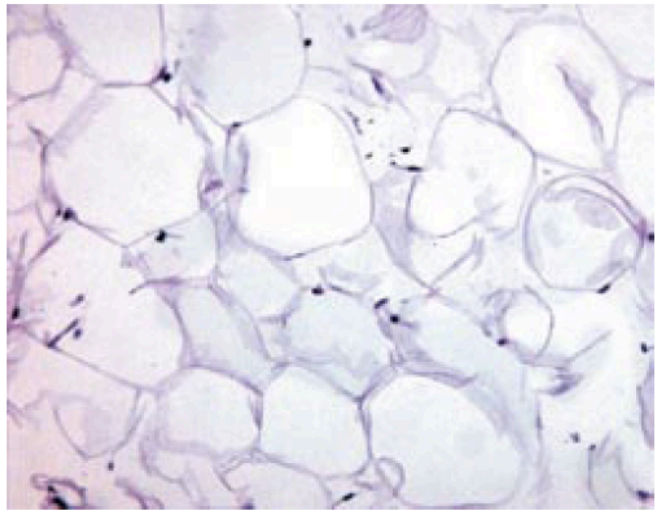
Brown fat vs White fat

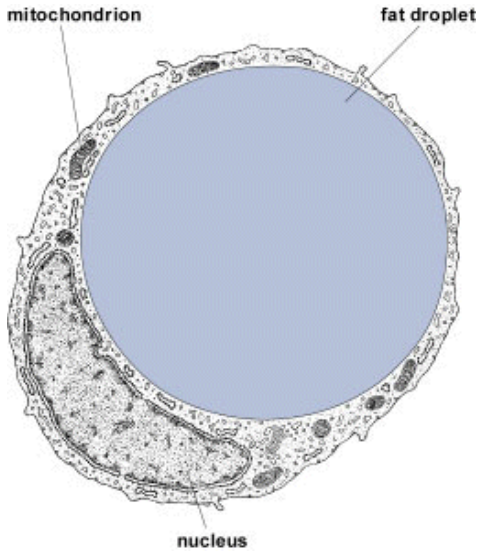
Brown Adipose Tissue





White Adipose Tissue





Temperature induced brown fat **activity**

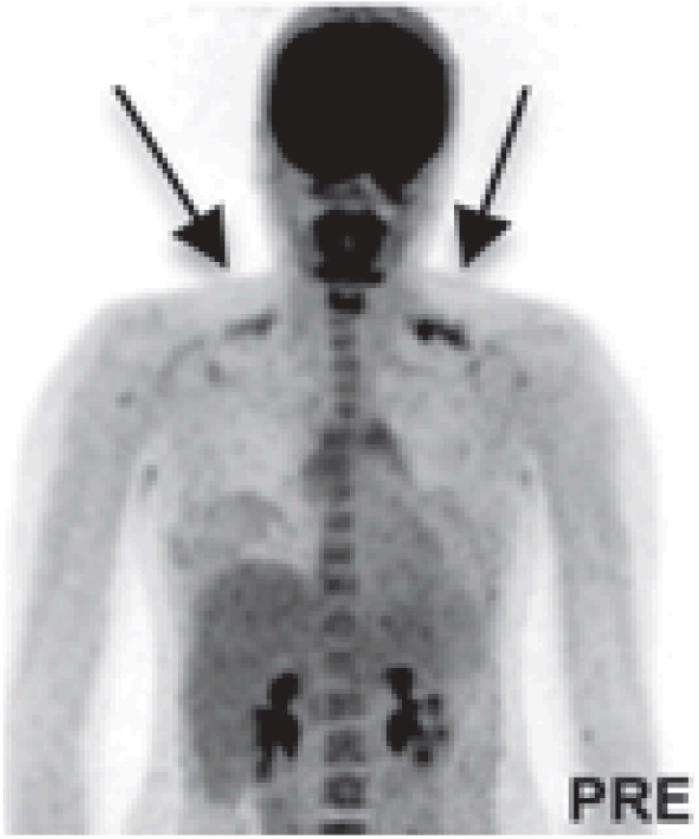
Thermoneutral

Mild cold

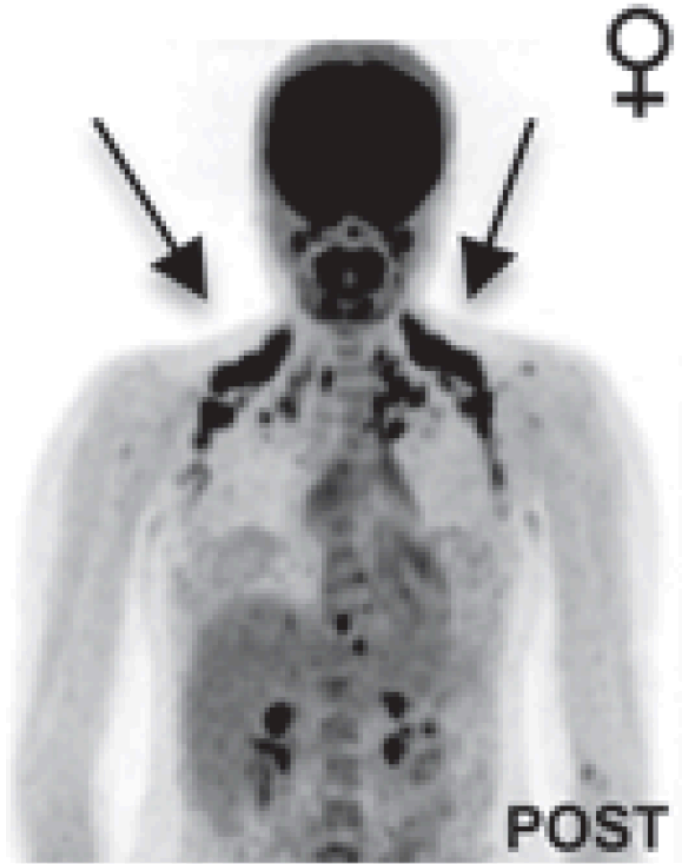
Van Marken Lichtenbelt et al., NEJM 2009; Virtanen et al., NEJM 2009
Saito et al. Diabetes 2009

Cold acclimatization: brown fat **recruitment**

Before



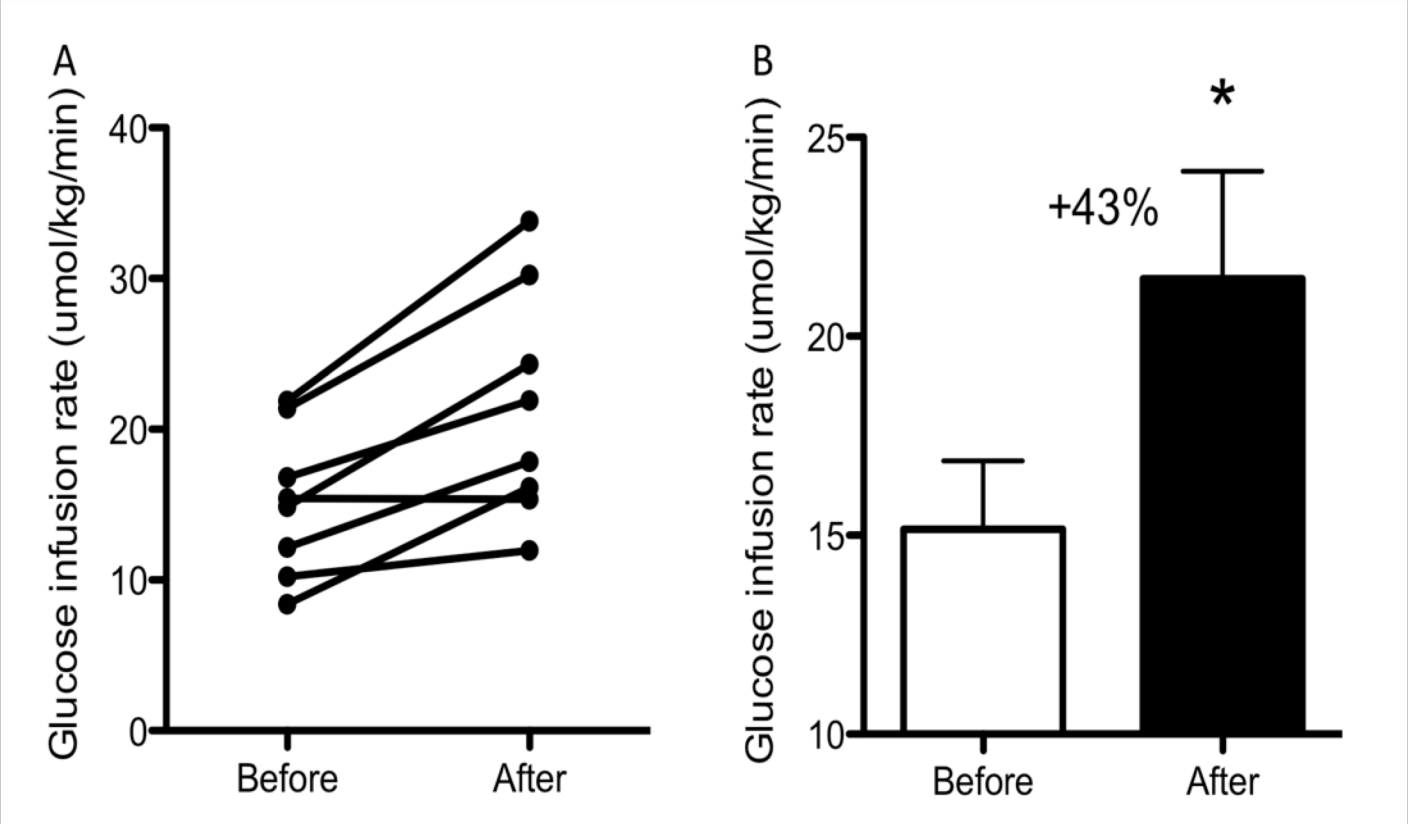
After (10 days 6 h/d)



Van der Lans et al. JCI 2013

Increase insulin sensitivity

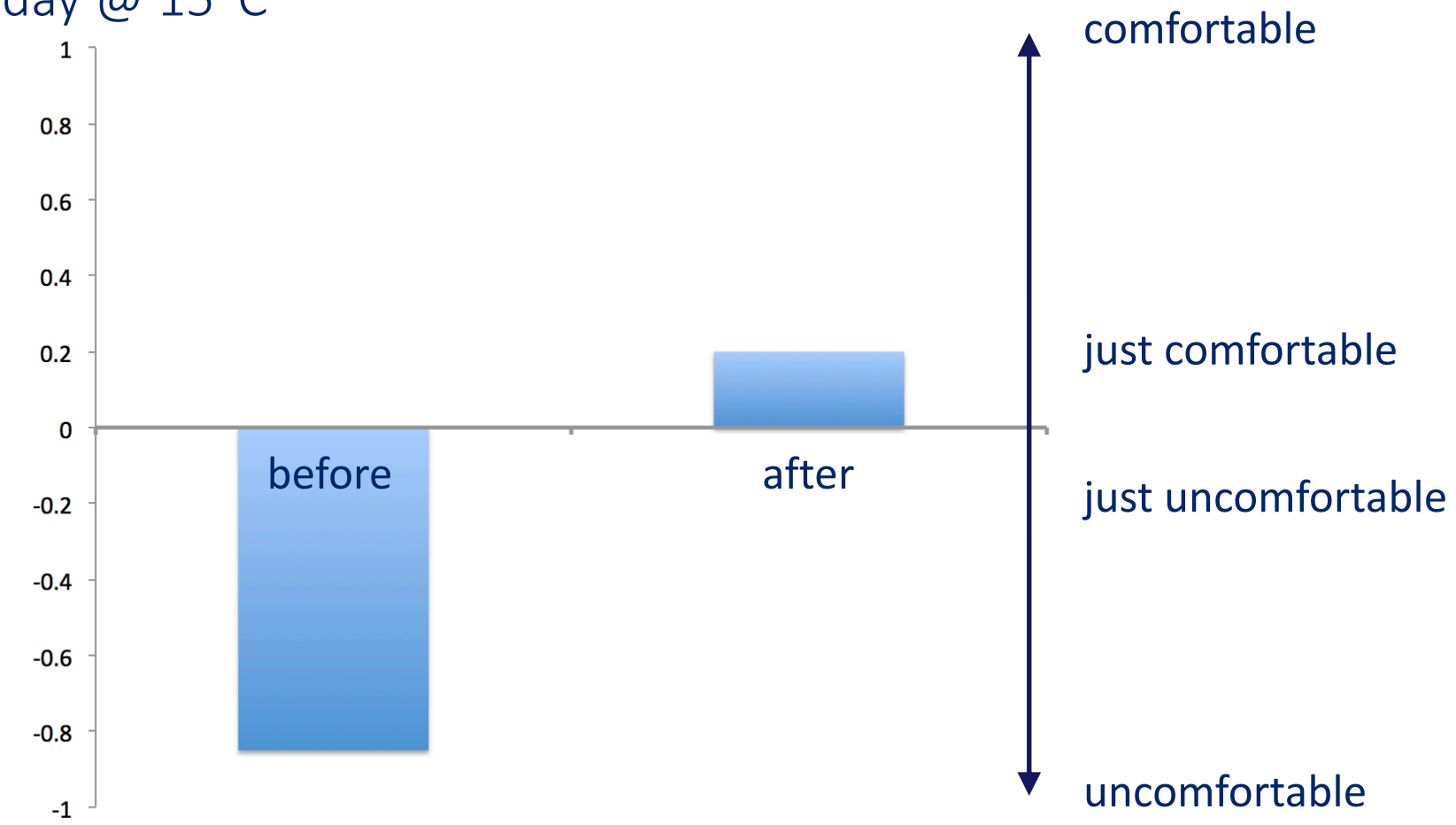
- Cold acclimation in diabetes type 2 increased insulin sensitivity



Hanssen et al., Nature Medicine 2015

Thermal comfort increase after cold acclimation

- 10 days, 6 h/day @ 15°C



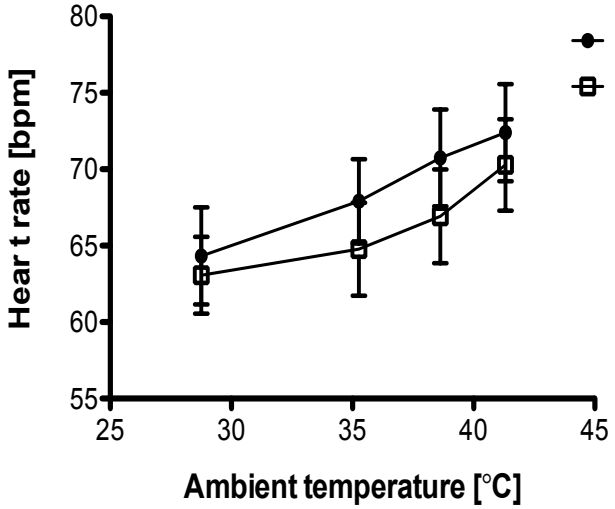
Hanssen et al., Nature Med 2015

Van der Lans et al. JCI 2013

Health effects of mild heat acclimation

Reduction in:

- blood pressure
- heart rate
- blood glucose



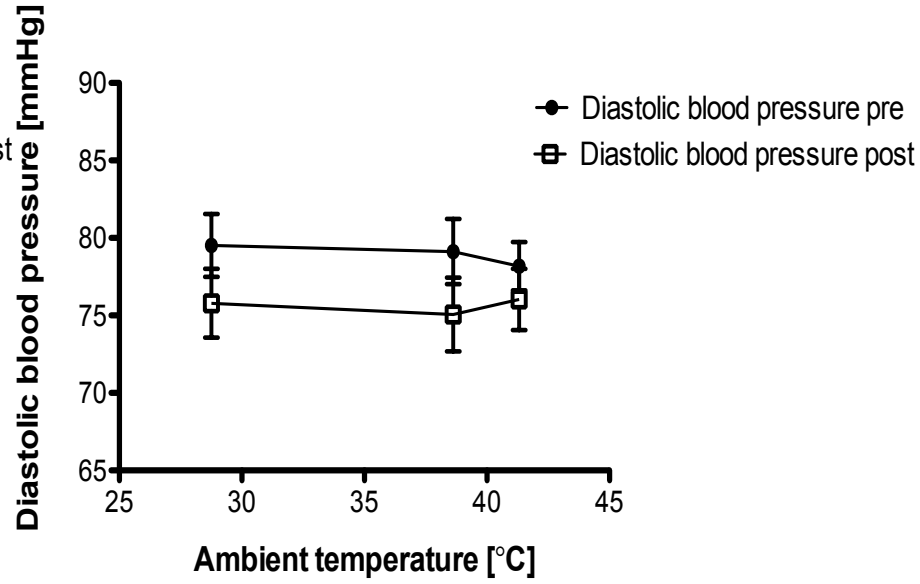


Table 4 | Blood metabolites				
	Pre PMHA	Post PMHA	Δ	P-value
Fasting plasma glucose [mmol/L]	6.0±0.50	5.8±0.4	-0.2±0.4	0.013*
Fasting plasma insulin [pmol/L]	96.7±54.7	84.0±49.3	-12.7±15.1	0.026*
HOMA-IR	4.3±2.4	3.6±2.1	-0.71	0.011

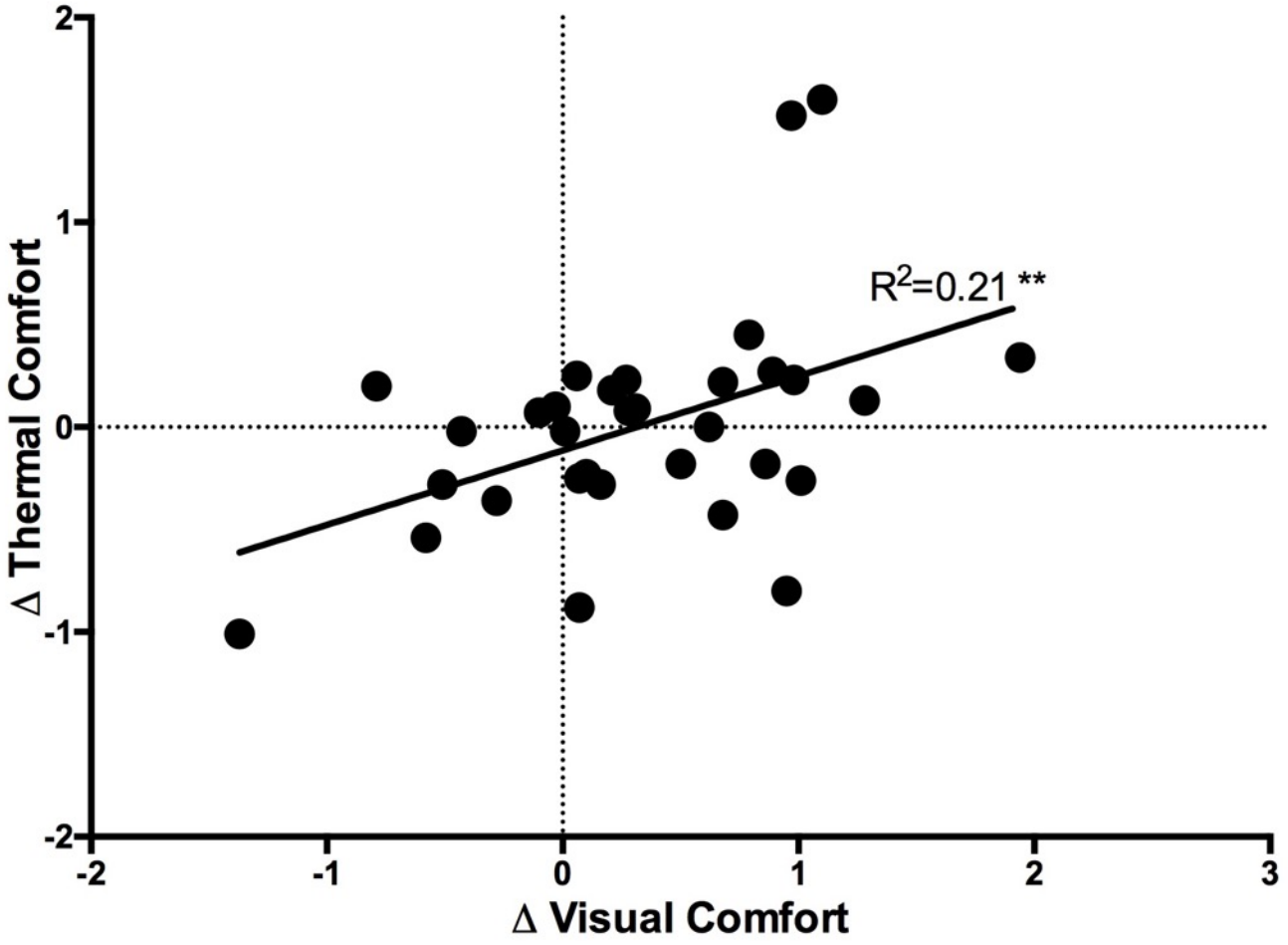
Data is presented as mean±SD. N=10. Δ denotes changes post vs. pre PMHA, * indicates P<.05 for changes post PMHA.

Effect of light on thermal comfort

LED wall washer

Thermal and visual (light) comfort

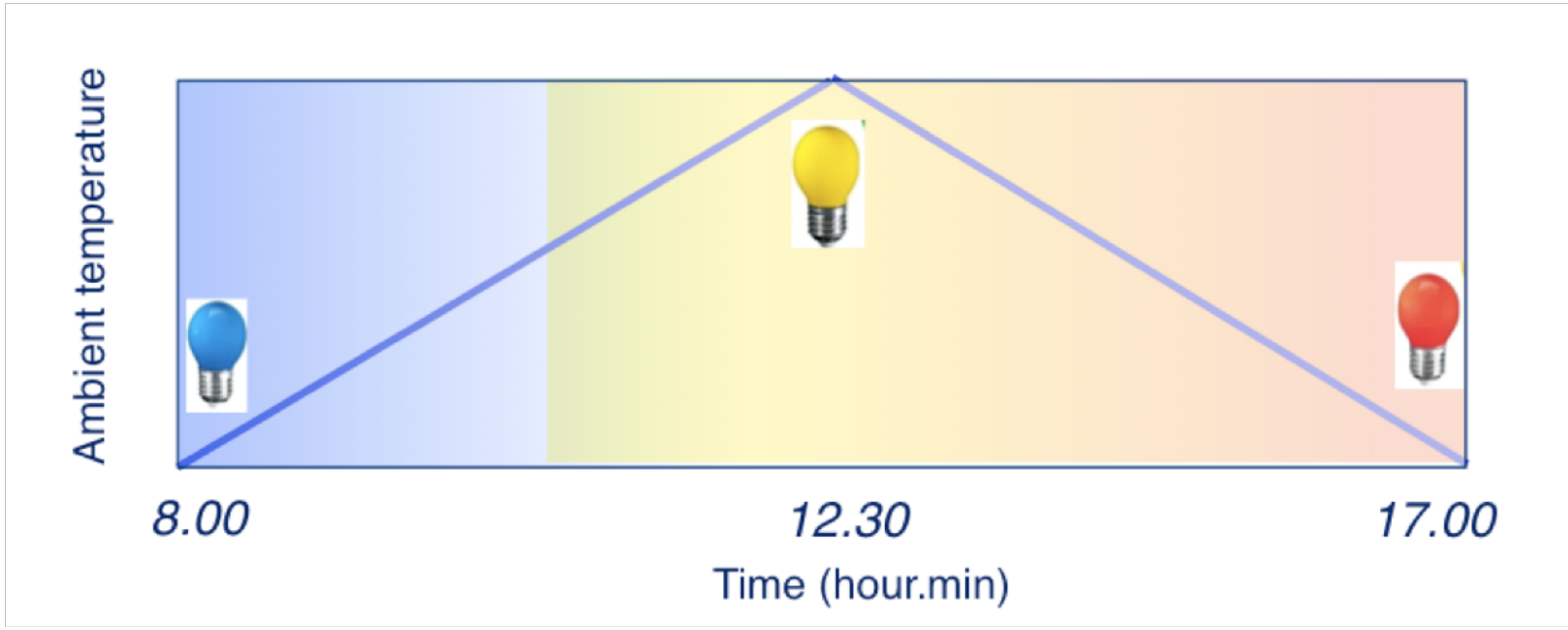
- Change in thermal comfort is related to change in visual comfort



te Kulve et al, submitted

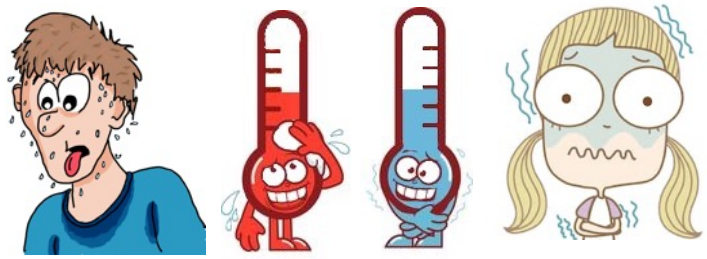
DYNKA project: Interaction dynamic temp and light

- Expand comfort temperatures
- Improve metabolic health
- Provide energy benefits
- Study productivity effects
- Study health effects



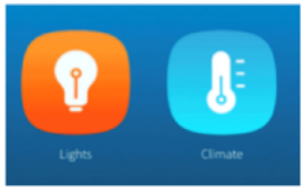
PERDYNKA project: DYNKA + Personal Control System

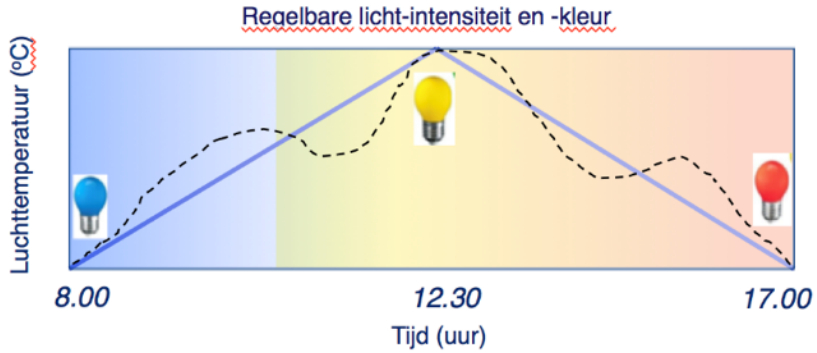
- One climate fits all? Individual Differences!
- Inhomogeneous Distribution of Temperature



Personal control system:

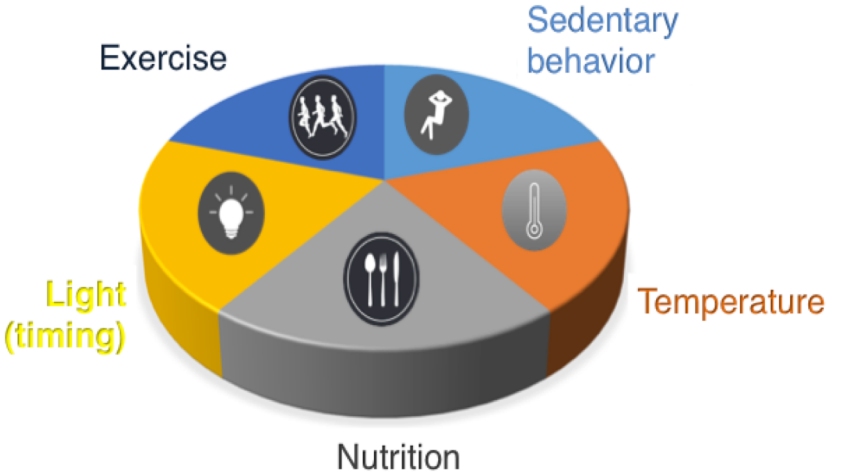
- Individual comfort
- Extended ambient temperature range:
  - Maintain health effects
  - Energy efficiency





Dynamic indoor environments: conclusions

- Need to exercise our thermoregulatory system as part of a healthy lifestyle (*use it or lose it*)
- Increase metabolic health and resilience to heat and cold (healthy ageing)
- Lifestyle programs should include: diet, physical activity in a healthy environment (**temperature**, **light** conditions)
- Substantial energy savings possible in the built environment



Thank you

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