IMPACTS OF OCCUPATIONAL HEAT STRAIN ON HEALTH & PRODUCTIVITY

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Vulnerable population groups
- workers
- elderly
- people with chronic diseases
Mission: to address the negative impacts of workplace heat stress on the health and productivity of workers in strategic European industries
Workers’ health and productivity under occupational heat strain: a systematic review and meta-analysis

Summary
Background: Occupational heat strain (i.e., the effect of environmental heat stress on the body) directly threatens workers’ abilities to live healthy and productive lives. We examined the effects of occupational heat strain on workers’ health and productivity outcomes.

Methods: Following PRISMA guidelines for this systematic review and meta-analysis, we searched PubMed and Embase from databases inception to 31 March 2018, for relevant studies in any labor circumstance and at any level of occupational heat strain. No restrictions on language, workers’ health status, or study design were applied. Occupritional heat strain was defined using international heat stress safety guidelines and standards. We excluded studies that calculated effects using simulations or statistical models instead of actual measurements, and any non-human. Risk factors, data extraction, and sensitivity analyses were performed by two independent investigators. We randomly selected meta-analyses to determine overall occupational heat strain, heat injury or acute heat injury, productivity loss, relative temperature, change in water-specific gravity, and odds of occupational heat strain occurring during the end of a work shift in heat stress conditions. The review protocol is available on PROSPERO registration number CRD42017161372.

Results: Of 956 reports identified through our systematic search, 113 studies done in 30 countries, including 467 million workers from more than 40 different occupations, were eligible for analysis. One meta-analysis showed that individuals working a single shift under heat stress (defined as worksheds global temperatures ≥ 24 or 26°C depending on work intensity) were 1.63 times (95% CI 1.24–2.15; 56,978 workers) more likely to experience occupational heat strain than an individual working in non-heated conditions, while their core temperature was increased by 0.7°C (8,656–13,347 studies with 3,165 workers) and their active specific gravity was increased by 0.006% (8,656–13,347 studies with 3,165 workers). During or at the end of a work shift under heat stress, 23% (26-33 studies with 15,000 workers) of workers experienced occupational heat strain, while 30% (13,350 studies with 33,000 workers) reported productivity losses. Finally, 21 studies with 13,710 workers of individuals who typically or frequently worked under heat stress reported 8.6 per day, 3 days per week, for 1 month of the most experienced labor force or acute labor injury. Overall, this analysis included a variety of populations, exposures, and occupations to comply with a wider adoption of evidence criteria, but resulted in large heterogeneity in our meta-analysis. Guiding of Recommendations, Assessment, Development and Evaluation approach revealed moderate confidence for most results and very low confidence in two scenarios (average over temperature and change in water-specific gravity) due to studies being funded by industry.

Interpretation: Occupational heat strain has important health and productivity outcomes and should be recognized as a public health problem. Continued international action is needed to mitigate its effects in light of climate change and the anticipated rise in heat stress.

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Introduction
Nearly a third of the world’s population is regularly exposed to climate conditions that could harm human thermal regulation capacity, leading to major increases in morbidity and mortality.1 Even as mitigation efforts continue to be adopted, many suggest that half of the world’s population will be exposed to such conditions by 2080 and onward.2-4 Thus, the resulting occupational heat strain will already threaten workers’ health, with corresponding negative effects on productivity, poverty, and socioeconomic inequality. Occupational heat strain refers to the physiological effect of environmental heat stress on the body and its role in a range of impacts on the ability to carry out productive and productive tasks. Nearly, 65 million work days are performed to be lost by 2050 due to occupational heat strain fatalities, with 20 million work days lost last because of reduced labor productivity.5 Existing evidence for extreme weather events has been primarily in more countries, but they are designed for the general
HEALTH & PRODUCTIVITY IMPACT OF OCCUPATIONAL HEAT

- PRISMA guidelines

- PubMed and Embase (date of inception to Feb 5, 2018)

- No search limits
  - labour environment
  - language
  - workers’ health status
  - study design

- Six random-effects meta-analyses estimated the impact of occupational heat strain on health and productivity outcomes

- Review protocol (CRD42017083271) available on PROSPERO

Flouris et al., 2018; Lancet Plan Health
HEALTH & PRODUCTIVITY IMPACT OF OCCUPATIONAL HEAT

60% of studies

Flouris et al., 2018; Lancet Plan Health
111 studies from 30 countries that assessed 447 million workers from >40 different jobs
Those who frequently work in the heat experience

- **4-fold** increase in the likelihood of having heat strain

- **0.7°C** higher body temperature

- **14.5%** increase in urine specific gravity

- **15%** risk for kidney disease / acute kidney injury

Flouris et al., 2018; Lancet Plan Health
During or at the end of a single work shift under heat stress, 35% of workers experience symptoms of occupational heat strain.
HEAT-SHIELD mission: to address the negative impacts of workplace heat stress on the health and productivity of workers in strategic European industries.
HEAT IN THE WORKPLACE

Construction

Agriculture

Flouris et al., Unpublished Data
HEAT IN THE WORKPLACE

Tourism

max core temp. recorded

Flouris et al., Unpublished Data
During or at the end of a single work shift under heat stress

- 35% of workers experience symptoms of occupational heat strain

Flouris et al., 2018; Lancet Plan Health
During or at the end of a single work shift under heat stress

- 30% of workers report productivity losses
IRREGULAR WORK BREAKS
DO YOU THINK THE HEAT AFFECTS YOUR PRODUCTIVITY?
DO YOU THINK THE HEAT AFFECTS YOUR PRODUCTIVITY?

Loss of 1% of labour time for every 1°C increase in environmental temperature.

Ioannou et al., Under Preparation
TEMPERATURE & LABOUR LOSS

- Low heat stress
- Moderate heat stress
- High heat stress

Ioannou et al., Under Preparation
Low heat stress
Moderate heat stress
High heat stress
Heat Stress & Labour Loss

Degrees Celsius (°C)

- Tair
- WBGT

- UTCI

Solar Radiation (W/m²)

- solR

<15
15-21
21-26
26-33

<10
10-20
20-30
30-40

<50
50-60
60-70
70-80

<900
900-1200
1200-1500

= one work shift lost per 10 work shifts

Ioannou et al., Under Preparation
Percentage of gross value added lost across Europe

agriculture  construction

manufacturing  tourism  transportation

Flouris et al., Under Preparation
Workplace heat generates significant adverse effects
- health risks
- loss of productivity with substantial effects on the economy
- Vulnerable population groups
  - workers
  - elderly
  - people with chronic diseases
THERMOREGULATION – AGING – DIABETES

**Graph:**
- **Heat gain:** ΔH_b
- **Heat loss**
- **204 kJ**

**Axes:**
- **Heat gain / heat loss (W)**
- **Time (min)**

**Source:** Kenny et al., 2017, Temperature
THERMOREGULATION – AGING – DIABETES

Body heat storage (W)

- **Young**
- **Older**
- **T2D**

Cumulative change (W)

0-30 31-60 61-90 91-120 121-150 151-180

Kenny et al., 2017, Temperature
RISK FACTORS FOR HEAT SUSCEPTIBILITY

Chronic health condition (e.g., type 2 diabetes, chronic volume depletion, skin disorder/burn, inability to increase cardiovascular output, heat shock protein dysregulation, neurocognitive conditions) and associated medication (e.g., ADHD drugs, antihypertensive drugs)

Acute illness (e.g., viral infection, fever, skin condition) and associated medication (e.g., diuretics, antihistamines, antipyretics)

Inadequate acclimation/acclimatization to the environmental conditions

Fluid imbalance (dehydration or inadequate fluid consumption)

Sleep deprivation

Age extremes (young children & elderly persons)

High intrinsic motivation to exercise/work and/or reluctance to report events or risk factors

Poor aerobic capacity

Individual health status

Individual characteristics

Preparedness

Environmental factors

Occupational/ Medical support

Personal strategies

Lack of emergency planning to detect and treat heat exhaustion

Delayed identification of early warning symptoms

Limited knowledge and/or awareness about heat exhaustion among health, professionals, organisers, coaches, etc.

Lack of or limited access to fluids prior to exercise/work or during breaks

Increased environmental heat load (high temperature and/or humidity and/or solar radiation)

High extrinsic motivation to exercise/ work (e.g., from peers or organization)

Inappropriate work-to-rest ratios or work/ exercise at a higher intensity and/or longer duration compared to typical routine

Use of protective clothing
Individuals exercising/working in the heat who are 31-70 years old are at higher risk for heat strain when demonstrating two or more of the following (♂, ♀):

- age
  - ≥53/56 years

- body composition/morphology
  - BMI: ≥30/26 kg/m²
  - adiposity: ≥29/35 %
  - body surface area: ≤2.0/1.7 m²

- aerobic fitness
  - VO₂peak: ≤48/41 mlO₂/kg FFM/min
Heat strain
- Psychophysical
- Physiological
- Performance

Intra-individual factors
- Illness/Medication
- Consecutive work
- Shift duration
- Acclimation
- Hydration
- Sleep

Heat stress
- Metabolic heat
- Environment
- Clothing

Inter-individual factors
- Physical characteristics
- Chronic disease
- Age
- Sex
IMPACTS OF OCCUPATIONAL HEAT STRAIN ON HEALTH & PRODUCTIVITY

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