

Finnish Institute of
Occupational Health

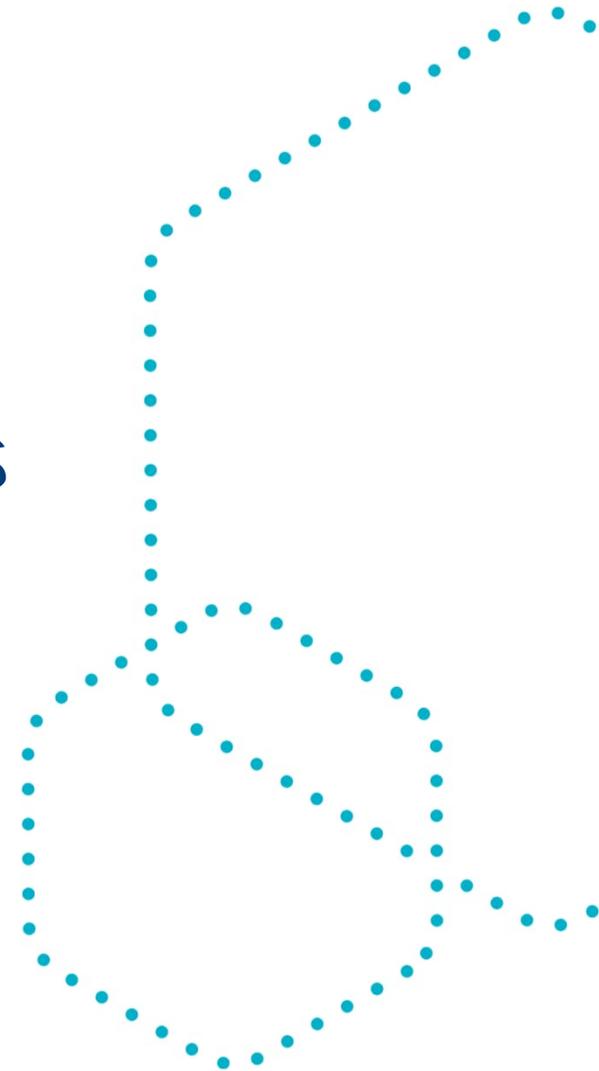
80 YEARS OF
WELL-BEING
THROUGH WORK

Heat strain while working indoors under high relative humidity and temperature with cooling vests

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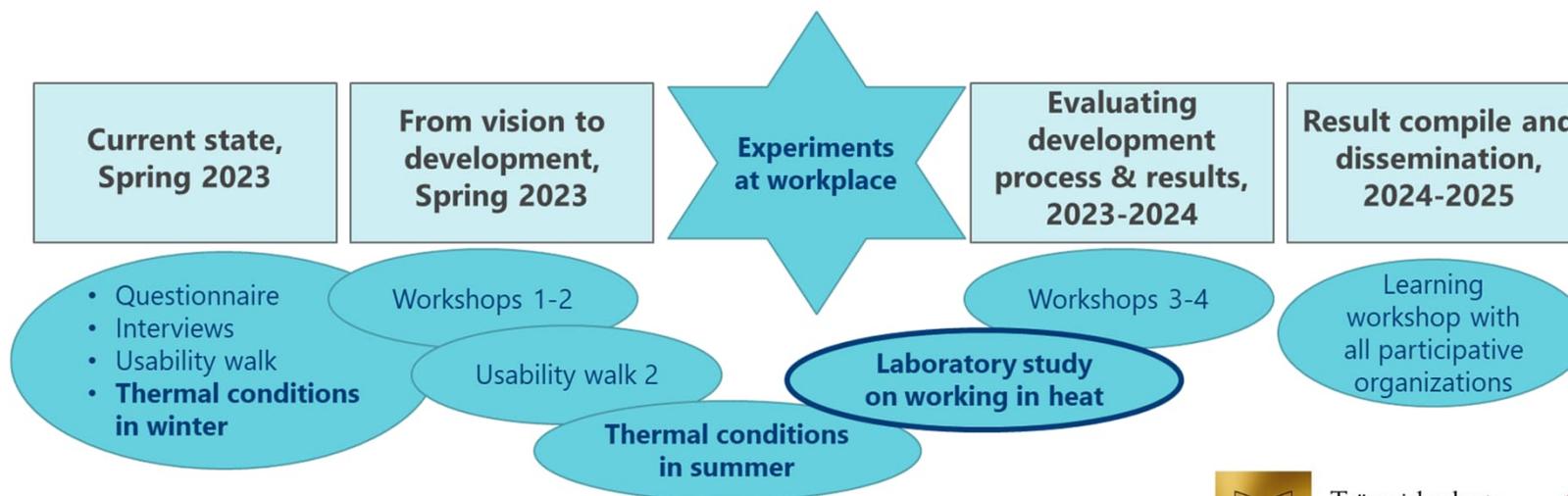


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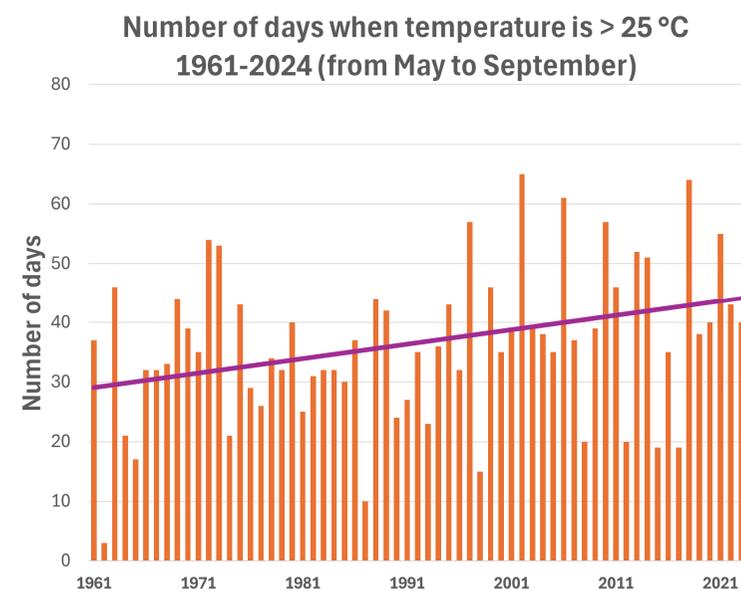
Workplaces as climate actors, sustainable solutions through co-creation – TILKE (8/2022-6/2025)

- How can work communities become active change agents in adapting and mitigating to climate change?
- Produce a “TILKE model”: agency index and co-creation process description.
- Case processes with rescue services, primary school, **laundry**



Introduction

- Climate change increase ambient temperatures and extend the periods of heatwaves (>25°C) in summer, also in Northern regions.
 - Also elevates indoor temperatures.
- The ambient temperature > 28°C is the criterium for hot work in Finnish occupations.
 - Not taking into account relative humidity
- Working in heat:
 - Heat strain and heat related health problems increase
 - Well-being and occupational safety decrease
 - Productivity decrease

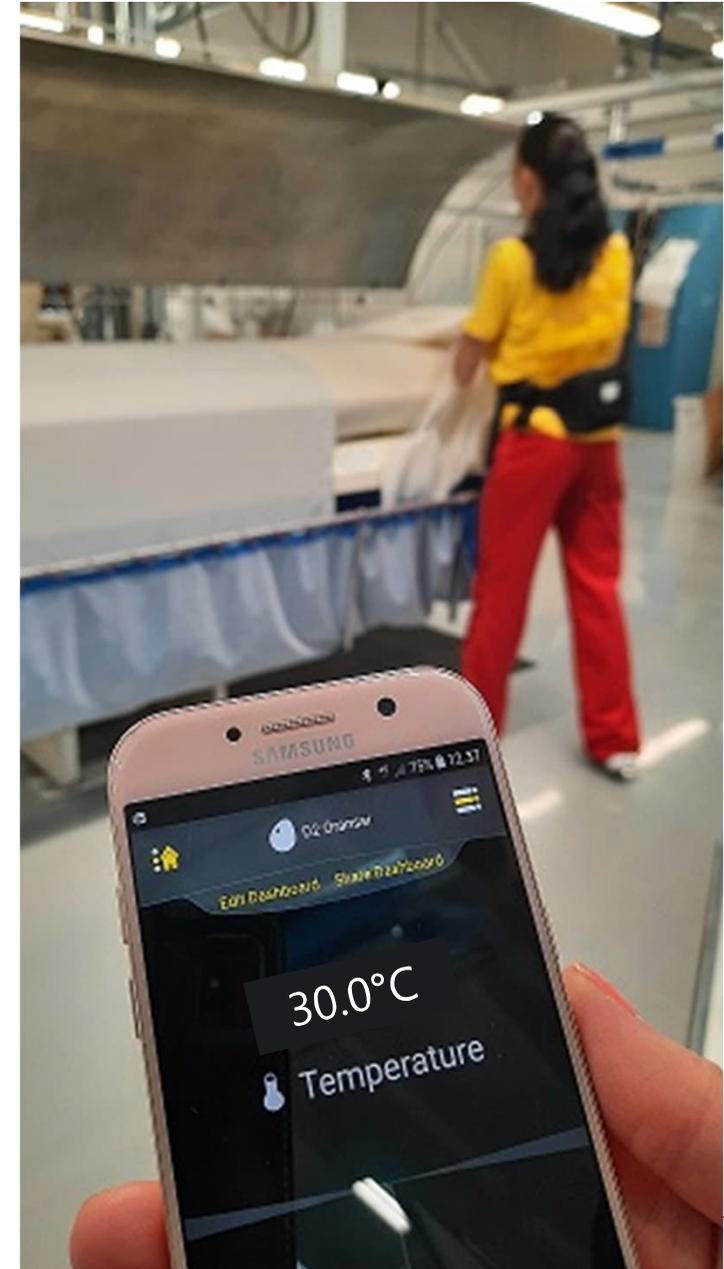


Reference: Finnish Meteorological Institute



Objectives

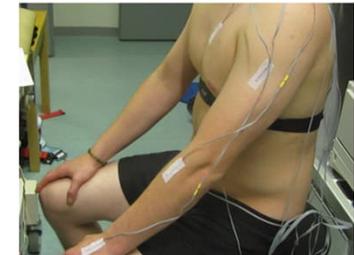
- Motivation for this study was based on the questionnaire and interviews.
- The study aimed:
 1. to find how high relative humidity (Rh) effects on heat strain while working in heat,
 2. to find if heat strain can be mitigated by cooling vest.





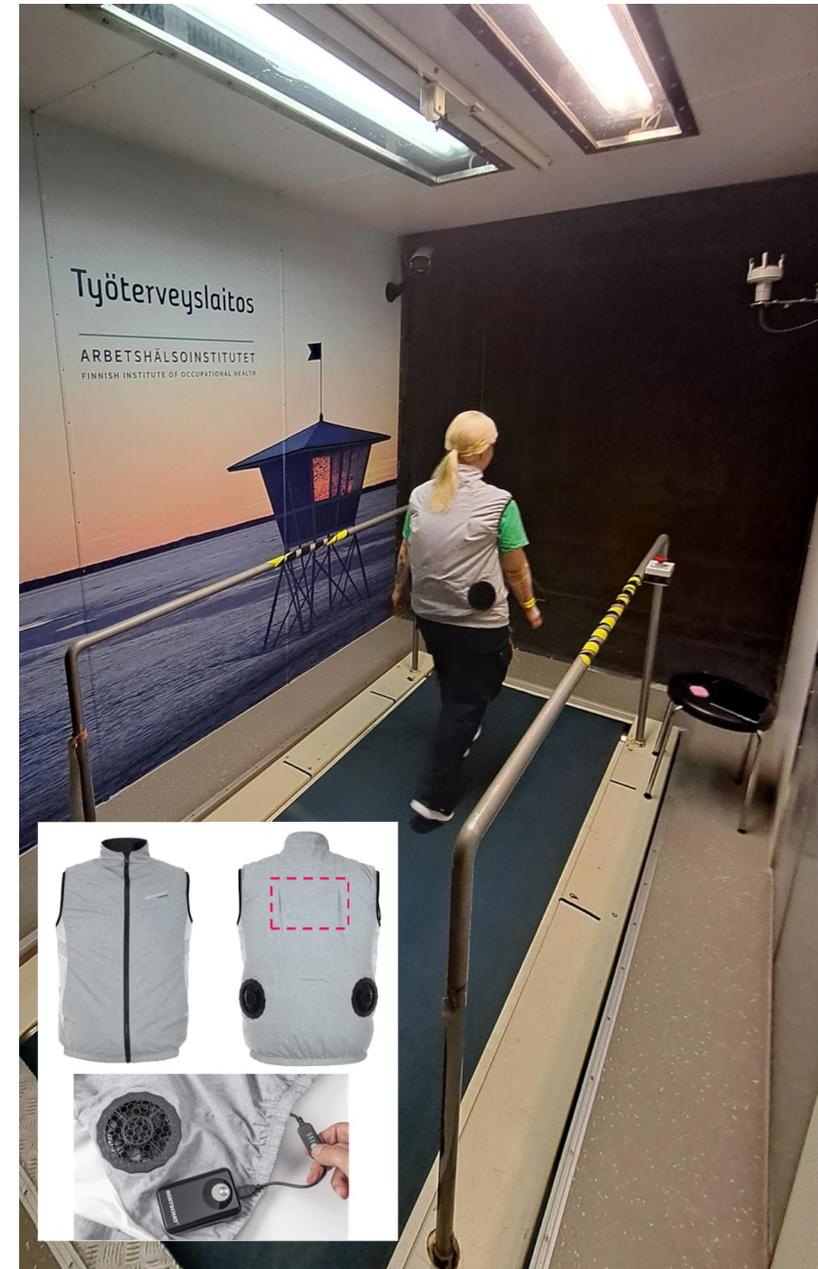
Test subjects and methods

- Testing conditions were selected based on real work environment (measured 2023) and physical activity at a laundry:
 - Conditions: $T_a=30$ °C, Rh 40% and 75%, wind speed 0.5 m/s
 - Work intensity: light work
- Six test subjects: female/male, age 38.2 years ($SD\pm 15.3$ years), BMI 23.8 ($SD\pm 4.9$)
- Measurements:
 - Heart rate, core and skin temperatures (9 sites),
 - Moisture accumulations by weighing the garments, Rh inside clothing by iButtons
 - Thermal sensation, thermal comfort, skin moisture sensation and Rated Perceived Exertion (RPE) were asked from the test subjects in every 10 min.
- Test protocol:



Material – Cooling vests

- The studied ensembles:
 1. No Cooling: fans OFF
 2. Fan Cooling: fans ON
 3. Hybrid Cooling: fans ON and cooling packages on the upper back
- Clothing worn during the test protocol was:
 - T-shirt (cotton),
 - thin working trousers (cotton),
 - socks and running shoes.



Results: High relative humidity (40% → 75%) increased heat strain

- The mean T_{sk} was approx. by 0.5°C elevated (T-test, $p < 0.001$)
- Increase of core temperature at the end of the test was (T-test, $p < 0.001$):
 - Rh 40%: 0.25°C; Rh 75%: 0.42°C
 - Thermal sensation at the end of work: Rh 40% "Very warm"; Rh 75% "Hot"
 - Thermal comfort at the end of work: Rh 40% "Uncomfortable"; Rh 75% "Very uncomfortable"
- Heart rate increased an average by 3.4% during working (T-test, $p < 0.001$)
 - RPE at the end of work: Rh 40% was 12; Rh 75% was 14
- Sweating: approx. 3.5 times higher moisture accumulations (T-shirt and trousers)
 - The moisture sensations at the end: Rh 40% "Damp"; Rh 75% "Wet"



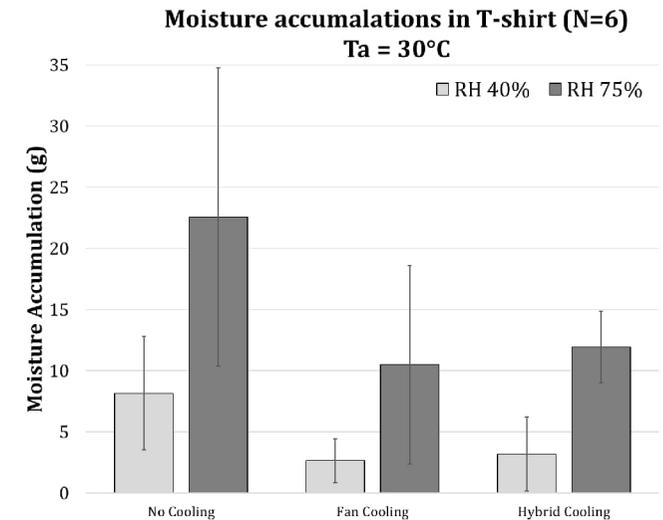
Results: Use of cooling vests

- Skin temperatures declined → great impact on local temperatures close to cooling elements
- No impact on core temperatures
- Thermal sensation at the end of work, Rh 75%: No Cooling “Hot”; Cooling vest “Very warm”
- Thermal comfort at the end of work, Rh 75%: No Cooling “Very uncomfortable”; Cooling vest “Uncomfortable”
- Heart rate:
 - Lower with cooling vests at the end of work and break
 - Greater impact when Rh 75%
 - RPE at the end of the tests at Rh 75%: No Cooling: 14; Fan Cooling: 12; Hybrid Cooling: 13



Results: Moisture accumulations with cooling vests

- The lowest moisture accumulations with the Fan Cooling vest
 - Increased ventilation and evaporation
- Relative humidity in the T-Shirt was 8% lower with cooling vests at the end (Rh 75%)
 - The moisture sensations (Rh 75%)
 - With cooling vests “Damp” and without “Wet” → No difference between vests



Conclusion

High relative humidity in heat increases heat strain of the workers

- Special attention is required to workers with vulnerabilities related to working in heat → in co-operation with health care professionals
- Sweating increased → prevention of dehydration and sufficient energy gain
- No cooling during breaks if they are held in same ambient condition → cooler places for breaks or other cooling methods applied

Use of cooling vests

- Decrease skin temperatures → improved experience of thermal comfort/sensation
- Decrease moisture in the garments → Fan cooling boost moisture and heat transfer
- Lowered perceived exertion during work and improved recovery during breaks
- No impact on core temperature

Climate change effects on work should be considered as part of occupational safety and health (OSH) planning



Thank you for your attention!

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