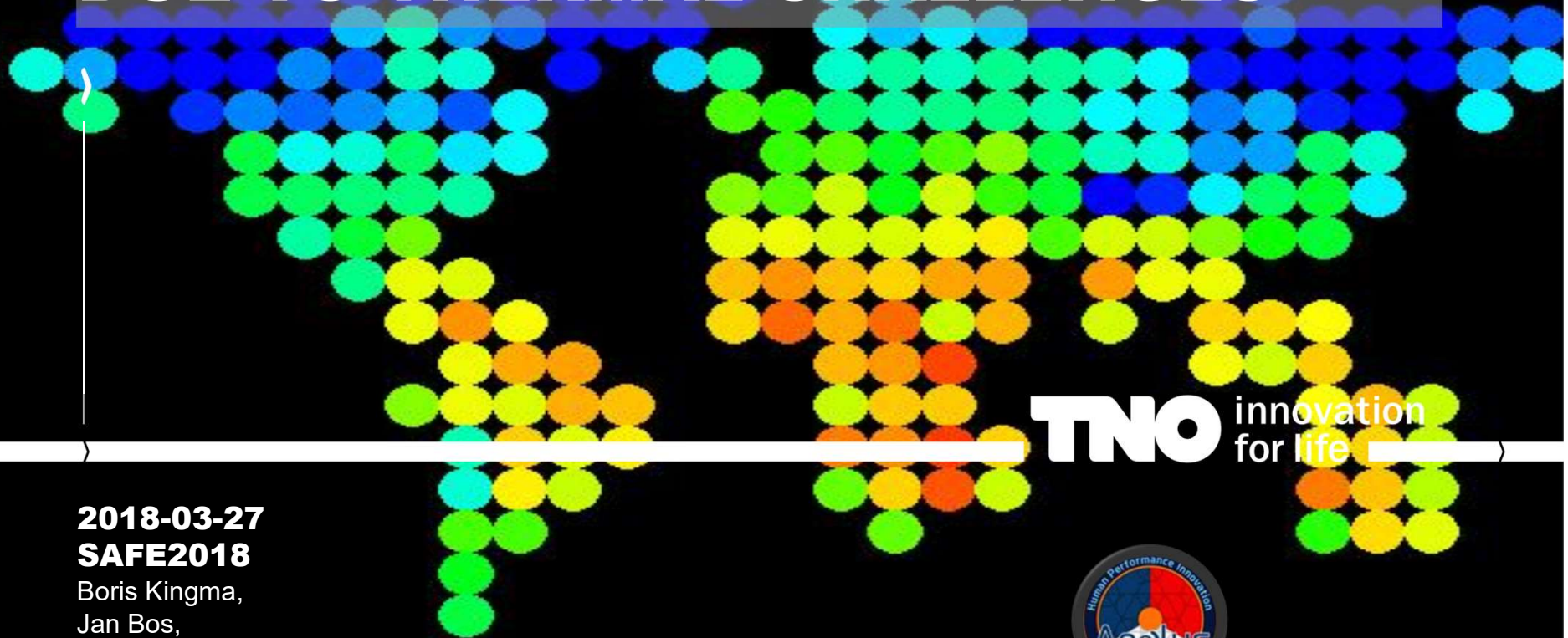


FORECASTING PERFORMANCE LOSS DUE TO THERMAL CHALLENGES



TNO innovation
for life

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Boris Kingma,
Jan Bos,
Arend Woering
boris.kingma@tno.nl

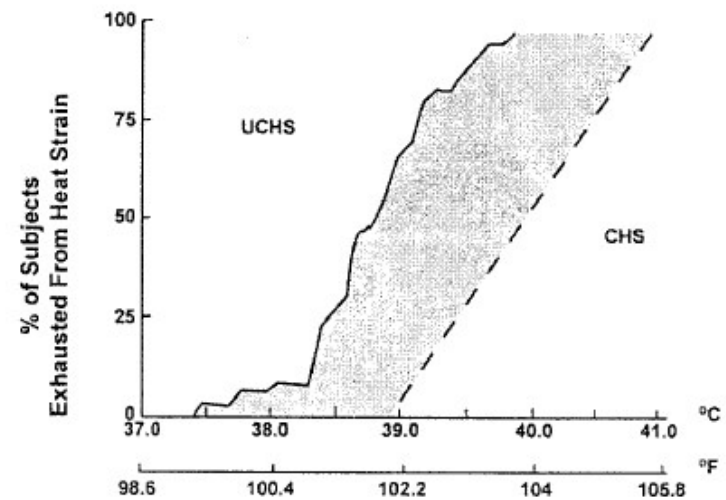


“37°C IS 5°C FROM DEATH”*

And a lot closer to loss of performance

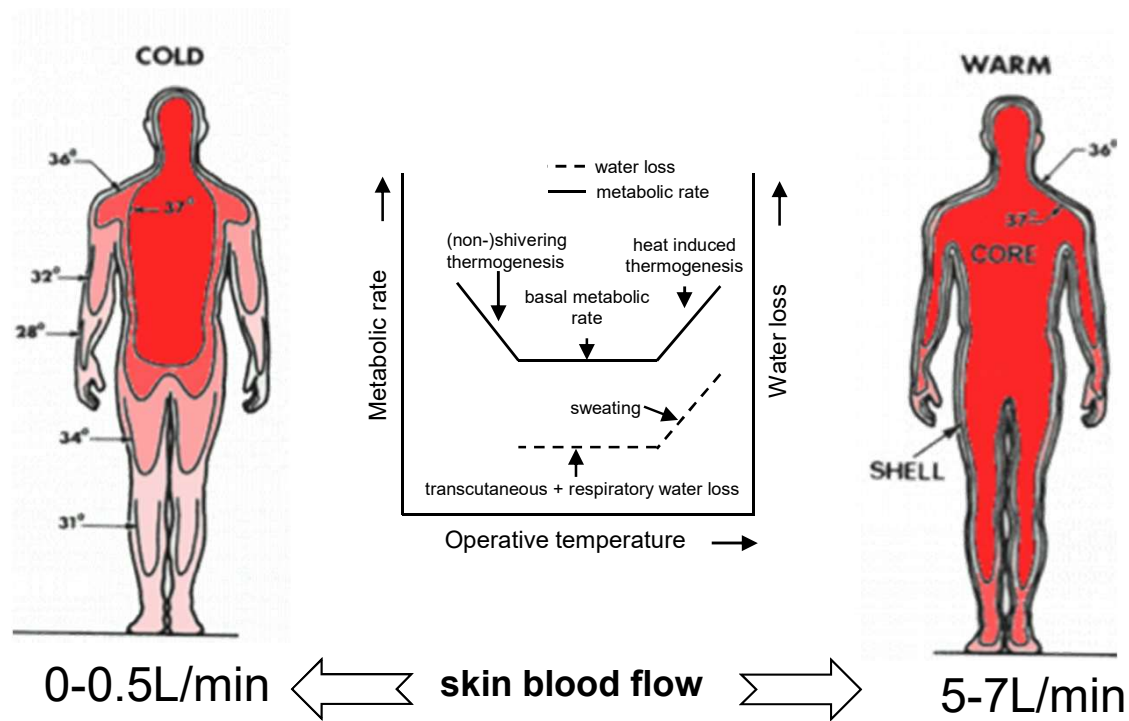
CORE TEMPERATURE

- › Core temperatures above 39 °C can be critical
 - › Heat cramps
 - › Heat exhaustion
 - › Heat stroke



- › However, the critical core temperature is individual dependent
 - › Marathon runners have been observed with $T_c = 42$ °C at the finish of a marathon, without heat illness
 - › Genetically or trained?

COST OF THERMOREGULATION



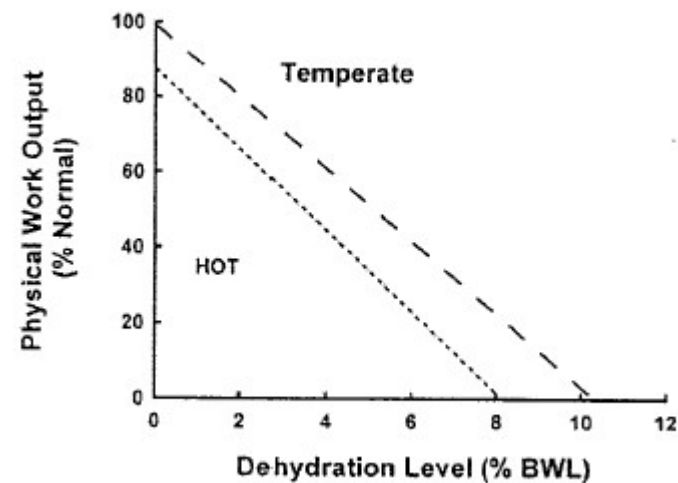
Male vs. Female?

Resting cardiac output = 5L/min

Source: Kingma et al. 2017

CARDIOVASCULAR EFFECTS

- › Competition for blood: skin vs. muscle
- › Skin blood flow can reach up to 7 L/min
- › Sweating can result in a reduction in blood volume
 - › Performance loss
- › Cardiac output increases in heat stress
 - › $Q = SV * HR$
 - › SV decreases
 - › HR increases



WHY IMPAIRED IN THE HEAT?

- › Increased cardiac strain
- › Dehydration
- › Glycogen depletion
- › Increased brain temperature
- › Discomfort

HEAT MITIGATION IN WARM CONDITION

WBGT



Work/Rest cycles en water consumption



Ergonomics: Temperature regulation

Work/Rest and Water Consumption Table
Applies to average sized, heat-acclimated soldier wearing BDU, hot weather. (See TB MED 507 for further guidance.)

		Easy Work		Moderate Work		Hard Work	
		Work/Rest (min)	Water Intake (qt/hr)	Work/Rest (min)	Water Intake (qt/hr)	Work/Rest (min)	Water Intake (qt/hr)
1	78° - 81.9°	NL	¼	NL	¼	40/20 min	¼
2 (GREEN)	82° - 84.9°	NL	¼	50/10 min	¼	30/30 min	1
3 (YELLOW)	85° - 87.9°	NL	¼	40/20 min	¼	30/30 min	1
4 (RED)	88° - 89.9°	NL	¼	30/30 min	¼	20/40 min	1
5 (BLACK)	> 90°	50/10 min	1	20/40 min	1	10/50 min	1

Heat Category	WBGT Index, F°	Easy Work		Moderate Work		Hard Work	
		Work/Rest (min)	Water Intake (qt/hr)	Work/Rest (min)	Water Intake (qt/hr)	Work/Rest (min)	Water Intake (qt/hr)
1	78° - 81.9°	NL	¼	NL	¼	40/20 min	¼
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Easy Work

- Weapon Maintenance
- Walking Hard Surface at 2.5 mph, < 30 lb Load
- Marksmanship Training
- Drill and Ceremony
- Manual of Arms

Moderate Work

- Walking Loose Sand at 2.5 mph, No Load
- Walking Hard Surface at 3.5 mph, < 40 lb Load
- Calisthenics
- Patrolling
- Individual Movement Techniques, i.e., Low Crawl or High Crawl
- Defensive Position Construction

Hard Work

- Walking Hard Surface at 3.5 mph, ≥ 40 lb Load
- Walking Loose Sand at 2.5 mph with Load
- Field Assaults

Notes:

- The work/rest times and fluid replacement volumes will sustain performance and hydration for at least 4 hrs of work in the specified heat category. Fluid needs can vary based on individual differences (± ¼ qt/hr) and exposure to full sun or full shade (± ¼ qt/hr).
- NL = no limit to work time per hr.
- Rest = minimal physical activity (sitting or standing) accomplished in shade if possible.
- **CAUTION: Hourly fluid intake should not exceed 1½ qts.**
- **Daily fluid intake should not exceed 12 qts.**
- If wearing body armor, add 5°F to WBGT index in humid climates.
- If doing Easy Work and wearing NBC (MOPP 4) clothing, add 10°F to WBGT index.
- If doing Moderate or Hard Work and wearing NBC (MOPP 4) clothing, add 20°F to WBGT index.

For additional copies, contact: U.S. Army Center for Health Promotion and Preventive Medicine Health Information Operations Division
tel: (800) 222-9698 or CH2PMA - Health Information Operations@ajpa.army.mil
For electronic versions, see <http://ichppm-www.apgea.army.mil/heat>. Local reproduction is authorized.
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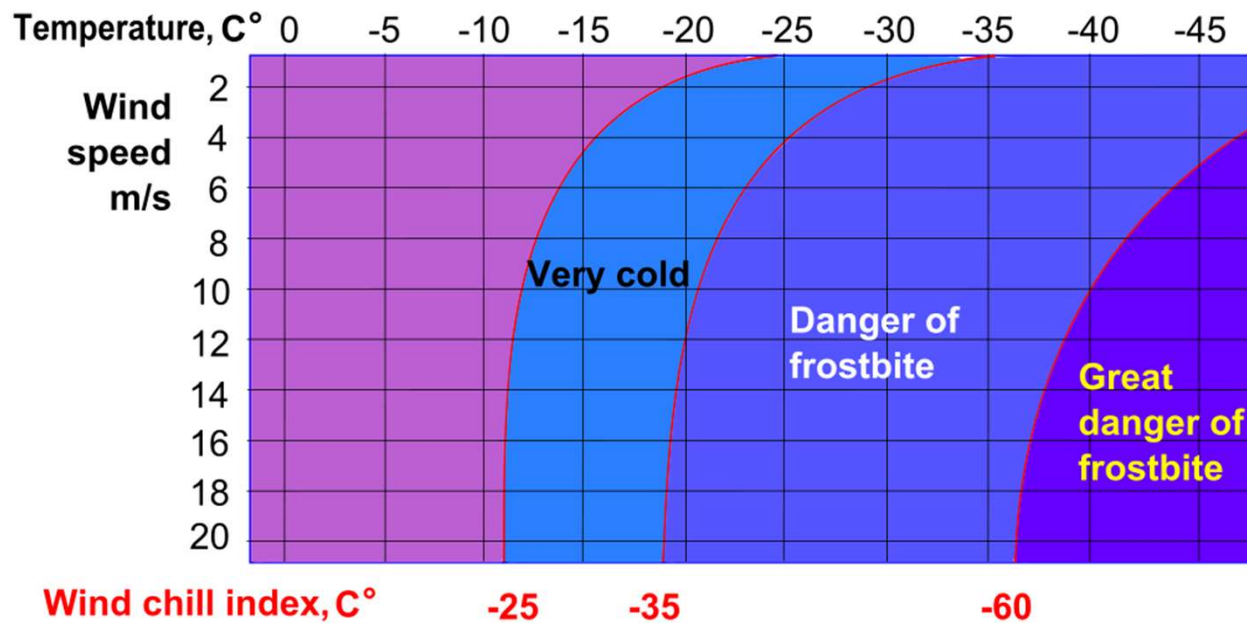
EXAMPLE WORK REST CYCLE AND PLANNING

- › Patrolling for 1 hour in a mild thermal environment
 - › Work Rest Cycle > 4 hours
 - › Required: 1 person

- › Patrolling for 1 hour in a hot thermal environment
 - › Work 20 minutes, Cool down 40 minutes
 - › Required: 3 persons

WIND CHILL INDEX (JAG – TI)

WIND CHILL





USE CASE WEATHER FORECAST?