The effects of temperature on human health

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Photo: Ilpo Okkonen
Effects of heat and cold exposure

- Unpleasant sensations
  - Cold, pain, hot
- Decreased performance
  - Physical and cognitive
- Symptoms, morbidity
  - Cardiovascular and respiratory diseases
- Injuries
  - Frostbite, hypotermia, hypertermia, heat stroke
- Mortality
Factors affecting heat balance

Environment

Exercise

Clothing

Individual factors:
Age
Gender
Fitness
Subcutaneous fat
Shape and form
Health
Medication
Adaptation

Individual factors:
Age
Gender
Fitness
Subcutaneous fat
Shape and form
Health
Medication
Adaptation
Why study extreme temperatures and health?

- Increased morbidity with the ageing population
- Increased frequency of extreme weather events due to climate change
- Need to identify vulnerable population groups
- The adverse health effects are often preventable with relatively simple measures
- Development of management model
  - Improved functional and working ability
  - Reduced health care costs
  - A higher share of cold- and heat-related mortality can be prevented
Symptoms in cold ja hot environments
Asthma and allergic rhinitis increase respiratory symptoms in cold weather among young adults

Henna Hyrkäs a, b, c, Maritta S. Jaakkola a, b, c, d, Tina M. Ikäheimo a, c, e, Timo T. Hugg a, c, e, Jouni J.K. Jaakkola a, b, c, e, *
Asthma, allergic rhinitis and respiratory symptoms in cold

Hyrkäs et al. 2013 Respir Med

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Prevalences (%) and prevalence ratios (PR) and their 95% confidence intervals (CI) of cold weather-related respiratory symptoms according to having asthma with or without allergic rhinitis or allergic rhinitis alone.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of subjects with symptoms and prevalence (%)</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>Healthy</td>
</tr>
<tr>
<td></td>
<td>Allergic rhinitis</td>
</tr>
<tr>
<td></td>
<td>Asthma without allergic rhinitis</td>
</tr>
<tr>
<td></td>
<td>Asthma with allergic rhinitis</td>
</tr>
<tr>
<td>Phlegm production</td>
<td>Healthy</td>
</tr>
<tr>
<td></td>
<td>Allergic rhinitis</td>
</tr>
<tr>
<td></td>
<td>Asthma without allergic rhinitis</td>
</tr>
<tr>
<td></td>
<td>Asthma with allergic rhinitis</td>
</tr>
<tr>
<td>Wheezing</td>
<td>Healthy</td>
</tr>
<tr>
<td></td>
<td>Allergic rhinitis</td>
</tr>
<tr>
<td></td>
<td>Asthma without allergic rhinitis</td>
</tr>
<tr>
<td></td>
<td>Asthma with allergic rhinitis</td>
</tr>
<tr>
<td>Prolonged cough</td>
<td>Healthy</td>
</tr>
<tr>
<td></td>
<td>Allergic rhinitis</td>
</tr>
<tr>
<td></td>
<td>Asthma without allergic rhinitis</td>
</tr>
<tr>
<td></td>
<td>Asthma with allergic rhinitis</td>
</tr>
<tr>
<td>Chest pain</td>
<td>Healthy</td>
</tr>
<tr>
<td></td>
<td>Allergic rhinitis</td>
</tr>
<tr>
<td></td>
<td>Asthma without allergic rhinitis</td>
</tr>
<tr>
<td></td>
<td>Asthma with allergic rhinitis</td>
</tr>
</tbody>
</table>

Note: CI = confidence interval; statistically significant results are bolded.

* Adjusted for gender, age, marital status, education, having children, smoking, exposure to secondhand smoke (SHS) and cold exposure.
Original Research

Cold-related symptoms among the healthy and sick of the general population: National FINRISK Study data, 2002

S. Näyhä a,b,*, J. Hassi a, P. Jousilahti c, T. Laatikainen c, T.M. Ikaheimo a

a Institute of Health Sciences, University of Oulu, Finland
b Finnish Institute of Occupational Health, Oulu, Finland
c National Institute for Health and Welfare, Helsinki, Finland
Cold-related symptoms in healthy and those with a disease

<table>
<thead>
<tr>
<th>MUSCULOSKELETAL PAIN</th>
<th>RESPIRATORY SYMPTOMS</th>
<th>FINGER SYMPTOMS</th>
<th>PERIPHERAL SYMPTOMS</th>
<th>CARDIOVASC SYMPTOMS</th>
<th>ANY COLD-RELATED SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL RESPIRATORY</td>
<td>44</td>
<td>66</td>
<td>17</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Asthma</td>
<td>42</td>
<td>69</td>
<td>17</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>Chronic bronchitis</td>
<td>32</td>
<td>65</td>
<td>23</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>Only respiratory disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL CARDIOVASCULAR</td>
<td>41</td>
<td>31</td>
<td>19</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td>57</td>
<td>57</td>
<td>26</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Stroke</td>
<td>34</td>
<td>30</td>
<td>15</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Only cardiovasc disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>42</td>
<td>56</td>
<td>13</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>JOINT/BACK DISEASE</td>
<td>45</td>
<td>33</td>
<td>20</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>Only joint/back disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MENTAL DISEASE</td>
<td>49</td>
<td>40</td>
<td>24</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Depression</td>
<td>50</td>
<td>42</td>
<td>25</td>
<td>27</td>
<td>10</td>
</tr>
<tr>
<td>Only mental disease</td>
<td>30</td>
<td>25</td>
<td>22</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>HEALTHY</td>
<td>23</td>
<td>18</td>
<td>12</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>ALL</td>
<td>31</td>
<td>26</td>
<td>15</td>
<td>13</td>
<td>4</td>
</tr>
</tbody>
</table>

Näyhä, Public Health 2011
Heat-related thermal sensation, comfort and symptoms in a northern population: the National FINRISK 2007 study

Simo Näyhä¹,²,³, Hannu Rintamäki³,⁴, Gavin Donaldson⁵, Juhani Hassi¹,², Pekka Jousilahti⁶, Tiina Laatikainen⁵,⁷,⁸, Jouni J. K. Jaakkola¹,²,⁹, Tiina M. Ikäheimo¹,²
## Heat-related symptoms at the population level

Näyhä et al. 2013  Eur J Public Health

<table>
<thead>
<tr>
<th>Symptom</th>
<th>All % (95% CI)</th>
<th>Men (%)</th>
<th>Women (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thirst</td>
<td>67.5 (64.8-70.2)</td>
<td>61.4</td>
<td>72.5</td>
</tr>
<tr>
<td>Drying of mouth</td>
<td>43.0 (40.9-45.1)</td>
<td>40.0</td>
<td>45.4</td>
</tr>
<tr>
<td>Impaired endurance</td>
<td>42.7 (40.6-44.8)</td>
<td>36.3</td>
<td>48.1</td>
</tr>
<tr>
<td>Sleep disturbances</td>
<td>32.4 (30.6-34.3)</td>
<td>26.1</td>
<td>37.7</td>
</tr>
<tr>
<td>Headache</td>
<td>19.0 (17.7-20.5)</td>
<td>10.6</td>
<td>26.1</td>
</tr>
<tr>
<td>Impaired concentration</td>
<td>18.6 (17.2-20.1)</td>
<td>13.2</td>
<td>23.1</td>
</tr>
<tr>
<td>Strong fatigue</td>
<td>16.1 (14.9-17.5)</td>
<td>10.8</td>
<td>20.7</td>
</tr>
<tr>
<td>Dizziness</td>
<td>13.9 (12.8-15.2)</td>
<td>7.7</td>
<td>19.2</td>
</tr>
<tr>
<td>Impaired muscular strength</td>
<td>11.2 (10.2-12.3)</td>
<td>8.5</td>
<td>13.6</td>
</tr>
<tr>
<td>Nausea, vomiting</td>
<td>4.4 (3.8-5.2)</td>
<td>1.7</td>
<td>6.7</td>
</tr>
<tr>
<td><strong>Any symptom</strong></td>
<td><strong>78.5 (75.7-81.4)</strong></td>
<td><strong>71.7</strong></td>
<td><strong>84.2</strong></td>
</tr>
</tbody>
</table>
• Thermal comfort a +22°C
• Decreases by 1-5°C due to ageing

Cold and heat exposure and morbidity
Temperature and blood pressure

Relationship Between Blood Pressure and Outdoor Temperature in a Large Sample of Elderly Individuals

The Three-City Study

Annick Alpérovitch, MD; Jean-Marc Lacombe, MSc; Olivier Hanon, MD; Jean-François Dartigues, MD; Karen Ritchie, PhD; Pierre Ducimetière, PhD; Christophe Tzourio, MD

The effect of temperature on systolic blood pressure

Adrian G. Barnett\textsuperscript{a}, Susana Sans\textsuperscript{b}, Veikko Salomaa\textsuperscript{c}, Kari Kuulasmaa\textsuperscript{c}, Annette J. Dobson\textsuperscript{a} and for the WHO MONICA Project\textsuperscript{d}
Increased blood pressure in cold

- Both acute and long-term effects on blood pressure (BP)
- Three-City Study in Europe
  - Temperature and BP correlated negatively in elderly people (+80 yrs, n=8801)
  - Seasonal difference in BP 8 mmHg (8-21°C)
- Worldwide WHO MONICA analysis:
  - 25 populations, 16 countries (n=115 434)
  - 1°C decrease in temperature increases BP 0.19 mmHg (also indoor temperature correlated with BP)
  - Larger seasonal difference in BP in those living closer to the equator
  - Stronger effect of temperature in women than men

Alperovitch et al.
Arch Intern Med. 2009

Barnett et al.
Blood Pressure Monit 2007
• Increased amount of coronary events with decreased temperature
  – More frequently among women than men and in a warmer compared with colder climate
Decline in temperature and humidity increases the occurrence of influenza in cold climate

Kari Jaakkola¹⁹, Annika Saukkoriipi², Jari Jokelainen³,⁴, Raija Juvonen⁵, Jaana Kauppila⁶, Olli Vainio⁶,⁷, Thedi Ziegler⁸, Esa Rönkkö⁹, Jouni JK Jaakkola³,⁹,¹⁰,¹¹, Tiina M Ikäheimo³,⁹,¹¹* and the KIAS-Study Group
Respiratory infections and cold

- 892 conscripts, with cold exposure and outdoor training
- 1°C decrease in temperature increases the risk of URTI 4%, flu by 2% and laryngitis by 2%
- Decrease in absolute humidity (1 g/m³) increases the risk of URTI by 10%
- Respiratory tract infections occur most commonly below 0 °C

Mäkinen ym Respir Med 2009
• 1°C decrease in temperature and 0.5 g decrease per m³ in AH increased the estimated risk by 11% [OR 1.11 (1.03 to 1.20)] and 58% [OR 1.58 (1.28 to 1.96)], respectively.
• 305 men from London (1995-2009)
• More exacerbations in winter (1,052) than summer (676)
• Recovery longer in winter (10 days) than summer (9 days)
• Outdoor activity reduced more related to exacerbation in winter (14 days) than summer (8 days)
• Hospital care more often in winter (8.4%) than summer (4.6%)
High Temperature and Hospitalizations for Cardiovascular and Respiratory Causes in 12 European Cities

Paola Michelozzi¹, Gabriele Accetta¹,², Manuela De Saro¹, Daniela D’Ippoliti¹, Claudia Marino¹, Michela Baccini²,³, Annibale Biggeri²,³, H. Ross Anderson⁴, Klea Katsouyanni⁵, Ferran Ballester⁶, Luigi Bisanti⁷, Ennio Cadum⁸, Bertil Forsberg⁹, Francesco Forastiere¹, Patrick G. Goodman¹⁰, Ana Hojs¹¹, Ursula Kirchmayer¹, Sylvia Medina¹², Anna Paldy¹³, Christian Schindler¹⁴, Jordi Sunyer¹⁵, and Carlo A. Perucci¹, on behalf of the PHEWE Collaborative Group*

- PHEWE-project, 12 European cities
- For a 1°C increase in maximum apparent temperature above a threshold, respiratory admissions increased by +4.5% and +3.1% in the 75+ age group in Mediterranean and North-Continental cities
- No apparent effect on cardiovascular or cerebrovascular admissions

• Questionnaire to men and women aged 25-74 years (n=6951)
• Annual incidence of mild **12.9%** (330/2550) and blister-grade frostbites **1.1%** (95/8788) (FINRISKI 97 ja 2002)
• Environmental factors: working in outdoor occupations and exposure to cold
• Individual risk factors: diabetes, white fingers, cardiac insufficiency, coronary heart disease, cerebral hemorrhage, depression and heavy alcohol use
• Over half of those who have received a frostbite suffer from different sequelae
Hypothermia

- Occurs infrequently in daily life
- Accidents, extreme weather events, substance abuse
- Environmental, behavioral and individual risk factors
- Vulnerable populations
  - Homeless
  - Elderly
  - Diseases
Heatstroke

France heat wave death toll set at 14,802

PARIS (AP) — The death toll in France from August's blistering heat wave has reached nearly 15,000, according to a government-commissioned report released Thursday, surpassing a prior tally by more than 3,000.

Scientists at INSERM, the National Institute of Health and Medical Research, deduced the toll by determining that France had experienced 14,802 more deaths than expected for the month of August.

Occurrence:

- Very young or elderly persons
- Those who have no access to air conditioning
- Among persons with chronic mental disorders or cardiopulmonary disease
- Those receiving medications that interfere with salt and water balance, such as diuretics, anticholinergic agents, and tranquilizers that impair sweating
- **Exertional heat stroke** may be seen in manual laborers, military personnel, football players, long-distance runners
Extreme temperatures and mortality
Global variation in temperature and mortality

- The temperatures with the lowest mortality were around the 75th percentile of temperature in all the countries/regions.
- The estimated effects of cold and hot temperatures on mortality varied by community and country.

Guo et al Epidemiology 2014
Temperature and mortality in Finland

- Minimum mortality in Finland at $+12 \, ^\circ C$ (2000-2005)
- In Finland the excess mortality related to heat is 160 and to cold 2,400 persons/year
- The majority of deaths occur at -15 - -5 $^\circ C$

Figure 1. Daily numbers of deaths in Finland, 2000–2005, by mean daily temperature. Circles indicate mean counts of deaths in each 1 $^\circ C$ interval; line shows regression-based smoothed values.

Tiina M Ikäheimo 2013
Effects of Cold Weather on Mortality: Results From 15 European Cities Within the PHEWE Project

- A 1 degrees C decrease in temperature was associated with a **1.35%** increase in the daily number of total natural deaths and a **1.72%**, **3.30%** and **1.25%** increase in cardiovascular, respiratory, and cerebrovascular deaths, respectively.

- The increase was greater for the older age groups

- The cold effect was found to be greater in warmer (southern) cities and persisted up to 23 days

Analitis ym. 2008 Am J Epidemiol
Effects of Cold Weather on Mortality: Results From 15 European Cities Within the PHEWE Project
Summer heat accounted for approximately more than 23,000 years of life lost per year, 55% of which was among individuals younger than 75.

When 30 day mortality displacement was taken into account, the overall impact reduced on average by 75%.

Harvesting was more pronounced in North-continental cities than in Mediterranean cities.
• The city-specific exposure-response functions have a V shape.
• The estimate of the threshold was 29.4 °C for Mediterranean cities and 23.3 °C for north-continental cities.
• The estimated overall change in all natural mortality associated with a 1°C increase in maximum apparent temperature above the city-specific threshold was 3.12% in the Mediterranean region and 1.84% in the north-continental region.
• Stronger associations were found between heat and mortality from respiratory diseases, and with mortality in the elderly.
Management of cold and heat
Vulnerable populations related to heat and cold

- Elderly people
  - Living in institutions
- Those with chronic diseases
- Children
- Women (+65-years)
- Place of residence: People adapted to cold climates cope worse with heat and vice versa
- Sosioeconomic factors
  - Social isolation
- Living and infrastructure
  - Heating is inversely associated with cold-related mortality;
  - Air conditioning reduces heat-related mortality
  - Exceptional situations (long electricity breaks)
- Immigrants
  - Lack of experience
Management of **cold** and **heat**

- **Individual’s appropriate behaviour in cold and heat**
  - Recognising personal warning signals
  - Amount of cold/heat exposure, exercise, clothing, nutrition, hydration

- **Guidance and care of patients by health care experts**
  - Susceptible groups to cold and heat
  - Behaviour, adjustment of medication, treatment
Management of **cold** and **heat**

- **Clothing:**
  - Cold: Multilayered clothing, protection of extremities, respiratory tract protection (face mask)
  - Heat: Use of textile materials that are permeable and with good moisture transfer qualities, use of hats

- **Technical solutions:**
  - Cold: Insulating or heating materials that are touched, wind shelters, prevention of slipping, lightning
  - Heat: Air conditioning, passive cooling of buildings

- **Organisatorial solutions (for work in cold and heat)**
  - Organisation of work, pauses, places where cold or heat exposure can be interrupted, workspaces (how to diminish or prevent cold/heat exposure)
Information and guidance