Bulletin n°26

Veille thermique
Période : janvier-mai 2025

Objectifs :

L'INRS est de plus en plus sollicité sur des questions concernant les activités en entreprise par forte chaleur : les activités en extérieur, l'été en période de canicule, mais aussi les activités en intérieur, dans des lieux aux conditions thermiques extrêmes. L'objectif de cette veille est de se tenir informé sur ces thématiques, dans une période où la problématique thermique croît avec les changements climatiques.

La bibliographie extraite de la base de données INRS-Biblio, permet la consultation des ressources en version PDF.

Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS.

Table des matières

INRS-Biblio

- **Documents INRS**

N. Chabanne.

Les vêtements de protection.

IC Brochure - Moyens de prévention. Paris: Institut national de recherche et de sécurité (INRS). p. 56.

https://www.inrs.fr/media.html?refINRS=ED%206546

Ce guide s'adresse à toute personne qui doit procéder au choix d'un vêtement de protection pour une situation de travail où il existe un risque d'altération de la santé par contact cutané. Il propose la démarche à suivre permettant de choisir le vêtement de protection adapté à la situation de travail. Il donne des informations non seulement sur les différents vêtements de protection, mais également sur l'acquisition, l'utilisation, l'entretien et le stockage de ces équipements.

EPI, matériaux protecteurs/refroidissants

- **EPI et matériaux pour protéger de la chaleur**

OPPBTP.

Équipements rafraîchissants - Panorama mondial et étude comparative des solutions innovantes en période de fortes chaleurs. 2024.

https://www.preventionbtp.fr/ressources/documentation/ouvrage/equipements-rafraichissants-panorama-mondial-et-etude-comparative-des-solutions-innovantes-en-periode-de-fortes-chaleurs_KCF3EDLgxA7TZR5Kw97VkH

Ce rapport d'étude offre un panorama international des équipements rafraîchissants et notamment une sélection des différentes technologies de refroidissement pour prévenir le stress thermique. Une analyse comparative réalisée sur plusieurs secteurs et sur plusieurs régions géographiques est présentée dans cet ouvrage. Mise à jour du rapport le 06/05/2025.

I. Z. Chowdhury, S. Mandal, R. J. Agnew, S. I. Tushar, A. Petrova, E. Denhartog and L. M. Boorady.

Characterizing the thermal protective performance of textiles under flame exposure.

JOURNAL OF INDUSTRIAL TEXTILES. 2025;55.

https://doi.org/10.1177/15280837251321138

Annually, thousands of firefighters suffer injuries, with burn injuries making up 7%-8% of these cases. Despite wearing protective clothing, burn injuries still occur, which underscores its limitations. The effectiveness of protective clothing is heavily influenced by the unpredictable and variable conditions firefighters face during hazardous incidents. This study compared the effects of heat flux, air gaps, and fabric attributes on TPP in multilayer systems. Results revealed a negative correlation between heat flux and TPP, with higher flux intensities increasing energy transfer through conduction and radiation, diminishing protection. Flame exposure highlighted differences in heat transfer mechanisms, with conduction and radiation dominating at high flux, whereas at low heat flux, convection, even though minimal, significantly impacts TPP. Air gaps improved TPP up to 6-mm, providing maximum insulation. However, performance plateaued or declined at 12-mm due to the transition of a stagnant air gap into a convective medium. Under prolonged, low-flux exposure, the protective benefits of 6-mm gaps diminished, revealing possible interactions between air gap size and exposure conditions. This challenges the established thresholds for air gap effectiveness for different exposure conditions. Fabric attributes further influenced TPP, with air permeability showing a positive correlation in multilayer systems due to entrapped air-enhancing insulation, which contrasts traditional findings for single-layer fabrics. Additionally, fabric weight demonstrated dual effects, improving TPP in short, high-flux exposures but reducing it under low-flux, prolonged conditions due to stored heat and thermal diffusivity. These findings underscore the interplay between the study parameters, offering critical insights into the evaluation and design of thermal protective clothing.

R. Edirisinghe and L. Gunathilake.

IoT-based smart vest for heat stress management in construction.

INTERNATIONAL JOURNAL OF CONSTRUCTION MANAGEMENT. 2025.

https://doi.org/10.1080/15623599.2025.2504550

Heat stress is a major challenge in construction, affecting workers' safety and productivity. However, existing systems often lack real-time monitoring capabilities, personalization features, and power efficiency, limiting their effectiveness. To overcome these limitations, this work presents an Internet of Things (IoT)-based smart vest, specifically designed for the construction sector. The experimental development of an IoT-based circuit followed rigorous circuit design guidelines and testing protocols. The components and sensors in the circuit were carefully designed, including IoT capabilities to cater for the construction sector's hostile work and environmental conditions. Workers' health status will be continuously monitored without disrupting regular work. The proposed system demonstrated strong performance, with an error range of -0.4 to 0.06 degrees C and continuous operation of data transmission. The developed IoT-based smart vest allows for seamless communication with cloud and local smart devices, enabling global access and effective real-time data visualization and warnings for workers and management. Temperature is used as the primary metric. Future research by the authors will incorporate heart rate variability, galvanic skin response, and humidity to enhance heat stress assessment. Sensor accuracy and reliability were validated with the potential for integration into construction safety protocols to enable a proactive response to heat stress management.

C. Farnham, J. Yuan and K. Emura.

Evaluation of the Cooling Effect of an Outdoor Misting Fan for Workers in Hot Environments Wearing Personal Protective Equipment (PPE).

CLEAN TECHNOLOGIES. 2025;7(1).

https://doi.org/10.3390/cleantechnol7010009

Heat stress on workers wearing PPE (Personal protective equipment) in hot outdoor environments is of rising concern, especially in cases when rest breaks and clothing changes are impractical. Mist fan evaporative cooling could provide low-energy continuous cooling, even during work activity. The cooling effect of a misting fan was compared to that of a fan alone, as well as natural convection. A thermal mannequin with heat flux sensors at eight body locations was exposed to an outdoor misting fan while being clothed in typical work clothes and PPE. Work clothes were dry or saturated with water to simulate sweat. The distance from the misting fan ranged from 4 m (wetting common) to 7 m (wetting unlikely). On average, the misting fan had a cooling effect of 0.31 met (18.3 W/m2) higher than natural convection when PPE is worn with wet work clothes, and 0.35 met (20.3 W/m2) higher than when PPE is worn with dry work clothes. This equates to reducing the thermal metabolic load from light industrial work to walking about in office work, or from standing to reclining. Under the ISO 7243 international standard for workers in hot environments, this would increase the acceptable WBGT (wet bulb globe temperature) by over 0.6 degrees C.

Z. H. Gao, D. M. Zheng, K. Guo, H. C. Zou, W. S. Ding, Z. Q. Du, J. L. Xue, G. Jin and H. B. Mou.

Numerical analysis of dry heat transfer in textiles and clothing microclimate.

TEXTILE RESEARCH JOURNAL. 2025.

https://doi.org/10.1177/00405175241301433

The computational fluid dynamics approach has been widely applied to explore the comfort level of human clothing. In many studies, the human limbs and trunk are treated as a uniform cylinder, yet there is a failure to consider the uniformity of airflow velocity and temperature on the surface of

clothing. This poses challenges for the testing of cylindrical fabric thermal and moisture resistance to assess clothing comfort. In this study, a 2D heat transfer model for porous textiles under different airflow and temperature conditions was established. Then, a comparative analysis was conducted of three air supply methods. The results show that the wind speed difference rates generated on the surface of the clothing by these three air supply methods were 83.3%, 65.1%, and 1.9%, respectively. To ensure that the wind speed on the surface of the clothing is as uniform as possible, method 3 was adopted to establish the wind field. In this study, the combined influences of thermal conduction, natural convection, and forced convection were incorporated to investigate the distribution of temperature and wind fields within the model, as well as the changes in clothing performance under various environmental conditions. Additionally, the microclimate between the skin and clothing directly affects human comfort. Therefore, in this study, heat transfer phenomena within the microclimate were also explored under different environmental conditions. The model in this paper is intended to provide an effective and accurate method for cylindrical fabric thermal and moisture resistance testing, to study the comfort of clothing.

S. Kumar, B. Rajput, A. Das and P. Talukdar.

Bayesian inverse estimation of thermophysical and radiative properties of flame-retardant fabrics for enhanced thermal protection in fireproof clothing.

THERMAL SCIENCE AND ENGINEERING PROGRESS. 2025;61.

https://doi.org/10.1016/j.tsep.2025.103579

This research aims to estimate the thermophysical and radiative properties namely thermal conductivity (k), and specific heat capacity (cp), transmissivity (tau) and emissivity (epsilon) of flame-retardant fabrics such as, High Retardant, Kermel Viscose, and Flame-Retardant (FR) Cotton using the Bayesian inverse methodology. Accurate estimation of these properties is essential for effectively modeling heat transfer within the fabrics, which is crucial for designing fireproof clothing. The inverse methodology employed combines Genetic Algorithm (GA) and Bayesian inference along with the Metropolis-Hastings Markov Chain Monte Carlo (MH-MCMC) sampling algorithm. The GA was initially used to estimate the thermophysical and radiative properties. The properties estimated using the GA are employed in the Bayesian inference as priors to address the ill-posed nature of the inverse problem. These properties are then refined using the Bayesian method with MH-MCMC algorithm to achieve more accurate estimates. The marginal posterior probability density functions (PPDFs) for the properties were derived through the Bayesian route and used to compute the mean, maximum a posteriori (MAP), and standard deviation values for each property. Validation against the experimental data showed that the estimated properties yield simulated temperatures within a 5% uncertainty range. Furthermore, the thermal performance of Protective Wear Assemblies comprising specified fabrics, air gaps, and human skin was evaluated under flame exposure. The results indicate that FR cotton fabric provides superior protection, as evidenced by the longest burn times for first, second, and third-degree burns. The study highlights the critical role of accurate property estimation in enhancing thermal protection offered by fireproof clothing.

R. Y. Li, P. I. Dolez, A. D. Lai, F. Gholamreza, S. Allen, R. Gathercole and R. Li.

Heat transfer through wavy clothing layers with varied permeability.

BUILDING AND ENVIRONMENT. 2025;280.

https://doi.org/10.1016/j.buildenv.2025.113114

The heat exchange between the human body and the environment is significantly influenced by the microclimate created between the clothing and the skin, which is essential for maintaining thermophysiological comfort. In the present study, a three-dimensional (3D) numerical model was developed to investigate heat transfer between the skin and the environment through wavy microclimate structures with different clothing permeability. The air penetration through the clothing was considered, and the clothing was treated as a porous and air-permeable material in the model. Viscous shear and inertial effects were included in the governing equations to accurately simulate airflow in the fabric domain. The numerical model was first validated against experimental data obtained from a sweating guarded hotplate and showed good agreement. The validated model was then used to study the effect of airflow direction on the heat transfer performance. The results showed that airflow parallel to the fabric folds enhances heat transfer compared to airflow perpendicular to the fabric folds. Additionally, the effects of the wavy fold aspect ratio (amplitude to wavelength, W/H=2.4, 4.8 and infinite) and fabric air permeability (10-14 m2 to 10-6 m2) were analyzed. The findings revealed that heat dissipation is more effective in wavy shapes than flat configurations. Moreover, heat flux decreased with increasing permeability until a critical minimum was reached, after which heat flux started to increase sharply. This research provides detailed insights into heat transfer in clothing microclimates, which is valuable for advancing clothing design.

X. Li, X. Wang, R. Yan, Q. Song, B. Ning, S. Y. Liu and Q. Wang.

Evaluation of a lightweight water circulation cooling blanket for the prevention of exertional heat stroke.

JOURNAL OF THERMAL BIOLOGY. 2025;129.

https://doi.org/10.1016/j.jtherbio.2025.104130

Background: Exertional heat stroke (EHS) is acknowledged as a leading cause of sudden death among athletes and manual laborers. Rapid cooling treatment serves as a primary strategy for preventing and managing exercise-induced hyperthermia, underscoring the growing demand for swift and effective cooling devices. Objectives: This study aimed to evaluate the cooling performance and effectiveness of a lightweight water circulation cooling blanket. Methods: This randomized crossover design study recruited 12 male volunteers engaged in professional endurance exercise training outdoors. Participants completed a 3-km exercise session in a hot chamber (ambient temperature ti 40 degrees C; relative humidity [RH] ti 40 %), which was immediately followed by a 15-min cooling test (ambient temperature ti 31 degrees C; RH ti 65 %). During this cooling phase, participants were assigned to either lay on a lightweight water circulation cooling blanket (LWC condition) or to receive natural cooling (CON condition). Subsequently, all participants were required to complete another 3-km endurance exercise and a subsequent cooling phase under the same environmental conditions as those in the first round. The analysis included measurements of core temperature (Tcore), heart rate (HR), skin temperature (Tskin), thermal sensation, and rating of perceived exertion (RPE). Results: After two cooling sessions, Tcore measurements were significantly reduced in the LWC condition during the cooling phase. The peak Tcore recorded after the second exercise session was lower in the LWC condition compared to the CON condition. Additionally, HR, Tskin, thermal sensation, and RPE were lower in the LWC condition than those observed in the CON condition post-cooling. Conclusions: The lightweight water circulation cooling blanket demonstrated effective cooling capabilities and enhanced recovery of both HR and RPE. This device may serve as a practical solution for emergency cooling following intense exercise or during recovery intervals between training sessions in extreme heat, benefiting both athletes and manual laborers.

S. Maurya, R. Rathour, A. Das and R. Alagirusamy.

Water vapour transmission behaviour of the outer layer of multilayer thermal protective clothing.

INTERNATIONAL JOURNAL OF OCCUPATIONAL SAFETY AND ERGONOMICS. 2025.

https://doi.org/10.1080/10803548.2025.2456370

Ergonomics plays a significant role in fabric preparation, ensuring that the work environment, equipment and tasks are designed to enhance worker comfort, safety and efficiency. The intricate process of water vapour movement through textile structures is controlled by several variables, e.g., openness, thickness and pore size of the fabric as well as the inherent fibre characteristics. This study investigates the effect of tank temperature, pick density of the shell layer and fan speed on the reduction in relative humidity in the microclimate of the shell layer of fire protective clothing. The Box-Behnken model is used to make predictions and analyse the results. Analyses were performed for 3D surface plots at 22, 32 and 42 pick density for various tank temperature and fan speed combinations. The model is statistically significant (p = 0.0007). The results can be used for design and development of thermal protective clothing.

K. C. Miller.

Polar Life Pod Cooling Efficacy When Small Volumes of Water are Available to Treat Exercise-Induced Hyperthermia.

WILDERNESS & ENVIRONMENTAL MEDICINE. 2025.

https://doi.org/10.1177/10806032251332282

Introduction Cold-water immersion is the standard of care for treating exertional heatstroke (EHS). The Polar Life Pod (PLP; Polar Products Inc, Stow, OH), a body-bag-like device, is a novel, portable cold-water immersion device with excellent cooling rates (>0.18 degrees C<middle dot>min(-1)) when 151 to 208 L of water are used to treat hyperthermia. Unfortunately, these water volumes are not always available to treat EHS (eg, wilderness firefighting). Little research has examined whether the PLP with small water volumes meets expert recommendations for acceptable (ie, 0.08-0.15 degrees C<middle dot>min(-1)) or ideal cooling rates (ie, >0.16 degrees C<middle dot>min(-1)). Methods Thirty-two subjects (20 males and 12 females aged 21 +/- 2 y with a mass of 72.2 +/- 11.0 kg and a height of 170.4 +/- 7.2 cm) were assigned to 1 of 4 groups in this matched-pairs laboratory study. Participants wore a uniform and 9.5-kg rucksack and marched in the heat (wet-bulb globe temperature=26.1 +/- 0.1 degrees C) until their rectal temperature (T-REC) was 39.5 degrees C. Then they removed the uniform and sat in the heat (0 L) or lay in a PLP filled with 19, 38, or 76 L of similar to 8 degrees C water until T-REC was 38 degrees C. Results By design, all groups had comparable physical characteristics: body fat percentage (P=0.39), lean body mass (P=0.86), fat mass (P=0.13), body surface area (P=0.36), body surface area-lean body mass ratio (P=0.98), and body mass index (P=0.63). Subjects exercised for similar durations (P=0.66), and pre-immersion water temperatures were consistent between groups (P>0.05). T-REC cooling rates differed (0 L=0.03 +/- 0.01 degrees C<middle dot>min(-1), 19 L=0.13 +/- 0.08 degrees C<middle dot>min(-1), 38 L=0.10 +/- 0.03 degrees C<middle dot>min(-1), and 76 L=0.17 +/- 0.09 degrees C<middle dot>min(-1); P=0.002). No cooling-rate differences occurred between 19, 38, and 76 L (P<0.05). Conclusion PLP with 76 L met expert recommendations for ideal cooling rates; 19 and 38 L demonstrated acceptable cooling rates. PLP may help save lives from EHS when water access is limited.

M. Mlynarczyk, A. Greszta, M. Plocinska and A. Dabrowska.

Influence of care maintenance cycles on comfort-related parameters of clothing protecting against heat and flame.

TEXTILE RESEARCH JOURNAL. 2025.

https://doi.org/10.1177/00405175251330533

The life cycle of a product, such as protective clothing, includes a specific number of maintenance cycles, defined by the manufacturer. Beyond this number of washing cycles, the clothing can no longer be used, as its protective properties are no longer guaranteed after the stated limit is reached. This article presents the results of tests conducted to examine parameters related to the thermophysiological comfort of both finished products and the textile materials used in their production. These tests were conducted on items in their new condition (as supplied by the manufacturer) and after 50 maintenance cycles, which is the maximum number specified by the manufacturer. Additionally, the materials were tested after 5 and 25 maintenance cycles to assess intermediate changes. Experiments conducted on two types of material used in protective clothing for protection against heat have shown that both the area density and the number of maintenance cycles have a significant effect on parameters related to thermophysiological comfort. Additionally, changes in fiber morphology were visualized by scanning electron microscopy and measurements of the apparent length and thickness of weft yarns between successive warp coverings were made. The results of the analysis of individual material properties before and after successive washing cycles allowed us to identify key differences in the behavior of the two types of material used in protective clothing.

F. Momotaz, R. Eike, R. Li and G. W. Song.

Comparative Analysis of Thermal Comfort and Antimicrobial Properties of Base Fabrics for Smart Socks as Personal Protective Equipment (PPE).

MATERIALS. 2025;18(3).

https://doi.org/10.3390/ma18030572

This study investigates the unique interplay between thermal comfort and antimicrobial properties in base fabrics, shaping the foundation for the development of "Smart Socks" as advanced personal protective equipment (PPE). By delving into the inherent qualities of fibers such as cotton, polyester, bamboo, and wool and exploring fabric structures like single jersey, terry, rib, and mesh, the research captures the dynamic relationship between material composition and performance. Terry fabrics emerge as insulators, wrapping the user in warmth ideal for cold climates, while mesh structures breathe effortlessly, enhancing air circulation and moisture wicking for hot environments. Cotton mesh, with its natural affinity for moisture, showcases exceptional moisture management. Antimicrobial testing, focused on fabrics' interactions with Staphylococcus aureus, highlights the dormant potential of bamboo's bio-agents while revealing the necessity for advanced antimicrobial treatments. This study unveils a vision for combining innovative fabric structures and fibers to craft smart socks that balance thermal comfort, hygiene, and functionality. Future directions emphasize sensor integration for real-time physiological monitoring, opening pathways to revolutionary wearable PPE.

K. Prabhakaran and S. Raji.

Fire-resistant layered carbon composite panels from used cotton cloth for thermal insulation and EMI shielding applications.

CURRENT APPLIED PHYSICS. 2025;73:117-26.

https://doi.org/10.1016/j.cap.2025.03.007

A process for preparing thermally insulating carbon composite panels (CCP) from used cotton cloth is reported. The pliable cotton cloth is transformed into rigid carbon grid sheets by carbonization after impregnation with a sucrose solution. The layered carbon composite panels are obtained by hand layup of phenol-formaldehyde (PF) polymer solution-impregnated carbon grid sheet followed by curing and carbonization. The carbon composite panels exhibit grid-like pores in the X-Y plane and lamellar-type pores in the lateral plane. Due to their layered structure, the carbon composite panels exhibit pseudo-plastic failure under flexural mode. The density, compressive strength, and flexural strength are modulated in the ranges of 0.45 f 0.0004 to 0.57 f 0.0068 g cm- 3, 0.86 f 0.04 to 2.03 f 0.10 MPa, and 2.6 f 0.11 to 4.5 f 0.16 MPa, respectively, by varying the PF solution concentrations from 60 to 100 vol%. The carbon composite panels exhibit oxidation resistance up to 470 degrees C, excellent fire resistance, and low thermal conductivity in the 0.187 f 0.0004 to 0.273 f 0.0014 W m- 1. K- 1 range. The high EMI shielding effectiveness in the range of 40-67 dB exhibited by the carbon composite panels of 5 mm thickness is due to the conductive and dielectric losses and multiple internal reflections within the grid-like and lamellar-type pores.

R. Rathour, M. J. I. Amin, M. A. Islam, A. Das and R. Alagirusamy.

Evaluating the performance of the outer layer of extreme heat protective clothing using different woven structures.

INTERNATIONAL JOURNAL OF OCCUPATIONAL SAFETY AND ERGONOMICS. 2025.

https://doi.org/10.1080/10803548.2025.2468156

This study examines the interplay of weave patterns, picks per inch (PPI) and key performance metrics including heat protective performance (HPP), air permeability, thermal resistance and water vapor transmission rate (WVTR). Three weave structures (twill, sateen and honeycomb) using Nomex-IIIA yarn were tested. Heat flux of 80 +/- 2 kW/m2 was applied, combining flame and radiative heat. The honeycomb weave exhibited superior heat protection compared to twill and sateen. HPP increased by approximately 24% with the PPI rising from 40 to 64. Air permeability and thermal conductivity decreased by roughly 50% and 38%, respectively, with increasing PPI. Sateen and twill showed similar trends. WVTR increased with PPI up to 52, then declined. Overall, higher PPI enhanced HPP for all weave structures, with the honeycomb structure showing the best performance. Thermal conductivity and air permeability decreased as PPI increased due to the greater compactness in these three fabrics.

Y. Su, Y. X. Zhu, Y. W. Fan, S. Y. Liu and M. Tian.

Development of phase-change protective clothing for improving safety of firefighters in low thermal radiation.

INTERNATIONAL JOURNAL OF OCCUPATIONAL SAFETY AND ERGONOMICS. 2025;31(2):594-602.

https://doi.org/10.1080/10803548.2025.2454769

To enhance firefighters' safety in fire environments, new phase-change protective clothing was developed using a drip molding process to improve thermal protection and thermal comfort. The effects of the droplet interval (1, 1.5 and 2 cm) and droplet diameter (4, 6 and 8 mm) on the thermal protective performance under low thermal radiation were examined by the stored energy tester (SET). The results demonstrate that the drip molding process extended the second-degree burn time compared to phase change material-coated fabrics, reducing skin heat absorption and alleviating heat storage injuries. The optimal drip molding parameters (1.5-cm droplet interval and 8-mm droplet diameter) were identified based on the observed negative correlation between the second-degree burn time and the total heat loss. The drip molding process used in this study effectively improved the thermal protective performance and thermal comfort of protective clothing, offering enhanced protection for firefighters in low-radiation environments.

Z. Szalkai, F. Acs and A. Zsákai.

Human thermal bioclimate of the Swiss-Austrian alpine region based on estimates of the clothing thermal resistance model.

THEORETICAL AND APPLIED CLIMATOLOGY. 2025;156(4).

https://doi.org/10.1007/s00704-025-05433-y

Human thermal bioclimate of the Swiss-Austrian alpine region in the period 1991-2020 is simulated by using a clothing thermal resistance model. Clothing thermal resistance (rcl) is estimated for people that are either walking or standing. Climatic data are taken from the ERA5-Land dataset. The human anthropometric data used in the simulations correspond to that of a person with a body mass index of 25 kgm-2. The most important results of the study are as follows: 1) The rcl values are around 0-0.5 clo in the lower areas of the region in July, regardless of whether people are walking or standing. This thermal load causes a "neutral" thermal perception in the vast majority of people. Concerning the swiss region, it is the surroundings of Lake Geneva and the southernmost areas of Canton of Ticino that have the smallest heat deficit, while in Austria these are the vicinity of Lake Neusiedl. 2) In July, in the high mountains, the highest rcl values for a standing person are around 0.4-0.8 clo. 3) In January, the highest rcl values for a standing person can even reach 6 clo. In these cases the difference between the rcl values of standing and walking people can be as much as 2.5-3 clo. The main message of this study is that human thermal bioclimate maps can be used as climate maps, regardless of the fact that climate is not characterized in terms of water supply.

M. Tian, S. X. Fu, Y. Han and Y. Y. Wang.

Determining the critical air gap influencing heat transfer mode under firefighter's clothing exposed to different fire conditions.

INTERNATIONAL JOURNAL OF THERMAL SCIENCES. 2025;213.

https://doi.org/10.1016/j.ijthermalsci.2025.109830

Understanding the heat transfer mechanisms in the air gap under firefighter's uniform is crucial for accurately evaluating its thermal protective performance (TPP). However, existing research presents conflicting views regarding the air gap width (AGW) that natural convection begins and its relationship with the optimal TPP for the human body. To quantitively determine the critical AGW under clothing, experiments were conducted under three types of fire conditions, and the indicators for natural convection begin were calculated. Results indicated that both fire conditions and fabric layers affected the AGW in which natural convection began (9-18 mm). The largest t2nd (time to second degree burns)

was detected for single-layer fabric at 30 mm AGW. However, the t2nd reached the maximum value at an AGW of 18 mm under 84 kW/m2 hybrid heat environment, which was higher than no air gap (50 %) and 30 mm AGW condition (2.5 %), indicating an optimal TPP. Critical AGW also influenced the optimal TPP. The AGW of 18 mm at which multi-layer fabric achieved time-unsteady natural convection was comparable to the optimal TPP. The results of our investigation can provide theoretical reference for the structural design of fire-fighting suits and improve the safety of fire-fighting personnel.

M. Tian, X. R. Ren, Y. Han, Y. Su, F. Xue and T. Li.

The dual effects of the air gap on thermal aging and thermal protection of firefighting suits exposed to wildland fires.

INTERNATIONAL JOURNAL OF OCCUPATIONAL SAFETY AND ERGONOMICS. 2025;31(1):318-27.

https://doi.org/10.1080/10803548.2024.2439717

In wildland firefighting, the air gap (AG) between clothing and the human body can effectively decrease heat transferred to skin but has a negative impact on thermal aging of clothing. Heat transfer to skin from a fire source can led to burn injuries and heat is transmitted between adjacent AGs parallel to the skin surface. An open AG simulator was developed to explore the dual effects of the AG on fabric thermal aging and skin thermal protection. Results indicated that thermal aging of fabrics was affected by the size and boundary form of the AG. Open and closed AGs increased second-degree burn times by 37.2-232.9 and 32.4-160.3%, respectively. The 12-mm and 18-mm open AGs decreased thermal aging of the fabric while maintaining good thermal protection compared to other AG conditions. The findings indicate that an appropriate AG design can balance thermal aging and thermal protection of firefighter suits.

S. I. Tushar, S. Mandal, I. Z. Chowdhury, A. Petrova, L. M. Boorady and R. J. Agnew.

Thermal Protective Performance of Oil and Gas Field Workers' Clothing: A Review.

FIRE TECHNOLOGY. 2025.

https://doi.org/10.1007/s10694-025-01714-0

Over half of the world's countries produce oil and gas, which occasionally leads to fatalities and injuries, specifically skin burns among workers in the oil and gas fields (OGFs) due to fire hazards, i.e., flash fire. Hence, flame-resistant clothing (FRC) is a requirement for OGF workers. To ensure safety, it's important to regulate and verify the thermal protective performance (TPP) of FRCs, which depends on their constituent materials (i.e., fiber, yarn, and fabric). Also, the workplaces of OGFs are full of multiple oily substances, including hazardous and flammable liquids, i.e., crude oil, drilling fluid, pipe dope, etc. Most workers frequently come into contact with these substances, which can contaminate their FRCs and affect their TPP. This article provides a systematic review of how the physical and mechanical factors of fiber, yarn, fabric, and clothing design impact the TPP of FRC. Also, the presence of different substances in the OGF and their impact on the TPP has been thoroughly discussed to provide a holistic understanding of the parameters influencing the TPP. Additionally, the current limitations and challenges of FRC have been described, along with potential solutions that can benefit future research to improve the TPP of OGF workers' protective clothing.

S. I. Tushar, S. Mandal, I. Z. Chowdhury, A. Petrova, L. M. Boorady, R. J. Agnew, M. Kubicki, H. Park and P. Larson.

Characterizing the Heat Transfer Performance of Contaminated Flame-Resistant Fabrics.

FIRE AND MATERIALS. 2025;49(4):388-99.

https://doi.org/10.1002/fam.3288

For the safety of workers in the oil and gas field, flame-resistant clothing is recommended to reduce the risks of skin burns and fatalities resulting from heat and fire hazards. However, flame-resistant fabrics (FRFs) contaminated with flammable substances can compromise their flammability and heat transfer properties. Therefore, this study aims to evaluate the heat transfer performance (HTP) of the contaminated FRFs to improve workers' safety from burn injuries by understanding how contamination affects fabric thermal protection. The HTP in terms of second-degree burn time was evaluated and characterized by exposing the fabrics to 84 kW/m2 mixed convective and radiant heat flux. The peak temperature and average heat release rate of the FRFs were also evaluated. Two levels of contamination, consisting of drilling mud and crude oil, were added to three FRFs: Meta-aramid/cotton, meta-aramid/para-aramid, and para-aramid/polybenzimidazole. The HTP of drilling mud-contaminated fabrics increased, while the HTP of crude oil-contaminated fabrics varied by fabric type and contamination level. This may be attributed to drilling mud's higher specific heat capacity and lower flammability than crude oil. Among the fabrics tested, meta-aramid/cotton fabric showed the best HTP with higher second-degree burn times of 9.63 s with drilling mud and 9.07 s with crude oil. The relationship among contamination level, fabric properties, and HTP was developed using a multiple linear regression statistical model. The fabric's properties, such as fabric weight and air permeability, significantly contributed to the HTP of the contaminated fabrics.

P. G. Ünal, M. K. Akin, T. Aydin and B. Aydin.

Flame retardant properties of fabrics designed to be used in military camouflage.

INDUSTRIA TEXTILA. 2025;76(1):52-61.

https://doi.org/10.35530/IT.076.01.2024138

In this study, wool/aramid blended yarns, as well as viscose FR yarns, were used to produce flame-retardant woven fabrics. Many fire retardancy standards also include tear strength, abrasion resistance, tensile strength and dimensional change of the fabrics during fire hazards. Therefore, these tests were included to study the fire retardant performances of the fabrics produced with 100% wool/aramid blended fibres and viscose FR fibres in the warp and wool/aramid blended fibres in the weft direction. As a result of the study, no statistically significant differences were found in the mechanical properties of the fabrics. In contrast, the thermal protective performance of the fabrics produced with wool/aramid blended yarns was better than the ones produced with viscose FR warp yarns. On the other hand, the vertical flame-retardant performance of fabrics produced with viscose FR yarns was better than those produced with wool/aramid blended yarns in both directions. As a result of the study, it was found that the use of viscose FR fibre, which is a more accessible and comfortable alternative to the wool/aramid blend, in the warp or weft direction will minimize fabric costs while providing similar flame-retardant performance without losing fabric mechanical properties.

X. M. Yang, H. Chi, Y. Cao, J. Cui, C. Ji and J. F. Xie.

Cotton cloth-derived porous carbon skeleton with graphite layer for enhancing the thermal conductivity of energy storage phase change materials.

JOURNAL OF ENERGY STORAGE. 2025;121.

https://doi.org/10.1016/j.est.2025.116561

Phase change materials (PCMs) have advantageous energy storage capacity, but their poor shape stability and low thermal conductivity restrict their practical applications in the field of energy storage. In this study, the graphite flakes were adhered to the waste cotton strips, and the cotton strips were rolled up layer by layer to form a cotton-derived porous carbon skeleton after a high temperature carbonization. The graphite flake and the carbonized cotton cloth were connected to each other to forming a good heat conduction path. Composite phase change materials (CPCMs) were successfully prepared by vacuum impregnation of phase change material stearic acid (SA). The results showed that the thermal conductivity of CPCMs can be greatly improved in terms of forming the cotton-derived porous carbon skeleton. When the content of skeleton filler was 26.46 wt%, the normal thermal conductivity of the prepared CPCMs reached 5.51 W/(m center dot K), which was 21.19 times higher than that of pure stearic acid, along with a photothermal conversion efficiency of 82.6 % and phase change enthalpy of 148.99 J/g. Moreover, the CPCMs demonstrated great shape stability, obvious anti-leakage characteristic and advanced photothermal conversion capacity. The above results show that the CPCMs prepared by this method have broad application prospects in the field of solar thermal storage and thermal management.

H. Zhang, X. F. Wan, R. Zheng, Q. Chen, Z. Hu, Z. X. Kang and J. T. Fan.

A new model for evaluating dynamic clothing thermal comfort.

INTERNATIONAL JOURNAL OF THERMAL SCIENCES. 2025;215.

https://doi.org/10.1016/j.ijthermalsci.2025.109946

Clothing plays a key role in heat dissipation from the human body. Accurate clothing thermal resistance serves as a crucial reference during the design process, significantly enhancing thermal comfort. Most clothing thermal resistance models in the literature rely on experimental data from thermal manikins. However, most thermal manikins have fixed dimensions, and some are primarily static, failing to account for factors such as body shape and fabric performance, which are essential for designers. Therefore, this study developed a model for dynamic clothing thermal resistance based on clothing computer-aided design (CAD) software. In the CAD software, human body size, fabric type, and clothing style can be customized. The model calculated dynamic clothing thermal resistance by quantifying the volume change of the enclosed air layer. Experimental data were used to validate the model's accuracy for six ensembles at five walking speeds and three wind speeds. The results show that the model can predict the thermal resistance of clothing, with most relative errors less than 16 %. This model considers the impact of clothing style, size, and permeability on thermal resistance, providing designers with comprehensive theoretical guidance.

Z. H. Zhang, J. Ni and S. H. Xu.

Influence of fabric permeability and clothing fit on local wetness perception in warm and cool environments.

TEXTILE RESEARCH JOURNAL. 2025.

https://doi.org/10.1177/00405175251318956

This study was aimed at an investigation of the effect of ambient temperature coupled with clothing fit and fabric permeability on overall and local skin wetness perception. Twelve participants followed an incremental exercise protocol during eight experimental conditions: clothing (tight-fitting permeable clothing; tight-fitting impermeable clothing; loose-fitting permeable clothing; loose-fitting impermeable clothing) x environment (warm: 30 +/- 0.5 degrees C, relative humidity (RH) 35 +/- 5%; cool: 15 +/- 0.5 degrees C, RH 87 +/- 5%). During the test, heart rate, core and skin temperature, physical skin wetness, overall and local wetness sensation, and overall thermal and comfort sensation were recorded. The results show that the influence mechanisms of intensity and sensitivity of wetness perception are different; the intensity is mainly influenced by the skin's physical wetness, whereas the sensitivity is influenced by both cold and mechanical inputs. In the cool environment, the thermal sensation explained a total of 54.6% of the variance of thermal discomfort, and the wetness sensation contributed to another 21.3%. However, in the warm environment, thermal sensation alone explained a total of 98.1% of the variance of thermal discomfort. In order, the body parts representing the most frequently perceived wetness were the upper back, chest, lower back, upper arm, forearm, abdomen, buttocks, thigh, and calf; this was consistent with the regional sweating rate, independent of the clothing type or environmental conditions. The findings provide a reference for the design of products where wetness sensation is the dominant factor affecting wearing comfort, such as protective or sports clothing.

J. Q. Zhao, R. Wang, C. Chun, C. Y. Zhao and B. Cao.

Does user-centric thermal environment control require real-time recognition of user's clothing condition? A laboratory pilot study.

BUILDING AND ENVIRONMENT. 2025;277.

https://doi.org/10.1016/j.buildenv.2025.112939

Accurate identification of individual thermal states is an important basis for meeting the diverse demands of occupants and achieving user-centric thermal environment control. Developing Personal Comfort Model (PCM) by measuring skin temperature with infrared thermography enables effective thermal sensation prediction. However, existing research is typically conducted under uniform clothing conditions. This experimental design does not consider the differences in clothing between occupants and autonomous clothing adjustment behaviors in real-world scenarios, which limits the application potential of the prediction model based on experimental data. In this study, we conducted experiments in a climate chamber to collect clothing-uncovered skin temperatures (face, neck, arms, and wrists) and subjective evaluation under different clothing insulation (0.35, 0.51, 0.76, 1.01 clo). Statistical analysis and modeling analysis were performed by combining subjective evaluations, skin temperatures, and environmental parameters. The result shows that clothing changes can be reflected in the skin temperature at clothing-uncovered areas, and skin temperature is consistent with thermal sensation. On this basis, the machine learning algorithms were used to evaluate the performance of the thermal sensation prediction model under different combinations of input parameters. The model constructed with artificial neural network algorithm achieved a prediction accuracy of 76.8 % using only nose temperature and air temperature as inputs while clothing information is not included. This represents

an approximately 5 % improvement over the PMV model, which requires clothing insulation as an input. This study demonstrates the generalizability of using physiological parameters to predict thermal sensation, providing the theoretical foundation for simplifying individual thermal demand recognition systems.

C. Y. Zheng, J. Li, Y. Su, M. X. Zhao and X. H. Zhang.

Investigation of cooling methods and efficiency of firefighters wearing protective clothing after heat exposure.

INTERNATIONAL JOURNAL OF OCCUPATIONAL SAFETY AND ERGONOMICS. 2025;31(2):494-503.

https://doi.org/10.1080/10803548.2025.2452761

Objectives. This study aimed to evaluate four cooling methods (natural cooling method [NCM], stripping cooling method [SCM], fan cooling method [FCM] and water-spray cooling method [WSCM]) for their effectiveness in reducing heat stress and skin burns in firefighters after heat exposure. Methods. Skin heat flow and fabric temperature were measured on a stored energy test device during the exposure and cooling stages. The study assessed thermal protective performance by comparing the cooling methods, noting the time to second-degree burns and the energy released to the skin. Results. The SCM showed the best thermal protective performance, followed by the FCM, NCM and WSCM. No skin burns were observed with the SCM. Compared to the NCM, the FCM extended the time to second-degree burns by 3.2% (F1 fabric system) and 10.7% (F2 fabric system). The SCM had the lowest accumulated energy released to the skin and the highest cooling efficiency. The accumulated stored energy and released energy of the FCM decreased with increasing wind speed, whereas the values for the WSCM increased with longer water spray durations. These results can guide the development of optimal cooling methods to enhance firefighter safety and protection.

G. Zhou, X. H. Qu, L. Q. Tong, B. Wei, Y. L. Sun, Z. L. Mou, Q. Zhang, S. Ramakrishna and Q. Z. Meng.

Preparation and performance of Zr-Si based ultra thermal-insulating ceramic aerogels inspired by alpaca wool under extreme temperatures.

CHEMICAL ENGINEERING JOURNAL. 2025;511.

https://doi.org/10.1016/j.cej.2025.162033

With the increasing frequency of global fires, firefighters face increasingly challenging rescue tasks, and existing thermal protective clothing struggles to provide consistent and reliable protection in extreme environments, demanding the advancement of superior thermal insulation materials. Currently, ceramic aerogels are emerging as a key area of interest in materials science, attributed to their outstanding thermal insulation performance. Motivated by the thermal insulating characteristics of alpaca wool, this study utilized sol-gel and coaxial electrospinning coupling technology to prepare ZrO2@SiO2 nanofiber aerogels with a skin-core heterostructure. The inner SiO2 layer endows the aerogel with excellent high-temperature resistance, while the outer ZrO2 layer, optimized through processing, offers outstanding mechanical strength at high temperatures. The synthesized ZrO2@SiO2 nanofiber aerogel demonstrates flexibility under compression, bending, and stretching, integrated with low thermal conductivity (0.031 W m(-1) K-1 at room temperature), remarkable porosity (99.78%), and a high heat shielding rate (87.44%) under direct sunlight. Furthermore, the ZrO2@SiO2 nanofiber aerogel exhibits excellent hydrophobicity and flame resistance, along with dynamic compressive resilience in extreme temperature conditions, exceptional high-temperature insulation (similar to 1200 degrees C), and remarkable thermal protection performance (TPP = 36.42 cal/cm(2)). Additionally, the

deformation charge density was modeled via density functional theory to explain the high-temperature stability mechanism. Therefore, this ZrO2@SiO2 nanofiber aerogel demonstrates extraordinary thermal protection performance and structural stability under extreme conditions, not only providing a robust safeguard for firefighters in high-temperature environments but also guiding the development of firefighting protective equipment.

• EPI et matériaux pour protéger du froid

A. Abuhay, M. G. Tadesse, B. Berhanu, B. Malengier and L. V. Langenhove.

Advancements in Clothing Thermal Comfort for Cold Intolerance.

FIBERS. 2025;13(2).

https://doi.org/10.3390/fib13020013

Due to constantly shifting environmental and personal circumstances, humans have a wide range of thermal comfort needs. Cold intolerance (CI) is a personalized thermoregulation disorder characterized by a persistently cold-feeling problem, regardless of weather conditions. Improvements in clothing thermal comfort can help maintain proper insulation levels, hence reducing excess heat loss brought on by thermoregulation disorders since the wearer's thermal comfort is impacted by controllable environmental and personal factors. Despite extensive research on cold-proof clothing, no studies have examined the current status of cold protective clothing systems when taking individual considerations into account, particularly those who use them and have cold sensitivity. There is a significant study gap in research on cold intolerance discomfort and advancements in appropriate cold protection apparel applied to individuals with thermoregulation disorders. Accordingly, this paper reviews the occurrence and severity of cold intolerance and its comfort challenges. It also addresses recent developments in cold protective clothing design, aimed at opening pathways for further investigation into adopting this cutting-edge technology for cold intolerance wear design. This review also aims to clarify the existing opportunities for enhancing the thermal insulation capabilities and other comfort factors of cold protection apparel, which are conducted during the stages of garment design and clothing material/textile manufacture. A thorough assessment of the research on introducing novel surface finishing methods in the pretreatment section and modifying the structural properties of garment materials at the fiber/yarn or weaving stage is conducted. Furthermore, we systematically discuss the potential design solutions regarding fit and size as well as stitching technologies during garment development for thermal insulation enhancement of cold protective clothing design.

W. Laohaudomchok, W. Phanprasit, P. Konthonbut, C. Tangtong, S. Rissanen, K. Jussila, T. M. Ikäheimo, J. J. K. Jaakkola and S. Näyhä.

Work clothing and cold sensitivity among poultry workers in Thailand: differences between subgroups.

INTERNATIONAL JOURNAL OF OCCUPATIONAL SAFETY AND ERGONOMICS. 2025.

https://doi.org/10.1080/10803548.2025.2484901

Objectives. Cold-related adversities among poultry workers in Thailand vary by subgroup, but the impact of clothing insulation (I-cl) is not well understood. Methods. The authors interviewed 283 poultry workers and compared I-cl values across subgroups, adjusting for confounding factors. Results. The average worksite temperature was 3.8 degrees C, with average I-cl of 1.23 clo. After adjustments, I-cl

was 0.38 clo lower in office workers compared to other job categories, and 0.11 clo lower in workers with the highest body mass index (37.5) compared to those with the lowest (15.6). I-cl was 0.08 clo higher in the oldest workers (age 57 years) compared to the youngest (age 18 years), 0.07 clo higher among weekly alcohol consumers compared to non-consumers, 0.06 clo higher in women than in men and 0.04 clo higher among those engaged in light compared to heavy work. Perceiving temperatures >0 degrees C as cold was associated with an increase of 0.22 clo in I-cl. Conclusions. Office workers should wear more clothing. Relatively high I-cl values observed in some subgroups suggest sensitivity to cold, warranting further individual examination to determine optimal I-cl levels. Targeting preventive measures at vulnerable worker groups in Thailand's poultry industry could reduce the burden of cold-related harm.

T. Lexi, W. Fumei, P. Tong, S. Yi, J. Zimin, H. Xinghua and S. Hua.

Investigation of thermal insulation of cold protective clothing under different underwear and ambient conditions.

INDUSTRIA TEXTILA. 2025;76(1):31-7.

https://doi.org/10.35530/IT.076.01.2023131

In this study, the thermal insulation of cold protective outerwear under various clothing combinations and ambient conditions was estimated using a thermal manikin. A series of cold protective outerwear, worn with various types of underwear, were evaluated in a conditioned room to explore the dependence of outerwear thermal insulation on the underwear. Besides, statistical studies were utilized to study the effect of ambient temperature on the thermal insulation performance of cold protective clothing ensembles. The thermal insulation of outerwear was observed to be different when it was measured with various fit styles, thicknesses and combinations of underwear. These discrepancies can be attributed to the variation in the air gap between clothing layers and the presence of stagnant air within the porous clothing. Furthermore, the ambient temperature was found to be a dominant factor affecting the thermal insulation performance of the clothing ensembles with high air content, as the airflow inside the porous material may be aggravated by the larger temperature difference between the clothing and the environment. Based on this study, ambient conditions for the assessments of different kinds of clothing can be divided into five groups, simulating the actual-used scenarios. The findings of this study are anticipated to enhance the comprehensiveness of thermal insulation evaluations for clothing systems and assist in the identification of optimal clothing choices for diverse ambient conditions.

H. Y. Wang, R. J. Yan, H. X. Lin, J. L. Sun, H. Meng, R. F. Hou, Y. W. Hao, S. T. Hu and J. Zhang.

Improving thermal comfort and cognitive ability of manual workers by cooling garment of different temperatures based on EEG analysis.

ENERGY AND BUILDINGS. 2025;331.

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Nowadays, hot waves happen frequently in summer, and lead to hot indoor environment where air-conditioning system is absent, which can be more intolerable for manual workers taking higher activity levels. This study investigates the effects of phase change cooling garments (PCCG) on thermal comfort, cognitive performance, and electroencephalography (EEG) signals of subjects under a hot condition of 33 degrees C. Twenty participants were asked to conduct an activity with metabolic rate of 2.7 met in three conditions (with normal garments, with PCCG of 21 degrees C and 17 degrees C). Skin

temperature, core temperature, EEG signals, heart rate were measured. Subjective votes (thermal sensation, thermal comfort, cold stimuli sensation) were collected. Four cognitive tests were performed including letter search test, picture recognition test, Stroop test, and number remember test. Results indicated that the PCCG significantly improved thermal perception votes. The PCCGs led to decrease in mean skin temperature and core temperature, with a more pronounced effect in the 17 degrees C condition. The 17 degrees C PCCG significantly reduced heart rate, and the heart rate variable index of RMSSD was increased, while the LF/HF was decreased. Subjects' cognitive performance was also effectively improved, and the lower the cooling temperature the better the cognitive performance. The total EEG power decreased significantly in the 17 degrees C condition. The use of PCCGs led to significant decrease in power of the 0-band, and increase in alpha and n-band. The alertness level and the concentration index were also increase, while the fatigue index was decreased. The effect of PCCG became more significant in the 17 degrees C cooling temperature. No significant difference was found between the two cooling temperature conditions. The power of alpha-band was negatively correlated with thermal sensation vote. Correlations between the EEG indicators and cognitive performance were found, and the attention ability was positively related to the power of alpha and n-band, respectively. The results indicate that the EEG can be used to evaluate thermal comfort and cognitive ability of manual workers during the use of cooling garments.

J. Yang and X. X. Yan.

Effects of firefighters' protective gloves on physiological responses, psychological responses, and manual performance in a cold environment.

JOURNAL OF SAFETY SCIENCE AND RESILIENCE. 2025;6(1):48-57.

https://doi.org/10.1016/j.jnlssr.2024.07.002

This study aimed to investigate the effects of firefighters' protective gloves on physiological responses, psychological responses, and manual performance in a cold environment through human trials. Twelve participants wearing firefighter protective equipment were exposed to a 16 degrees C environment, while their hands were exposed to a small chamber of 0 degrees C with (FPG) and without (CON) firefighting protective gloves. During the trials, physiological responses (core temperature (T-c), the mean skin temperature (T-sk), and heart rate (HR)), psychological responses (thermal sensation vote (TSV) and pain sensation vote (PSV)), and manual performance (handgrip strength, manual dexterity, maximum finger flexion, and tactile sensitivity)) were obtained. The results indicated a significant difference ($p < 0.05$) between FPG and CON regarding T-sk. Furthermore, pain sensation occurred when the mean skin temperature of the hand was between 15 degrees C and 20 degrees C. Gloves significantly ($p < 0.05$) reduced handgrip strength, manual dexterity, and tactile sensitivity in the cold exposure. This study provides fundamental knowledge for cold strain assessment and high-performance protective glove development with the potential to improve firefighters' safety and health.

Maladies liées à la chaleur

F. Brocherie, S. Racinais, M. Pascal, A. Verrier, L. Moutet and R. Lagarrigue.

Chaleur et performance sportive : quels moyens pour limiter les risques encourus ?

BULLETIN EPIDEMIOLOGIQUE HEBDOMADAIRE. 2025;7.

https://beh.santepubliquefrance.fr/beh/2025/7/2025_7_2.html

Quel que soit le niveau de pratique sportive, s'entraîner et/ou participer à des compétitions en plein air en conditions chaudes (température de l'air >30-35°C) pose de réels défis quant à la thermorégulation, l'hydratation et in fine la performance sportive. Ces conditions peuvent, dans les cas extrêmes, avoir des conséquences dramatiques si l'intensité et/ou la durée d'exercice est maintenue. Alors que le changement climatique entraîne une augmentation de l'exposition à la chaleur, il devient primordial de fournir les informations et recommandations qui permettront de minimiser les dangers encourus par les sportifs de tout niveau. Lorsqu'elle est possible, une exposition répétée à un stress thermique (par exemple, 60 à 90 minutes à 35-40°C et 40% d'humidité relative) pendant 7 à 14 jours permet à l'organisme de s'acclimater à la chaleur. L'hydratation tient également un rôle essentiel pour compenser les pertes hydriques (sueur, dont la quantité augmente en environnement chaud) qui permettent de dissiper l'excès de chaleur produit par les muscles. De même, le choix et l'usage de stratégies de refroidissement (par ex., application externe (immersion en eau froide), interne (boisson froide ou glace pillée), ou combinée, administrée avant, pendant ou après un effort en conditions chaudes) permettent une meilleure tolérance physiologique et psycho-cognitive et une amélioration de la performance sportive. Indépendamment de ces mesures, un certain nombre de recommandations sont à adopter pour les sportifs et tout autre participant, actif ou passif, à l'entraînement ou en compétition sportive (officiels, coachs, travailleurs/bénévoles et spectateurs), tout en prévoyant la restriction, le report ou l'annulation des activités physiques et sportives extérieures.

N. Rossello, M. Pascal, R. Lagarrigue, D. Casamatta, K. Laaidi and T. Bénet.

Effet des canicules sur les passages aux urgences pour insuffisance rénale aiguë, décompensation cardiaque et ischémie myocardique en Auvergne-Rhône-Alpes, 2015-2022.

BULLETIN EPIDEMIOLOGIQUE HEBDOMADAIRE. 2025;7.

https://beh.santepubliquefrance.fr/beh/2025/7/2025_7_3.html

Introduction – Les périodes de canicule induisent une surmortalité et augmentent l'impact de certaines comorbidités. Cependant, il existe un manque de recul sur l'influence sur les passages aux urgences en dehors de quelques pathologies très spécifiques de la chaleur. L'objectif de l'étude est d'étudier l'impact de la chaleur sur les passages aux urgences pour trois syndromes morbides actuellement non surveillés en routine en France : l'insuffisance rénale aiguë, la décompensation cardiaque et l'ischémie myocardique. Méthodes – La période d'étude couvre les étés (1er juin au 15 septembre) 2015 à 2022 pour les 12 départements de la région Auvergne-Rhône-Alpes. Les données sanitaires ont été extraites du système de surveillance syndromique SurSaUD® (Surveillance sanitaire des urgences et des décès). Une analyse multivariée des nombres moyens de passages quotidiens en fonction des périodes de dépassement effectif de seuil canicule et des périodes de vigilance a été réalisée par régression binomiale négative. Résultats – Un total de 14 060 passages aux urgences pour insuffisance rénale aiguë, 29 841 pour décompensation cardiaque et 17 749 pour ischémie myocardique sont survenus entre 2015 et 2022 durant les périodes d'étude en Auvergne-Rhône-Alpes. Le risque de passage aux urgences pour insuffisance rénale aiguë augmente de +47% (intervalle de confiance à 95%, IC95%: [39-

56]) lorsque les températures dépassent les seuils d'alerte météorologiques, indépendamment du sexe, de l'âge, du département, du jour et du mois, ou en cas de température maximale >24°C, avec un risque croissant en cas de température très élevée. Ces effets ne sont pas mis en évidence pour les passages aux urgences pour décompensation cardiaque et pour ischémie myocardique. Conclusion – Le risque de passages aux urgences pour insuffisance rénale aiguë augmente pendant les canicules et devrait inciter à mettre en place des mesures spécifiques de prévention de cette pathologie en période estivale.

N. Louis and L. T. d. l'ingénieur.

Un modèle pour prédire la mortalité liée aux températures extrêmes en Europe. 2025.

https://www.techniques-ingenieur.fr/actualite/articles/un-modele-pour-predire-la-mortalite-liee-aux-temperatures-extremes-en-europe-141149/?r=1011295283

Des scientifiques ont développé un nouveau modèle capable de prédire un taux de mortalité lié aux températures extrêmes dans plusieurs régions d'Europe, plus de 10 jours en avance en hiver et 8 jours en été. Ce délai doit ensuite permettre de mettre en place des plans d'urgence adaptés en fonction de l'ampleur de la mortalité anticipée.

D. W. Degroot, A. C. Litchfield, C. A. Blodgett, B. B. Rhodehouse and K. P. Hudson.

Chain of survival for a severe exertional heat stroke casualty.

JOURNAL OF APPLIED PHYSIOLOGY. 2025;138(3):699-705.

https://doi.org/10.1152/japplphysiol.01006.2024

Exertional heat stroke is characterized by profound central nervous system dysfunction and core (rectal) temperature typically >40 degrees C. With prompt recognition and response, the probability of survival is excellent; however, there are limited cases with Tc >43.3 degrees C associated with good outcomes. A 23-yr-old male soldier was conducting land navigation training and was found unresponsive by a nonmedical cadre. Emergency medical services personnel obtained a rectal temperature of 44.3 degrees C, which is the highest-ever body core temperature recorded in a patient with exertional heat stroke who survived without significant sequelae. In this case, we report numerous key decisions that contributed to the good outcome. Among those were the use of a GPS-enabled tracking device that enabled the location of the patient on the land navigation course, and the rapid recognition and response by nonmedical personnel at the point of injury. In addition, prioritizing airway, breathing, and circulation over the choice of cooling modality was important in the setting of a patient in acute respiratory distress. Finally, the careful selection of pharmaceutical agents in the Emergency Department minimized additional stress, primarily on the liver and kidneys, which were already significantly stressed. After transfer to a higher level of care due to developing heat-induced disseminated intravascular coagulation and liver failure, the patient was transferred to inpatient rehabilitation 3 wk postinjury. He recovered by 14 mo postinjury, has been medically cleared to return to active duty without limitations, and is continuing his military service. NEW & NOTEWORTHY We present the details surrounding an exertional heat stroke casualty who had the highest-ever body core temperature, 44.3 degrees C, and survived without significant sequelae. Critical decisions that contributed to this outcome, from the point of injury through the first 24 h, are detailed. Treatment considerations included rapid cooling, maintaining the patient's airway, and hemodynamic stability, and minimizing further physiological strain due to the choice of pharmaceutical agents.

D. W. DeGroot, B. Ruby, A. Koo and F. G. O'Connor.

Far from Home: Heat-Illness Prevention and Treatment in Austere Environments.

WILDERNESS & ENVIRONMENTAL MEDICINE. 2025.

https://doi.org/10.1177/10806032251332283

Austere environments present unique challenges concerning the prevention and treatment of exertional heat-illness patients that may greatly increase the risks of morbidity and mortality. For athletes, occupational groups, and others who may work, train, or compete in austere environments, proper preparation and planning may be lifesaving. The roles of acclimatization and hydration are often emphasized in the literature, but other important risk factors may be overlooked. Work capacity, especially aerobic work capacity, will always be reduced in hot environments, and individuals should understand that simply slowing down, to reduce metabolic heat production, can be considered the universal precaution to mitigate heat stress and strain. Conversely, appropriate rehydration alone does not mitigate other risk factors, such as metabolic heat production, high ambient temperature, or inadequate physical fitness. Risk factor-specific mitigation recommendations are provided, and areas where additional research is needed are identified. The ability to recognize the signs and symptoms of heat illness early in the progression of illness is especially important in austere environments due to the possibility of delayed access to higher levels of medical care. Treatment considerations in austere environments include knowledge of availability and effectiveness of cooling modalities such as natural bodies of water. Medications such as antipyretics, dantrolene, and nonsteroidal anti-inflammatory drugs are not recommended to treat a suspected heat casualty. Aggressive cooling, with the objective of reducing core temperature to <39 degrees C within 30-min, is the treatment priority.

H. W. Hess, M. E. Heikkinen, E. Tourula, M. J. Hite, K. Rivers, R. S. Zoh, B. D. Johnson, D. Hostler and Z. J. Schlader.

Influence of work intensity on acute kidney injury risk during simulated occupational heat stress.

JOURNAL OF APPLIED PHYSIOLOGY. 2025;138(3):706-17.

https://doi.org/10.1152/japplphysiol.00590.2024

Violation of the National Institute of Occupational Safety and Health (NIOSH) heat stress recommendations by exceeding the allowable wet bulb globe temperature (WBGT) for a given work intensity and work-rest ratio augments acute kidney injury (AKI) risk. Here, we tested the hypothesis that exceeding the allowable work intensity at a given WBGT and work-rest ratio would also worsen AKI risk. Twelve healthy adults completed two NIOSH recommendation compliant trials and one noncompliant trial consisting of a 4 h (half workday) exposure. Work-rest ratio was fixed at 30 min of walking and 30 min of rest each hour. Work intensity (metabolic heat production) was prescribed as a function of WBGT-412 +/- 51 W [27.3 +/- 0.3 degrees C; high-intensity compliant (Chigh)], 290 +/- 75 W [31.6 +/- 0.2 degrees C; low-intensity compliant (Clow)], and 410 +/- 61 W [31.7 +/- 0.2 degrees C; high-intensity noncompliant (NChigh)]. AKI risk was quantified by the product of urinary insulin-like growth factor-binding protein 7 and tissue inhibitor of metalloproteinase 2 normalized to urine specific gravity ([IGFBP7<middle dot>TIMP-2]USG). Peak core temperature was higher in NChigh trial (38.3 +/- 0.4 degrees C) compared with the compliant trials (Chigh: 38.0 +/- 0.3 degrees C; Clow: 37.8 +/- 0.4 degrees C; P <= 0.0095). [IGFBP7<middle dot>TIMP-2]USG increased from pre- to immediately postexposure in all trials (time effect: P = 0.0454) but the peak increase was not different between trials [Chigh: 0.89 +/- 1.7 (ng/mL)2/1,000; Clow: 0.78 +/- 1.7 (ng/mL)2/1,000; NChigh: 1.0 +/- 1.4 (ng/mL)2/1,000; P = 0.7811]. Violating the NIOSH recommendations by exceeding either the allowable work intensity (i.e., NChigh vs. Clow) or WBGT (i.e., NChigh vs. Chigh) resulted in a modest elevation in

peak core temperature but did not modify AKI risk. NEW & NOTEWORTHY We demonstrate that violation of the National Institute for Occupational Safety and Health heat stress recommendations by exceeding allowable work intensity by similar to 120 W or environmental limits by similar to 4 degrees C wet bulb globe temperature (WBGT) at 30-min work-rest per hour results in a modest elevation in peak core temperature but does not augment acute kidney injury risk compared with scenarios that adhered to the NIOSH recommendations during simulated occupational heat stress.

K. A. Horan, M. Schlenk, H. Anderson, C. McNamara and B. Moore.

Heat Strokes in Active-Duty Military.

MILITARY MEDICINE. 2025.

https://doi.org/10.1093/milmed/usaf067

Introduction Military service members are at risk of heat stroke, particularly due to physical exertion during training and tasks. Due to the serious nature and potentially fatal consequences of heat stroke, it is important to understand trends over time and among subgroups of service members in diagnoses of heat stroke. We aimed to replicate and extend recent work by Williams and Oh1 by examining the incidence of heat stroke in military service members from 2016 to 2021 and performing subgroup comparisons for sex, age, race, marital status, pay grade, and service branch.Materials and Methods Data were obtained from the Defense Medical Epidemiology Database (DMED). Incidence rates were calculated per 10,000 between 2016 and 2021. Single-sample chi-square analyses were used to examine trends related to heat stroke in subgroups relative to their group's population density within the military.Results Findings revealed that incidence rates for heat strokes declined by 5.46% in the study period. The total number of heat stroke cases between 2016 and 2021 was 2,295. Single sample chi-square analyses revealed overrepresentation in heat stroke diagnoses for male, younger, un-married, and White service members, for those in the Army and Marine Corps, and for those in junior paygrades, compared to what would be expected based on their population density within the military.Conclusion Incidence rates of heat stroke among military service members declined from 2016 to 2021. Subgroups overrepresented in incidence rates likely reflect differences in training, tasks, and supervision. These results highlight the importance of ongoing attention to policies designed to prevent, recognize, and properly treat heat stroke in military settings.

K. Kato, T. Nishi, S. Lee, L. Li, N. Evans and K. Kiyono.

Evaluating Heat Stress in Occupational Setting with No Established Safety Standards Using Collective Data from Wearable Biosensors.

SENSORS. 2025;25(6).

https://doi.org/10.3390/s25061832

In recent years, living and occupational environments have been increasingly exposed to extreme heat. While the risk of heatstroke rises with greater heat stress, conventional knowledge and safety standards may no longer adequately assess heat stress under such extreme conditions. To address this issue, we propose a method for evaluating heat stress using collective data from wearable biosensors that monitor heart rate and physical activity in a group of workers. The novelty of this approach lies in utilizing collective data from wearable biosensors to assess environmental heat stress rather than individual health status. To quantify heat stress in specific environments or conditions, we introduce the heart rate response intercept, defined as the heart rate at 1 MET when the heart rate response to physical activity is approximated linearly. Using this heat stress index, we examined the effects of

ambient temperature, aging, and obesity on heat stress. Our findings indicate that heat stress among obese workers was significantly high and should not be overlooked. Furthermore, because this method can quantify the effectiveness of heatstroke countermeasures, it serves as a valuable tool for improving occupational environments.

N. Khan, S. Ahmad and S. Shahid.

Assessing the Deadly Heat Waves Over South Asian Cities: An Insights From UTCI and WBGT Indices.

INTERNATIONAL JOURNAL OF CLIMATOLOGY. 2025.

https://doi.org/10.1002/joc.8806

This study analysed South Asia's most devastating heat waves over the past four decades using ERA5 hourly reanalysis data from the European Centre for Medium-Range Weather Forecasts (ECMWF). Two heat stress indices, the Universal Thermal Climate Index (UTCI) and Wet Bulb Globe Temperature (WBGT), were employed to evaluate the characteristics, meteorological variable behaviour and diurnal temperature range (DTR) across four selected cities. The findings revealed that while both indices effectively captured heat wave events, WBGT demonstrated superior performance, particularly in assessing nighttime heat stress, where UTCI often underestimated the severity. For instance, during the 1995 heat wave in Bareilly, daytime UTCI exceeded the extreme heat stress threshold of 46.0 degrees C during the second event but dropped close to the lower limit of 26.0 degrees C at night. In contrast, nighttime WBGT consistently remained above the lowest threshold of 25.6 degrees C. In Karachi (2015), WBGT surpassed the extreme heat stress level of 32.2 degrees C during the day and remained above 25.6 degrees C at night for consecutive days. Inland heat waves were marked by air temperature spikes above 40 degrees C and reduced wind speeds (below 2 m/s), while coastal cities like Visakhapatnam experienced prolonged nighttime UTCI above 26.0 degrees C and daytime values fluctuating between 38.0 degrees C and 46.0 degrees C. DTR analysis further demonstrated UTCI fluctuations exceeding 20 degrees C during inland events, while WBGT remained within a 6.6 degrees C range, highlighting its stability and better representation of persistent heat stress. Further analysis of the results revealed that higher WBGT sensitivity to local meteorological variables like relative humidity and wind speed has made it particularly effective in regions with high humidity.

M. Li and J. Y. Xu.

Heat health assessment and risk simulation prediction in eastern China: a geospatial analysis.

FRONTIERS IN PUBLIC HEALTH. 2025;13.

https://doi.org/10.3389/fpubh.2025.1521997

Background High temperatures pose significant health risks and societal challenges in China, with spatial variations in heat health risks. Furthermore, due to the constraint imposed by heat health risk assessment on the construction of the public health security framework, it is necessary to explore the heat health risk pattern of spatial distribution and the trend of future risk development in eastern China.Methods Based on the Intergovernmental Panel on Climate Change (IPCC) and Risk Triangle framework which is combined with natural and socio-economic factors, the heat health risk assessment index system of eastern China is established in this paper. This paper enhances the accuracy of risk maps with the aid of high-resolution imagery. It also focuses specifically on the exposure of construction workers in urban areas and agricultural workers in rural areas. This paper also evaluates the heat health risk of eastern China from 2010 to 2019 by using ArcGIS and the CA-Markov model.Results The

heat health risk in most areas of eastern China is predominantly highest risk, with the proportion of highest and medium risk areas increasing steadily from 2010 to 2019. The spatial distribution pattern reveals that high-risk areas are concentrated in the central urban areas, while low-risk areas are primarily in the mountainous regions, suburbs, rural areas, and water source areas. The conversion of heat health risk areas mainly occurs between adjacent levels, with no mutation process. From 2010 to 2025, the heat health risk of eastern China has been improving, and the overall distribution pattern of risk levels remains consistent.Conclusion The research findings provide a basis for us to gain a deeper understanding of the vulnerability of different groups. This study not only presents spatial distribution maps of health risks, but offers a new perspective for us to comprehend the complexity and diversity of these risks. The research findings also establish a foundation for optimizing monitoring and warning systems. Furthermore, this study provides scientific evidence for policymakers to develop comprehensive heatwave mitigation plans. Nevertheless, we must acknowledge the limitations of the research and recognize that there is room for improvement in the future.

T. Liang, Z. L. Ai, H. Zhong, M. Y. Xiao, M. Z. Xie, X. L. Liang and L. Li.

The impact of temperature changes on the health vulnerability of migrant workers: an empirical study based on the China family panel studies.

FRONTIERS IN PUBLIC HEALTH. 2025;13.

https://doi.org/10.3389/fpubh.2025.1519982

Introduction Migrant workers constitute a significant portion of China's workforce, and their health directly affects labor supply and economic stability. Health vulnerability plays a crucial role in shaping the well-being of migrant workers, yet its determinants, particularly the impact of temperature change, remain underexplored. This study, based on the socio-ecological model, investigates how temperature variations influence the health vulnerability of migrant workers in China.Methods Using data from 2020, this study quantifies health vulnerability and examines the impact of temperature fluctuations across different seasons. Robustness checks, including dependent variable substitutions and model modifications, ensure the reliability of the findings. Furthermore, a mechanism analysis is conducted to explore the underlying pathways through which temperature change affects health vulnerability.Results The findings reveal that rising temperatures in spring, summer, and winter significantly exacerbate the health vulnerability of migrant workers, while increasing autumn temperatures mitigate it. Mechanism analysis identifies heightened psychological burden as a key channel through which temperature change worsens health vulnerability. Additionally, generational differences emerge: older migrant workers are more adversely affected by elevated spring temperatures, whereas younger workers exhibit greater sensitivity to rising summer temperatures.Discussion These results underscore the necessity of targeted health interventions and adaptive labor protection policies. By highlighting the seasonal and generational disparities in the effects of temperature change, this study offers theoretical and empirical support for enhancing the resilience of migrant workers to climate variations. The findings provide valuable insights for policymakers in designing strategies to safeguard the health and stability of the migrant workforce.

Y. C. Lin, C. R. Jung, B. F. Hwang and C. P. Chen.

Investigating wet-bulb globe temperature on heat-related illness in general population for alerting heat exposure: A time-stratified case-crossover study.

URBAN CLIMATE. 2025;59.

https://doi.org/10.1016/j.uclim.2025.102322

Assessing the effects of heat stress on heat-related illnesses and developing a heat alter system accordingly is an adaptive strategy to address global warming. The wet-bulb globe temperature (WBGT) effectively quantifies the heat stress on the human body, providing a more comprehensive measure than ambient temperature. However, few studies have assessed the association between WBGT and heat-related illnesses in the general population. We developed and validated a WBGT estimation model for the general population by incorporating in-situ measurements. A time-stratified case-crossover study was conducted to evaluate the effects of WBGT on heat-related illnesses. A total of 34,973 cases that occurred in Taiwan during 2004-2020 were retrieved from the National Health Insurance Research Database. Conditional logistic regression analysis was used to estimate effects as odds ratios (OR) with their 95 % confidence intervals (CI). We identified a significant association between WBGT and heat-related illnesses (OR = 1.414, 95 % CI: 1.399-1.428 per 1.0 degrees C increase). Although the risk of heat-related illnesses was the highest in summer, it remained significant in fall and spring, during temperature transitions. Additionally, males and the working-age population had a higher risk of emergency department visits. The WBGT ranks for alerting heat stress were categorized into "caution" (21.0-27.0 degrees C), "warning" (27.0-29.0 degrees C), "severe warning" (29.0-31.4 degrees C), and "danger" (>31.4 degrees C). This study extends the conventional use of WBGT in occupational management to include instruments for public health communication. The described WBGT rankings can be used to validate current heat alert systems for preventing heat-related illnesses.

P. Marcel-Millet, D. Gagnon and A. Malgoyre.

Exploring biases in heat tolerance testing with a conceptual heat balance approach.

JOURNAL OF THERMAL BIOLOGY. 2025;128.

https://doi.org/10.1016/j.jtherbio.2025.104085

Global climate change increases the number and intensity of heat days, which increases the risk of exertional heat illness. The heat tolerance test (HTT) is performed to classify individuals who have suffered exertional heat stroke as heat tolerant or intolerant, prior to their return to activity/duty. The current analysis aimed to i. examine potential biases within the HTT conditions or measures; ii. enhance the interpretation of the HTT results through the prediction of sweat rate required to reach thermal balance (Sreq). We calculated all the elements of the heat balance equation including metabolic heat production that was predicted using the Pandolf equation. The evaporative requirement for heat balance, the maximum evaporative rate possible and Sreq were calculated for a range of body masses (50-100 kg), body mass indices (18.5-30 kg & sdot;m- 2) and wind speeds (0-1.5 m & sdot;s- 1). The calculations suggest that, based on metabolic heat production, the change in rectal temperature appears to be a valid criterion to judge heat tolerance. However, the analysis of skin wettedness reveals that the HTT conditions are not physiologically compensable for more than 75% of the scenarios considered in the present study. Physiological strain will likely differ depending on the morphology of individuals. Thus, it may be necessary to ensure that the HTT conditions are compensable to improve HTT specificity. Finally, the prediction of Sreq appears to be a promising tool for interpreting heat intolerance and improving medical care, in cases of significant deviation between measured and estimated Sreq.

K. Nakamura, A. Okada, H. Watanabe, K. Oka, Y. Honda, H. Matsui, K. Fushimi, H. Yasunaga and Y. Kim.

In-hospital mortality of heat-related disease associated with wet bulb globe temperature: a Japanese nationwide inpatient data analysis.

INTERNATIONAL JOURNAL OF BIOMETEOROLOGY. 2025;69(4):873-84.

https://doi.org/10.1007/s00484-025-02867-x

Heat-related diseases have become a significant public health concern. Studies have shown that susceptibility to heat varies among regions; however, most studies used aggregated data on emergency transport in the regions. The present study used a nationwide inpatient database in Japan and examined the association between regional differences in Wet Bulb Globe Temperature (WBGT) and in-hospital mortality in patients with a heat-related disease, with adjustment for individual-level characteristics. We retrospectively identified participants from the Japanese Diagnosis Procedure Combination inpatient database during the five warmest months of the year (May 1 to September 30) from 2011 to 2019. We calculated the long-term average daily maximum WBGT for the prefectures and categorized the prefectures into three areas (low-, middle-, and high-WBGT). We conduced multivariable logistic regression analyses to compare in-hospital mortality between the WBGT areas, adjusting for individual-level covariates (including age, sex, body mass index, and comorbidities). A total of 82,250 patients were admitted for heat-related diseases. The mean age was 63.2 (standard deviation, 25.0) years, and 63.7% were male. In the multivariable logistic regression analysis, the low-WBGT area had a higher in-hospital mortality than that had by the high-WBGT area (odds ratio, 1.32; 95% confidence interval, 1.15-1.52), whereas no significant difference was observed between the middle- and high-WBGT areas (odds ratio, 1.00; 95% confidence interval, 0.89-1.12). After adjusting for individual-level risk factors, in-hospital death was more likely to occur in patients with heat-related diseases in lower WBGT areas compared with those in higher WBGT areas.

W. L. Ouyang, Z. Tan, Y. C. Chen and G. C. Ren.

Comparative evaluation of PET and mPET models for outdoor walking in hot-humid climates.

BUILDING AND ENVIRONMENT. 2025;271.

https://doi.org/10.1016/j.buildenv.2025.112636

In light of escalating climate change, causing more frequent and severe heatwaves, outdoor walking during the hot weather poses risks of heat stress and health issues. Evaluating pedestrian thermal comfort and physiological responses across varying outdoor environments is crucial. Physiologically Equivalent Temperature (PET) is a widely utilized thermal index, while modified PET was proposed to improve the application in high humidity regions. There has been a lack of comparative evaluations assessing the ability of PET and mPET models to predict physiological responses. This study aims to systematically evaluate the performance of PET and mPET in outdoor walking scenarios. Three typical outdoor environments and two age groups have been considered. Using the measured skin temperature (Tskin) and core temperature (Tcore) as benchmark, this study finds that mPET outperforms PET in dynamic walking processes, irrespective of environmental settings and personnel characteristics. The root mean square errors (RMSE) of Tskin based on PET and mPET estimations were 3.66 degrees C and 1.04 degrees C, respectively. While for Tcore, PET and mPET models presented RMSE of 2.02 degrees C and 0.24 degrees C, separately. Sensitivity tests highlighted the impact of personal characteristics (e.g., age, sex, weighting, height, etc.) on thermos-physiological responses. PET model overestimated Tcore and Tskin in all outdoor walking scenarios, indicating its limitations. This study contributes by (1) bridging the gap between theoretical modelling and practical applications, aiding in model selection for specific walking scenario; (2) providing valuable insights for improving physiological models, and designing health-conscious urban environments.

M. Puga-Bonilla, D. Hidalgo-García, H. Rezapouraghdam and F. J. L. Bolivar.

Risk of mortality and disease attributable to the heat stress index and its variability during heat waves: An observational study on the city of Madrid.

SUSTAINABLE CITIES AND SOCIETY. 2025;121.

https://doi.org/10.1016/j.scs.2025.106189

In recent years, global ambient temperatures have reached alarming levels, mainly due to global warming caused by climate change, pollution, and significant population growth. High temperatures have been linked to increased mortality and a higher risk of contracting various diseases, resulting in substantial healthcare costs for many governments and citizens who are unable to cope. As a result, it is critical to implement policies to mitigate these effects and improve people's lives. This research addresses the impact of high temperatures on human health, focusing on the relationship between urban morphological characteristics (Proportion of vegetation (VP) and Urban Index (UI), Heat Stress Index (HSI) and the risk of different cancers (prostate, breast, stomach, lung and colorectal) and diseases (dementia, stroke, suicides and chronic obstructive pulmonary disease (COPD)) in the different Local Climate Zones (LCZ) of Madrid, using Landsat 8 and 9 images and the UrbClim climate model. The main findings show that compact or high-density land cover zones exhibit a higher risk of contracting the examined diseases than open or low-density regions. This circumstance is motivated by the fact that such areas have less vegetation cover and experience higher rates of heat stress. Findings indicated that the lack of vegetation in compact and high-density areas reduces the ability to minimize extreme temperatures and heat, which is associated with a variety of health problems. This study provides valuable knowledge about the relationship between vegetation, HSI, and health in the different LCZs, providing a solid basis for sustainable urban planning strategies that improve the standard of living of the inhabitants not only of the city of Madrid but of the rest of the cities on the planet.

A. Reitmayer, S. C. Koth, K. R. Johnstone, C. Madigan and M. M. Cook.

Dynamic cooling: Thermal and temporal effects on cognitive load and performance in office environments.

BUILDING AND ENVIRONMENT. 2025;278.

https://doi.org/10.1016/j.buildenv.2025.112986

The integration of dynamic thermal environments, characterised by time-varying temperatures within a building, can contribute to increased energy flexibility and a reduction in overall energy consumption. Recent research indicates that exposure to varying temperatures has the potential to enhance worker performance and wellbeing. This study examined the time-dependent impacts of temperature exposure on cognitive load and performance. In a simulated real-world office environment, 36 participants were exposed to automated conditions, including a conventional constant temperature cooled (CC) condition of 23 degrees C and a dynamic cooled (DC) condition with a constant temperature of 26 degrees C in the morning and a temperature change of 1.5 degrees C/h after lunch, resulting in a temperature of 23 degrees C in the afternoon. In both conditions, performance tasks, mental workload, arousal and thermal perception questionnaires were conducted at hourly intervals throughout the working day, from 9:00 am to 4:00 pm. Results showed similar performance in both conditions with no direct relation to a set-point temperature. The analysis of the time of day revealed significant effects in both conditions. In the morning, participants rated feeling significantly more relaxed and thermally comfortable in the higher temperature in DC than in the lower temperature in CC. During the afternoon, an increase in self-reported fatigue was observed in the CC condition, which could be significantly mitigated by the dynamic condition. The findings of the study challenge the practice of maintaining

constant temperatures in offices, underscoring the need to consider the impact of time of day variations on workers' wellbeing.

C. M. Seluzicki, M. Razavi-Mohseni, F. Türker, P. Patel, B. Y. Hua, M. A. Beer, L. Goff and S. S. Margolis.

Regulation of translation elongation and integrated stress response in heat-shocked neurons.

CELL REPORTS. 2025;44(5).

https://doi.org/10.1016/j.celrep.2025.115639

Neurons deviate from a canonical heat shock response (HSR). Here, we revealed that neuronal adaptation to heat shock accompanies a brake on mRNA translation, slowed elongating ribosomes, phosphorylation of eukaryotic elongation factor-2 (p-eEF2), and suppressed the integrated stress response (ISR). Returning neurons to control temperature within 1 h of starting heat shock was necessary for survival and allowed for restored translation following dephosphorylation of eEF2. Subsequent to recovery, neurons briefly activated the ISR and were sensitive to the ISR inhibitor ISRIB, which enhanced protein synthesis and survival. Ribosome profiling and RNA sequencing (RNA-seq) identified newly synthesized and existing transcripts associated with ribosomes during heat shock. Preservation of these transcripts for translation during recovery was in part mediated by p-eEF2 and slowed ribosomes. Our work supports a neuronal heat shock model of a partially suspended state of translation poised for rapid reversal if recovery becomes an option and provides insight into regulation between the HSR and the ISR.

M. J. Stacey, C. House, D. R. de Sa, S. J. Brett, C. Boot, A. Teggert, A. J. Allsopp and D. R. Woods.

Adrenal steroid hormone responses to exercise under thermal stress: Potential role for nonclassic congenital adrenal hyperplasia in heat illness susceptibility.

PHYSIOLOGICAL REPORTS. 2025;13(6).

https://doi.org/10.14814/phy2.70272

We queried whether adrenal insufficiency attributable to non-classic congenital adrenal hyperplasia (21 hydroxylase deficiency, 21OHD) might contribute to heat illness susceptibility. Patients referred to a specialist heat illness clinic (n = 2 with prior hyponatremia; n = 16 lacking documentary evidence) and controls (n = 16) underwent laboratory Heat Tolerance Assessment (HTA: 60-90 min walking, 60% relative intensity, 34 degrees C heat), synthetic adrenocorticotrophic hormone stimulation (heat illness only) and CYP21A2 genotyping (hyponatremic heat illness only). Copeptin, cortisol, 17-hydroxyprogesterone, and 21 deoxycortisol were assayed from blood at baseline and post-HTA, with precursor product [17-hydroxyprogesterone +21 deoxycortisol] expressed relative to cortisol. Saliva and urine were assayed for free cortisol (one hyponatremic case, controls). Versus controls, normonatremic heat illness exhibited greater ($p < 0.05$) serum cortisol across HTA, while hyponatremic heat illness showed blunted responses in aldosterone and free cortisol (salivary cortisol 1.6 and 1.6 vs. 6.0 [4.2, 19.4] and 4.2 [3.8, 19.2] nmol.L-1; urine cortisol 19 vs. 117 +/- 71 nmol.L-1). Hyponatremic heat illness demonstrated elevated precursor product consistent with 21OHD and multiple CYP21A2 mutations. One normonatremic case of heat illness also showed elevated precursor product. These data support the potential for 21OHD to precipitate heat illness under sustained physical stress and advance a case for targeted genetic screening.

A. Wang, S. C. Wang, F. Peng, J. Xia, H. Ren, M. L. Tan and B. Zhou.

Field questionnaire survey on thermal comfort of medical personnel in operating rooms for hospitals in Nanjing.

ENERGY AND BUILDINGS. 2025;332.

https://doi.org/10.1016/j.enbuild.2025.115423

The heating, ventilation and air conditioning (HVAC) system in the operating room is designed to provide clean air and reduce surgical site infection rates. Although the HVAC system provides a good indoor thermal environment for the surgical team and patients, the different thermal preferences of the surgical team pose challenges to meet the general comfort requirements. Therefore, we conducted a field survey on the thermal environment and thermal comfort of the operating room in Nanjing, and collected 254 questionnaires. The survey results show that the thermal comfort of personnel is related to the class of operating room and work responsibilities. It is shown that only 18.2 % of the medical staff said that the thermal environment in the operating room had no effect on the operation process. 22.7 % of the staff said that the thermal environment in the operating room affected the operation and needed to be improved. The thermal comfort level of the circulating nurse was better. The surgeon felt hot, while the anesthesiologist felt cold. The difference of medical staff's responsibilities leads to the difference of thermal comfort. As the cleanliness level of the operating room decreases, the thermal comfort level of the medical staff increases. This study provides a basis for improving the thermal environment of the surgical team in the operating room.

R. Wibowo, M. Satow, C. Quartucci, T. Weinmann, D. Koller, H. A. M. Daanen, D. Nowak, S. Bose-O'Reilly and S. Rakete.

Impact of heat stress and protective clothing on healthcare workers: health, performance, and well-being in hospital settings*.

ANNALS OF WORK EXPOSURES AND HEALTH. 2025.

https://doi.org/10.1093/annweh/wxaf026

Introduction Heat stress poses a recognized threat to human health. Despite growing evidence, its impact on healthcare workers (HCWs) remains underexplored. This study evaluates occupational heat stress in HCWs, assessing physiological responses and subjective well-being.Methods Twelve HCWs from a German university hospital were monitored in non-air-conditioned intensive care units (ICU) and non-ICU settings during the summer of 2022 (mean indoor temperature of 26.5 degrees C) and again in the autumn of the same year or in March 2023 (mean indoor temperature of 23.6 degrees C). Physiological data (core body temperature, heart rate, and skin temperature) and subjective perceptions were measured using wearable sensors and questionnaires.Results In summer, mean core body and skin temperatures were higher by 0.4 degrees C and 0.3 degrees C, respectively. ICU workers exhibited higher heart rates and reported greater mental demands, frustration, and discomfort, particularly when using personal protective equipment (PPE). Common symptoms included sweating, fatigue, and headaches.Conclusion We observed some evidence suggesting that elevated indoor temperatures and reported PPE usage contribute to increased HCWs' heat strain, which could potentially affect health, safety, and performance. Given the observed trends, we recommend considering cooling vests and revising workplace standards to mitigate heat stress.

Outils et capteurs de mesure

L. Moutet, R. Lagarrigue, F. Brocherie, G. Fifre and M. Pascal.

Indicateurs thermiques et recours aux soins d'urgence en France hexagonale entre 2015 et 2019.

BULLETIN EPIDEMIOLOGIQUE HEBDOMADAIRE. 2025;7.

https://beh.santepubliquefrance.fr/beh/2025/7/2025_7_1.html

Introduction – Chaque été, des augmentations de recours aux soins pour des causes spécifiques de la chaleur, comme les hyperthermies, sont observées en France hexagonale. Une meilleure compréhension de ces impacts est nécessaire pour accompagner les politiques de prévention. Une des questions porte sur la manière de caractériser l'exposition à la chaleur, prenant en compte uniquement la température ou d'autres variables météorologiques. Méthodes – Cette étude compare l'influence de quatre indicateurs thermiques (température moyenne (Tm), la température au thermomètre globe mouillé (WBGT), le heat index (HI) et le universal thermal climate index (UTCI)) sur les passages aux urgences de 33 départements hexagonaux, pendant les étés (juin-septembre) de 2015 à 2019. Cinq causes ont été étudiées : hyperthermie, déshydratation, hyponatrémie, fièvre isolée et malaise. Les analyses s'appuient sur des régressions de quasi-Poisson. Résultats – Avec tous les indicateurs, la chaleur est associée à un excès de risque de recours aux soins d'urgence pour hyperthermie, déshydratation, hyponatrémie, fièvre isolée et malaise. Les risques relatifs (RR) sont d'ordres de grandeur similaires entre indicateurs, sauf pour le HI. Par exemple, pour les hyperthermies, une augmentation d'exposition correspondant à l'intervalle interquartile est associée à un RR de 3,97 (intervalle de confiance à 95%, IC95%: [3,82-4,13]) avec la Tm, 3,81 [3,67-3,95] avec le WBGT, 4,22 [4,01-4,33] avec l'UTCI, et 1,22 [1,21-2,23] avec le HI. Conclusion – Les résultats confirment qu'en France hexagonale, la Tm est un bon indicateur pour caractériser la chaleur du point de vue des effets sur la santé. Les indicateurs plus complexes incluant d'autres variables météorologiques n'expliquent pas mieux les effets. Des travaux documentant les circonstances d'exposition seraient utiles pour mieux comprendre l'intérêt de ces indicateurs d'exposition dans des contextes spécifiques comme, par exemple, les événements sportifs.

M. Avraham, S. Bouscher, J. Nemirovsky and Y. Nemirovsky.

Measurement of emissivity with a new grey body and novel IR thermal sensor dubbed TMOS.

JOURNAL OF INFRARED AND MILLIMETER WAVES. 2025;44(1):17-24.

https://doi.org/10.11972/j.issn.1001-9014.2025.01.003

The concept of emissivity has been with the scientific and engineering world since Planck formulated his blackbody radiation law more than a century ago. Nevertheless, emissivity is an elusive concept even for experts. It is a vague and fuzzy concept for the wider community of engineers. The importance of remote sensing of temperature by measuring IR radiation has been recognized in a wide range of industrial, medical, and environmental uses. One of the major sources of errors in IR radiometry is the emissivity of the surface being measured. In real experiments, emissivity may be influenced by many factors: surface texture, spectral properties, oxidation, and aging of surfaces. While commercial blackbodies are prevalent, the much-needed grey bodies with a known emissivity, are unavailable. This study describes how to achieve a calibrated and stable emissivity with a blackbody, a perforated screen, and a reliable and linear novel IR thermal sensor, 18 dubbed TMOS. The Digital TMOS is now a low-cost commercial product, it requires low power, and it has a small form factor. The methodology is based on two-color measurements, with two different optical filters, with selected wavelengths conforming

to the grey body definition of the use case under study. With a photochemically etched perforated screen, the effective emissivity of the screen is simply the hole density area of the surface area that emits according to the blackbody temperature radiation. The concept is illustrated with ray tracing simulations, which demonstrate the approach. Measured results are reported.

A. J. Grundstein, S. W. Yeargin, E. R. Cooper, L. Cargile, J. Clark, R. M. Lopez, K. C. Miller, A. M. Montalvo, S. Scarneo-Miller and R. L. Stearns.

Evaluating Heat Risk: Comparing On-Site WBGT Measurements Versus Smartphone Application Estimates.

GEOHEALTH. 2025;9(3).

https://doi.org/10.1029/2025GH001347

Exertional heat illness poses a significant risk for workers, athletes, and military personnel participating in outdoor activities during hot weather. An important component of heat safety is to monitor environmental conditions through heat stress indices like the wet bulb globe temperature (WBGT) and adjust activity as conditions get progressively hotter. Traditionally, on-site (OS) WBGT measurement devices are used, but phone applications (PAs) offering WBGT estimates have emerged as a potential alternative. However, there is little information on how closely PA-derived WBGTs match OS measurements to guide decision-making. This study compared the PA-derived Zelus WBGT estimates with OS measurements from Kestrel 5400 devices and their impact on activity modification categorization. A 2-month observational study collected 1,056 paired (OS and PA) WBGT measurements from 26 high schools across 11 states in the United States and over diverse surfaces (artificial turf 53%, natural grass 44%, others 3%). WBGT values were categorized using regional activity modification thresholds to account for local acclimatization. Our findings indicated that while exhibiting high correlation (r = 0.89), PA WBGTs were on average about 1 degrees C cooler, with differences of 2-3 degrees C at higher WBGTs. Findings were similar for both grass and artificial turf surfaces. Further, significant discrepancies were observed in WBGT-based activity modification categories, with the PA more frequently indicating lower modification categories compared to OS devices, especially in hotter conditions. In light of these findings, the PA requires further validation prior to its adoption as a replacement for OS measurements.

Y. Hashimoto, K. Noto, S. Tada and Y. Nishida.

Wearable Multimodal Sensor Probe for Monitoring Core Body Temperature, Electrocardiogram, Heart Rate, and Sweat Rate.

IEEE ACCESS. 2025;13:70769-78.

https://doi.org/10.1109/ACCESS.2025.3561288

Global warming and the associated increase in heatwaves have made the prevention of heat-related illnesses such as heatstroke a critical global challenge. Monitoring physiological indicators such as core body temperature, heart rate, and sweat rate is beneficial for preventing excessive accumulation of heat stress and ensuring safe activities in hot environments. However, existing methods typically require multiple separate sensors, limiting their practicality for real-world applications. In this study, we describe the development of a compact and easy-to-use wearable multimodal sensor probe capable of simultaneously measuring the core body temperature, electrocardiogram, heart rate, and sweat rate. The prototype features an innovative design that integrates a heat flux probe for simultaneous measurement of the core body temperature and cardiac potentials with a computational model for

estimating the sweat rate. Validation experiments were conducted with ten healthy adult men performing cycling exercises under controlled environmental conditions, with the accuracy of each measurement obtained from the prototype evaluated by comparison with reference values. The results showed root mean squared errors of 0.087 degrees C for core body temperature and 131 g for total water loss, both surpassing the accuracy of previous studies. However, the prototype exhibited a tendency to overestimate the core body temperature and sweat rate during the exercise and post-exercise recovery phases compared to the resting condition before exercise. This was attributed to thermoregulatory responses, such as evaporative heat loss from sweating and increased skin blood flow, during exercise and recovery. Despite some remaining challenges in validation, this study represents a significant advancement in wearable sensor technology by offering a practical and comprehensive solution for real-time monitoring in hot environments. The proposed system has the potential to contribute to heat stress prevention in occupational, sports, and everyday settings.

A. Hon, C. Laury, C. Carraro and R. Maboudian.

Potentials of In-Cabin CO2 Sensing to Prevent Hot Car Deaths.

IEEE SENSORS JOURNAL. 2025;25(9):16020-6.

https://doi.org/10.1109/JSEN.2025.3548034

Temperatures within a vehicle vary alongside outdoor weather conditions. However, even in moderate climates, heat can build up quickly inside a car, resulting in temperatures that are 10 degrees F- 20 degrees F higher than outside temperatures in a matter of minutes. If an infant or toddler were to be trapped inside a vehicle, this may result in hyperthermia, and in severe cases death. A child detection system that takes advantage of CO2 exhalation is examined in this article. If noticeable increases or sudden fluctuations in CO2 levels are detected, the system could trigger warnings such as alarms or cellphone notifications and engage life saving measures, such as turning on AC or slightly opening windows, for instance. Our studies show that while changes in CO2 concentration can be recognized correctly by a logistic regression algorithm, the slowness of CO2 diffusion interferes with the accuracy of the model. Sensors that measure weight or detect motion can be applied to further optimize the entire detection system.

M. A. Maher, A. H. Aly, M. S. Esmail and S. E. S. Abd El-Ghany.

Maximizing temperature sensitivity in a one-dimensional photonic crystal thermal sensor.

SCIENTIFIC REPORTS. 2025;15(1).

https://doi.org/10.1038/s41598-024-82889-4

This paper focuses on a defective one-dimensional photonic crystal thermal sensor with fabricated layers of gallium nitride, glycerin, and air. The transmission features of this sensor have been presented based on the transfer matrix approach using MATLAB software. Interest in the sensor's sensitivity to temperature variation is for the sake of the photonic bandgap behavior of the 1D photonic crystal and the thermo-optic effect of glycerin must be preserved over a long time in protecting archaeological artifacts. In this direction, theoretical modeling together with numerical simulation studies are conducted to optimize the refractive index of GaN to enhance sensitivity. This work is going to evaluate the performance of the sensor in terms of the shift in the transmission spectrum of the sensor with the imposition of changes in temperature. The effect of the thickness of the defect layer together with the incident angle on the performance of the sensor will be discussed further. Sensor sensitivities are about 10 nm/degrees C, with a quality factor reaching a high value of 35,443 at an incident angle of 30

degrees, while sensitivities at an incident angle of 65 degrees have 20 nm/degrees C and a quality factor of 14,723.

S. Saxena, S. Sharma, B. Khan, N. Kumar, S. Das and V. R. Rao.

Highly Sensitive Thermal Sensor Design Using a Gate-Bias-Controlled TCR in MoSe<roman>2</roman> FET.

IEEE TRANSACTIONS ON ELECTRON DEVICES. 2025;72(6):3148-54.

https://doi.org/10.1109/TED.2025.3564929

Temperature coefficient of resistance (TCR) is an important property for the design of thermal sensors. It is calculated as per the relative shift in electrical resistance for every degree of thermal variation. Furthermore, tunable TCR implies controlling the TCR through the manipulation of gate voltage. In this article, we have investigated the TCR tunability of the layered semiconductor material molybdenum diselenide (MoSe2) with gate-bias control. Atomic force microscope (AFM) is used to measure flake height, and Raman spectroscopy is used to characterize the MoSe2 flakes. Their TCR is higher by about two times that of MoS2 and five times that of metallic films, which are typically around 0.5% K-1. Its TCR can be tuned to about two times higher than its value for 15-nm-thick flake within a gate voltage change of 7 V, with the highest recorded value being -2.75% K-1. Similarly, 65-nm-thick flake has a TCR tunability of 4.5 times higher than the minimum value. Additionally, the average relative uncertainty in TCR is observed to be 3.8% for the 65-nm devices and 4.6% for the 15-nm devices, respectively.

Y. H. Sun, K. Y. Wen, F. Z. Du, C. K. Deng, W. M. Li, J. Q. He, Q. Y. Hu, Y. Jiang, R. Sokolovskij, Q. Wang, Y. L. Jiang and H. Y. Yu.

A Novel AlGaN/GaN SBD Thermal Sensor With Ultralow Power, Excellent Linearity, and High Sensitivity.

IEEE SENSORS JOURNAL. 2025;25(5):8024-31.

https://doi.org/10.1109/JSEN.2025.3532657

A novel AlGaN/GaN Schottky barrier diode (SBD) thermal sensor featuring a recessed anode and a thin Al0.25Ga0.75N barrier layer is fabricated, which is demonstrated to have ultralow power, excellent linearity, and high sensitivity for thermal sensing. The AlGaN layer thickness is employed to trade-off the tunneling current proportion against the 2-D electron gas (2DEG) density for the thermionic emission (TE)-dominated electron transportation with better linearity and high sensitivity of thermal sensing at ultralow power. A sensitivity of 1.39 mV/K with a linearity of 0.995 operating at 0.082-0.324 V for a constant current of 10(-7) A is revealed. The proposed SBD sensor shows the great potential application for on-chip, low-power, and high-performance thermal sensing in monolithic AlGaN/GaN heterostructure-based power ICs.

W. Zhang, L. Li, Y. M. Wang, X. Dong, C. Y. Liu, L. Y. Sun, Q. L. Guan, F. Zhang and S. G. Xu.

Continuous Core Body Temperature Monitoring for Heatstroke Alert via a Wearable In-Ear Thermometer.

ACS SENSORS. 2025;10(2):1440-9.

https://doi.org/10.1021/acssensors.4c03470

Heatstroke, a global concern exacerbated by climate change, poses significant health risks, potentially leading to multiorgan damage and fatalities. Core body temperature (CBT) is a critical and precise indicator of heatstroke, and its continuous monitoring could serve as a pivotal tool for early detection. Traditional CBT measurements, often invasive (e.g., surgical intubation, rectal or oral placement), and disrupt daily activities, whereas existing wearable devices predominantly measure skin temperatures which is susceptible to ambient environment, thus unreliable for heatstroke alert. To overcome these limitations, this study introduces an innovative in-ear wearable device to measure CBT via the cochlea, which allows for accurate CBT monitoring and timely heatstroke alerts during activities in high-temperature and high-humidity environments. The device comprises a negative temperature coefficient (NTC) thermometer integrated into a flexible precision circuit (FPC), a compact Bluetooth module, an 8 mA h micro battery, and a biocompatible, low-stimulus silica gel casing. With dimensions of 27 mm x 18 mm and a maximum in-ear diameter of 5 mm, weighing just 1.3 g, the device offers high portability and comfort, with a continuous operational lifespan of at least 24 h postcharging. A complementary software system facilitates continuous CBT monitoring, heatstroke alerts, and device management. Preliminary human trials demonstrate the device's accuracy in CBT measurement, rivaling that of rectal thermometry, and superior to the performance of surface body temperature measurement at different body parts. Long-term experiments affirm the device's efficacy in detecting rapid CBT escalations, enabling timely preventive measures against heatstroke.

Travail dans une ambiance thermique extrême

M. L. Bian and L. Li.

Application of human thermal comfort evaluation method in deep stope of Xiadian Gold Mine.

DISCOVER APPLIED SCIENCES. 2025;7(5).

https://doi.org/10.1007/s42452-025-06878-6

The high temperature environment in the deep part of the mine has a serious impact on personnel health and safety in production. The thermal comfort of human body is an important index to evaluate the working environment of mine. In this paper, several stopes of Xiadian gold mine in China are taken as that research object, the thermal comfort equation of human body is established, and the thermal environment parameter of - 652 m level 55,102 stope, - 692 m level 55,001 stope and - 700 m level 55,203 stope are evaluated according to the HSI and the PMV-PPD index, and the thermal comfort parameters of work environment are obtained. The heat storage rates of the three stopes are 77.15 W/m2, 81.05 W/m2 and 85.73 W/m2 respectively, the HSI are 246.62, 257.88 and 270.84 respectively, and the PMV-PPD values are 2.75, 97.31%; 2.89, 98.52%; 3.10, 99.47% respectively. The evaluation index shows that the heat dissipation of the working body cannot reach the balance state under the environment, the heat will be accumulated in the human body, and the environment will harm the health of the operators.

C. M. I. da Silva and F. G. Amaral.

Participatory risk diagnosis: A preliminary approach to confined space work in the oil, gas, and petrochemical industries.

WORK-A JOURNAL OF PREVENTION ASSESSMENT & REHABILITATION. 2025;80(1):212-23.

https://doi.org/10.3233/WOR-230703

BACKGROUND: Confined space work poses a significant threat to worker safety and health, especially in industrial environments like petrochemical plants and refineries. These environments present additional hazards beyond those inherent to confined spaces, such as high pressures, temperatures, and exposure to toxic, flammable, and combustible substances.OBJECTIVE: This study aimed to apply the Deparis method (Participatory Risk Diagnosis) to confined space work in the oil and gas industry. The goal was to identify the key risk factors involved from the perspective of the workers themselves, propose risk reduction measures where feasible within the Deparis framework, and highlight factors that require more sophisticated methodologies for risk mitigation.METHODS: The study employed the Deparis method to assess 20 different working conditions. The survey yielded a range of results, encompassing issues with readily achievable on-site solutions to more intricate challenges requiring specialized expertise and resources.RESULTS: The Deparis method successfully identified risk factors present in the tasks from the workers' perspective. The application of risk reduction measures proposed by the method allowed for the criticality of most factors to be reduced to acceptable levels. However, certain critical areas, such as physical space constraints, task organization, communication with confined space workers, and exposure to chemical and biological hazards, were found to require alternative approaches to achieve the desired safety levels.CONCLUSIONS: The study underscores the effectiveness of the Deparis method as a valuable tool for evaluating risks in confined space operations and advocates for its broader adoption due to its demonstrated efficacy. Additionally, the study highlights the need for further research and development of more sophisticated risk mitigation strategies for specific critical areas in confined space work within the oil and gas industry.

C. J. Jia, Y. Q. Hu, L. Dai, C. H. Shi and Y. N. Zheng.

Optimized ventilation design for high-geothermal tunnels considering worker comfort.

APPLIED THERMAL ENGINEERING. 2025;267.

https://doi.org/10.1016/j.applthermaleng.2025.125772

In high-geothermal tunnels, extreme heat and humidity pose significant health risks to workers, making an optimized ventilation design crucial for improving worker comfort. A numerical model is developed to analyze the evolution of temperature and humidity within high-geothermal tunnels. A sensitivity analysis of the ventilation parameters is conducted using the wet-bulb globe temperature (WBGT) as an indicator. Field tests on worker comfort are performed, and changes in skin temperature and heart rate with the WBGT are determined. The response-surface methodology (RSM) is employed to optimize the tunnel-ventilation parameters. The results indicate that the airflow field of the tunnel is divided into three zones: jet, vortex, and recirculation. For a tunnel with an initial temperature of 80 degrees C and humidity of 60 %, temperatures near the tunnel wall remain above 35 degrees C, with humid air accumulating in this area after 7 h of ventilation. The distance between the ventilation outlet and tunnel face, wind speed, airflow temperature, and rock temperature significantly influence the spatiotemporal evolution of the WBGT. Monitoring revealed that the heart rates and skin temperatures of workers exceed normal levels in high-geothermal tunnels, with heart rates increasing linearly and skin temperatures increasing exponentially with the WBGT. Response-surface analysis identified the ventilation-flow rate, temperature, and duration as key factors affecting the WBGT. Tunnels with rock temperatures of 80 degrees C require additional cooling measures when ventilation outlet temperatures exceed 20 degrees C. The research findings are of great significance in mitigating health risks to workers arising from the adverse conditions of high-geothermal tunnel environments and in ensuring safe tunnel-construction practices.

I. Kaser, M. Valdes-Berriz, A. C. Schilder, M. McGuire, C. Carpenter, E. Brokaw, M. Dimock and G. M. Solomon.

Developing Effective Protocols to Protect Farmworkers from Heat Stress and Illness While Working in Polytunnels.

JOURNAL OF AGRICULTURAL SAFETY AND HEALTH. 2025;31(1):15-30.

https://doi.org/10.13031/jash.16111

Polytunnels-also known as hoop houses-are used worldwide to grow certain crops year-round, primarily to protect plants from precipitation and cool temperatures. Farmworkers may be at increased risk in polytunnels due to higher temperatures and relative humidity. In the Central Coast region of California, polytunnels are commonly used to grow berries and other crops, but information on measures used to reduce heat stress in farmworkers working in polytunnels or how many workers are potentially exposed to these conditions is scarce. The purpose of this study was to: (1) estimate the area under polytunnels and the number of workers in them in California's Central Coast region; (2) assess current practices to manage heat and protect workers in polytunnels; and (3) use this information to develop proposed best practices for protecting farmworkers in polytunnels. Using satellite imagery and crop production records, the area under polytunnels in the region was estimated at 5,162 ha with a conservatively estimated 46,000 farm- workers. Through key informant interviews, we found that farms are generally following OSHA worker safety regulations. However, additional measures may be needed to protect workers because environmental conditions inside polytunnels are variable and difficult to predict. For instance, wet bulb globe temperature would be a more accurate measure of heat stress risk than

temperature alone. We propose recommendations that follow the hierarchy of controls to reduce the risk of heat-related illness among workers inside these structures.

M. R. Kelly, D. M. Emerson, T. M. Torres-McGehee, N. A. Uriegas, M. O. Smith, K. Kloesel and A. B. Smith.

Self-reported exertional heat illness and risk factors among collegiate marching band artists.

SPORTS MEDICINE AND HEALTH SCIENCE. 2025;7(2):132-42.

https://doi.org/10.1016/j.smhs.2024.04.004

Marching band (MB) artists are often part of the general student population and not required to complete a pre-participation health screening to identify predisposing medical conditions or risks for injury/illness. Anecdotally, exertional heat illnesses (EHI) are a concern for MB artists. As more athletic trainers provide MB healthcare, research is needed on EHI occurrence and MB associated EHI risk factors. We utilized an exploratory cross-sectional study design to determine EHI risk factors, including previous EHI occurrence, among collegiate MB artists. MB artists (n = 1 207; age = [19.6 +/- 1.3] years) actively participating in their college/university's MB during the 2019 football season completed an online survey to characterize demographics, medical history, medication and supplement use, and nutrition behaviors. Chi-square and binomial logistical regressions assessed associations between categorical variables. Previous EHI was reported by 50.6% of MB artists, with 466 (76.3%) experiencing exertional heat exhaustion and 31 (5.1%) exertional heat stroke. More females reported exertional heat exhaustion overall (68.2%, p < 0.001) and in the previous year (73.3%, p < 0.001). Experiencing a previous EHI was significantly associated with having a mood/neurological condition (63.5%, p < 0.001), diagnosed (74.3%, p = 0.004) or perceived eating disorder (66.7%, p < 0.001), and taking prescription medications (59.4%, p < 0.001), over-the-counter medications (58.9%, p = 0.002), and supplements (55.4%, p = 0.037). Half of collegiate MB artists reported experiencing previous EHIs and engaged in behaviors known to increase EHI risk. MB artists should complete pre-participation examinations to identify pre-existing medical conditions and risks for adverse medical events. Healthcare providers working with MB artists should develop policies and procedures to mitigate EHI risks and occurrence.

E. J. Tetzlaff, N. V. Kirby, L. G. Ioannou, R. D. Meade, F. K. O'Connor, A. Flouris and G. P. Kenny.

An exploratory survey assessing the determinants of heat stress and heat strain in the Canadian mining industry from the worker's perspective.

JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL HYGIENE. 2025;22(5):400-24.

https://doi.org/10.1080/15459624.2025.2449947

With mines extending deeper and rising surface temperatures, workers are exposed to hotter environments. This study aimed to characterize heat stress and strain in the Canadian mining industry and evaluate the utility of the Heat Strain Score Index (HSSI), combined with additional self-reported adverse health outcomes. An exploratory web-based survey was conducted among workers (n = 119) in the Canadian mining industry. The survey included 74 questions on workers' risk perception, strategies for heat stress management, and the HSSI-a validated tool to classify workplace heat stress based on various workplace factors and indicators of heat strain. Most workers reported that heat stress is an occupational hazard associated with their duties and tasks (89%). Based on the HSSI, 22% of respondents were classified as high risk, 42% at moderate risk, and 36% at low risk for heat stress and heat strain. Those with higher HSSI scores self-reported more heat-related adverse signs and symptoms with a higher prevalence of self-reported heat-related illness (p < 0.01). Despite workers

reporting various self-initiated practices (e.g., drinking water) and management-enforced heat mitigation practices (e.g., rest breaks), many workers reported still having experienced signs or symptoms of heat stress (86%) and heat-related illnesses (37%). The study found elevated heat stress and strain levels among a sample of workers in the Canadian mining industry despite workers employing various heat-mitigating strategies. Heat stress management programs considering mining-specific factors and challenges are needed to safeguard worker health and safety.

H. T. Wang, K. K. Lei and J. F. Zhai.

Human thermal comfort in the high-temperature radiant heat workshop.

INTERNATIONAL JOURNAL OF THERMAL SCIENCES. 2025;211.

https://doi.org/10.1016/j.ijthermalsci.2025.109683

Safety in production has always been a basic national policy in China, but there are still many high-temperature work scenarios in China, which seriously endangers the physical and mental health of workers. In this paper, the equivalent temperature (EQT) was selected as the evaluation index of human thermal comfort, and the equivalent temperature of each segment of the human body was calculated by selecting appropriate measurement points and placing a human body model, and the skin temperature on the human surface was accurately set according to the biothermal equation. The calculated equivalent temperature was compared with the temperature range that the human body felt comfortable with, and the relationship between the local temperature of the human body and the comfortable temperature was quantitatively judged. FLUENT is used to obtain physical quantities such as air velocity, air temperature, and indoor average radiation temperature around each segment of the human body, and then substitute the formula to solve the EQT of each segment of the human body. By comparing the equivalent temperature of each part of the human body with the equivalent temperature range value that the human body feels comfortable with, it is found that when the air inlet wind speed is 3 m/s without thermal insulation measures and 0.5 m/s when there are thermal insulation measures, all parts of the human body are within the comfortable range. This paper provides ideas for the cooling improvement of the thermal environment of high-temperature plants.

J. Wang, C. Jiang, G. Yang, F. K. Meng, J. Y. Kang, S. X. Yu and G. Bai.

Energy efficiency and air distribution characteristics of jet ventilation in crossflow for long-narrow mining working faces.

PHYSICS OF FLUIDS. 2025;37(1).

https://doi.org/10.1063/5.0246257

Long-term exposure to extreme heat in mines jeopardizes worker health and reduces productivity. This study introduces and evaluates the air distribution of jet ventilation in crossflow (JVIC) mode for localized mine cooling. Experimental and numerical simulations reveal two distinct wake structures: single wakes for wall-attached and impinging jets, and double wakes for deflected jets, influenced by counter-rotating vortex pair (CVP) structures, which accelerate cooling loss. Key parameters-jet-to-crossflow velocity ratio (R), vent equivalent diameter-to-roadway height ratio (C), and jet-to-crossflow Reynolds number ratio-govern flow modes and CVP dynamics, while jet-to-crossflow temperature ratio (T) primarily affects cooling distribution within the jet, confirming a velocity-dominated flow field. A quantitative model was developed to characterize JVIC air distribution, detailing boundaries, diffusion widths, and velocity and temperature trajectories. The model demonstrates that wall-attached and highly deflected jets enable more stable cooling with slower diffusion and reduced energy loss. Under

conditions of R = 1 and C = 3, the jet achieves the highest local cooling effectiveness (epsilon(t)), maintaining a cooling efficiency of 29.9% at x/d(m) = 3, demonstrating JVIC's ability to maintain effective cooling over extended distances. A practical evaluation shows that the novel JVIC mode achieves a cooling load of 184.9 kW, reducing energy consumption by 86.7% compared to traditional full-air cooling (1387 kW). These findings highlight JVIC's potential for efficient, targeted mine ventilation, advancing cooling efficiency and energy conservation.

X. M. Wang, Y. J. Wang, X. J. Lai, G. Y. Wang and C. L. Sang.

Investigation of heat stress and thermal response in deep hot-humid underground environments: A field and experimental study.

BUILDING AND ENVIRONMENT. 2025;270.

https://doi.org/10.1016/j.buildenv.2024.112506

As the depth of mineral resource extraction increases, heat stress in deep underground environments poses an increasing threat to worker's health and safety. Field experiments were conducted to examine the physical characteristics, environmental assessment (noise intensity vote (NIV), luminous intensity vote (LIV), air quality vote (AQV) and crowding intensity vote (CIV)), and thermal psychological responses (thermal sensation vote (TSV), thermal comfort vote (TCV), and sweating sensation vote (SSV)) of 112 miners who worked in a U-shaped tunnel at a depth of -1015 m. Furthermore, human trials were performed in a climate chamber to investigate variations in physiological parameters and TSV, TCV, SSV in 29 and 32 degrees C environments. The results demonstrate that the dry bulb temperature, relative humidity and air velocity ranged from 25.3 to 32.8 degrees C, 79.1 %-88.5 %, 1.45-0.6 m/s, respectively. The average metabolic rate of workers was 217.8 W/m2. The working face recorded the worst levels of NIV, CIV and TCV, whereas the outlet roadway exhibited the lowest AQV and largest TSV, SSV. The hot-humid environment with temperature of 32 degrees C resulted in a rapid increase in the subjects' thermal psychological and physiological parameters, particularly with maximum values of 35.99 degrees C, 37.62 degrees C, 111.2 bpm and 4.57 for mean skin temperature, core temperature, heart rate and physiological strain index, respectively. The findings provide a basis for exploring the extent and mechanism of thermal responses and offer methodological guidance for enhancing thermal protection for workers in deep underground environments.

Travail par fortes chaleurs et périodes de canicule

CNESST.

La planification des travaux en prévision des vagues de chaleur. 2025.

https://www.cnesst.gouv.qc.ca/fr/organisation/documentation/formulaires-publications/planification-travaux-en-prevision-vagues-chaleur

Chaque année, l'été amène son lot de vagues de chaleur, entraînant souvent des malaises, et même des décès chez les travailleurs. Avec la progression des changements climatiques, ces vagues de chaleur sont appelées à augmenter en nombre et en intensité. En chantier ou en établissement, en vertu du paragraphe 3º de l'article 51 de la Loi sur la santé et la sécurité du travail et de l'article 124 du Règlement sur la santé et la sécurité du travail, l'employeur doit s'assurer que l'organisation du travail ne porte pas atteinte à la santé de ses travailleurs, notamment en mettant en place des mesures permettant de limiter la contrainte thermique pour ceux-ci. Comme pour plusieurs sujets, la clé de la prévention est souvent dans la planification. L'élaboration d'une procédure pour les journées chaudes peut être un outil qui permettra à l'employeur d'économiser du temps et de l'argent, tout en respectant son obligation réglementaire.

A. Bauer.

Working from home as an adaptation strategy to heat: Comparing temperatures and workers' assessments for 203 offices and 107 homes.

BUILDING AND ENVIRONMENT. 2025;272.

https://doi.org/10.1016/j.buildenv.2025.112680

This contribution considers whether working from home (WFH) can be an effective adaptation to increasing summer heat for office workers. The mixed-method study presents temperature data from 203 offices and 107 home workspaces in Southern Germany, along with survey data from >100 workers at both locations during a hot period in June 2023. Home workplaces had both lower mean temperatures and less occurrence of elevated temperatures or overheating (operationalised as degree hours above 26 degrees C and 30 degrees C) than passive offices. A comparison with mechanically cooled offices is offered, but should be interpreted cautiously due to the small N and energy saving measures being in place at the time. Measured temperatures had significant effects on workers' perceived heat stress and productivity in a mixed-effects regression model. Individual variables age, gender, general activity level and general thermal preference were also explored. Barriers for WFH were explored through stakeholder interviews. We conclude that flexible WFH can be a means to protect workers' health depending on the specific office and work situation, and could offer workers better adaptive options and potentially a slight psychological benefit.

R. Edwards, N. Lanier, J. A. G. Balanay and E. Mizelle.

Heat risks in agriculture: Microclimate variability and worker safety in sweet corn and tobacco.

JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL HYGIENE. 2025;22(6):474-81.

https://doi.org/10.1080/15459624.2025.2473469

Agricultural work is one of the highest-risk U.S. occupations for heat-related illness (HRIs). Some tall-growing crops can block the cooling effects of wind or contribute to environmental humidity creating warm and humid microclimates (environments directly surrounding workers). The purpose of this study was to assess the differences in environmental heat stress within the center of tall-growing crop fields compared to the field perimeter. In the summer of 2023, two heat stress monitors collected daily measurements of wet bulb globe temperature (WBGT) in sweet corn and tobacco fields; results support that WBGT was higher at the field center of sweet corn and significantly higher at the field center of tobacco: 6.7% more hours in sweet corn and 13.6% more hours in tobacco were considered unsafe heat stress risk levels at the field center when compared to unsafe hours at the field perimeter. Unsafe heat stress risk levels were more likely to occur in the afternoons in the corn field while a high majority of all recorded hours in tobacco were considered unsafe, including the morning hours. The risk of laboring inside tall crop rows and heat-related illness should be considered in worker education and heat stress plans.

Y. Epstein, N. Charkoudian, D. W. Degroot, C. House, I. Ketko, L. Y. L. Law, A. Malgoyre, F. O'Connor, O. Tayari and J. K. W. Lee.

Exertional heat illness: international military-oriented lessons learned and best practices for prevention and management.

FRONTIERS IN PHYSIOLOGY. 2025;16.

https://doi.org/10.3389/fphys.2025.1456984

Climate change has resulted in more frequent and intense heat waves, leading to elevated global temperatures and posing a significant health threat to individuals working in hot environments such as military personnel. Ensuring both safety and performance, alongside the increasing risk of exertional heat illnesses (EHI) due to rising temperatures, is hence even more crucial. Extensive research conducted over many years has aimed to understand the causes and impacts of EHI and develop prevention and treatment strategies. This review summarizes the research on the impacts of heat on health and performance in military settings, consolidates evidence-based strategies for EHI prevention and pre-hospital management, summarizes sex differences in heat tolerance, and discusses best practices for recovery and return to duty post-EHI. The aim is to share the knowledge and practices derived from military research to protect the health and performance of individuals in various populations exposed to heat.

T. Y. Guo, J. H. Yang, Y. N. Fan, Y. Zhao, J. L. Liu and Z. S. Fang.

Thermal safety of indoor factory workers during summer in the subtropics: A dynamic thermal indicator.

BUILDING AND ENVIRONMENT. 2025;277.

https://doi.org/10.1016/j.buildenv.2025.112918

Extremely hot environments in indoor factories without effective air-conditioning systems are hazardous to the health of workers. This pose a potential threat to production safety on the factory floor, with workers often facing serious thermal safety challenges. Therefore, in this study, a full-scale experiment was conducted in three indoor factories in hot summer and cold winter regions of China during the summer of 2024 to investigate the effects of indoor thermal environments and activity states on worker heat stress by measuring thermal parameters and worker physiological indices in the field. The study resulted in the following findings: (1) Factories with high equipment surface temperatures

exhibited 6 degrees C higher average temperatures than others. (2) For air temperatures below 33.7 degrees C, the work status dominated metabolic rate and core body temperature variations by 69.3 % and 85.1 %, respectively. For air temperatures above 37.7 degrees C, the work status remained critical for metabolic rate (83.5 % weighting), with air temperature influence on core body temperature increasing to 44.1 %. (3) In an airconditioned environment, the standard effective temperature (SET) of workers was always within acceptable range at work in contrast to a SET of 38.4 degrees C in non-air-conditioned environments. (4) An improved heat index model incorporating metabolic rate adjustment enhanced the mean thermal sensation vote (MTSV) prediction accuracy in non-air-conditioned settings. (5) Symptoms of worker discomfort were more severe in non-airconditioned than air-conditioned environments. These results quantitatively demonstrate the critical role of activity-adaptive thermal management and provide guidelines for optimizing factory safety and worker comfort.

X. G. Han, J. S. Wu, Z. Q. Hu, C. Li and X. F. Hu.

A practical deep learning model for core temperature prediction of specialized workers in high-temperature environments.

JOURNAL OF THERMAL BIOLOGY. 2025;128.

https://doi.org/10.1016/j.jtherbio.2025.104079

The health issues of hazardous operations in high-temperature environments are increasing concerns to the public, especially since global warming and extreme weather conditions have made the high-temperature work more frequent and harsher. The abnormal elevation of human core temperature (Tcr) due to high temperatures directly leads to a decline in physiological functions and may trigger various heat-related health issues, which is especially threatening for those working in such conditions. However, continuous real-time Tcr monitoring and prediction are challenging, particularly considering the hazardous operations in extremely hot environments. To address this problem, a non-invasive Tcr prediction model combining a Kalman filter and a long-term sequence forecasting deep learning model was developed. This model leverages monitored skin temperature (Tsk) and heart rate (HR) as input features, enabling personalized real-time Tcr predictions for various groups of specialized operations personnel. The model's accuracy was validated using the data from a series of chamber experiments with 13 participants under ambient temperatures ranging from 34 to 40 degrees C and Tcr range of 37-39 degrees C. The optimal prediction results, evaluated by the test set using seven-point Tsk combined with HR, obtain a MAE value of 0.07, a RMSE value of 0.09, and a R2 value of 0.93. Additionally, the errors of 95% of all Tcr predictions fell within +/- 0.17 degrees C. The proposed model has the advantage of requiring simple input parameters/features and producing high-accuracy predictions, which makes it a practical tool for health monitoring and protection of hazardous operations in high-temperature environments.

A. M. Ierardi and B. Pavilonis.

New York City occupations at-risk of heat stress: integrating O*NET and BLS data for occupational insights.

ANNALS OF WORK EXPOSURES AND HEALTH. 2025.

https://doi.org/10.1093/annweh/wxaf022

Extreme heat poses a growing threat to occupational health and safety in the New York City (NYC) metropolitan region with projections indicating substantial increases in heat wave events and heat-related mortality in the coming decades. We, therefore, aimed to identify NYC occupations at greatest

*heat stress risk using publicly available data. Two databases were mapped and merged to compile available occupational information for job titles in the NYC metropolitan region. Two certified industrial hygienists identified variables within these databases to include in a heat stress risk model and weighted these accordingly. Inter-rater reliability and agreement statistics were calculated. The final model was applied to the merged database to identify the scope of the NYC-region worker population potentially impacted by heat stress. The final merged database included 717 Standard Occupational Classification codes with data for 407 categories from the Occupational Information Network (O*NET), as well as employment and wage data from the United States Bureau of Labor Statistics (BLS). Regarding the risk model, the raters' variable selection and weighting were generally consistent and entailed the inclusion of 11 variables. Upon applying the final risk model to the merged database, 178 880 total workers were found to constitute the top 25 at-risk job titles with total employment n > 500, with more than half of this identified workforce classified as landscaping and groundskeeping workers (n = 51 790) and construction laborers (n = 46 390). Our analysis successfully identified NYC occupations at greatest risk of heat stress, achieving our aim and providing a foundation for targeted mitigation strategies. The success of any extreme heat mitigation policies will depend on effective enforcement and outreach to impacted workers.*

T. Isaac, S. Ranjith, P. K. Latha, R. Shanmugam and V. Venugopal.

Physiological strain in outdoor workers: The hidden danger of high humidity.

ENVIRONMENTAL RESEARCH. 2025;276.

https://doi.org/10.1016/j.envres.2025.121495

Introduction: Outdoor workers in hot climates face significant heat strain, exacerbated by factors like air temperature and relative humidity (RH). While high temperatures' effects on health are well-documented, RH's critical role in influencing physiological strain is less explored. This study investigates RH's impact on the Physiological Strain Index (PSI) among outdoor workers, aiming to enhance safety in hot, humid conditions. Methods: We conducted a cross-sectional study of 1452 outdoor workers across India (2014-2022), collecting data on air temperature, RH, wet bulb globe temperature (WBGT), and physiological heat strain indicators in the summer and winter. Generalised Linear Mixed Models (GLMM) and Generalised Additive Models (GAM) were utilised to assess RH's influence on PSI, potential non-linear relationships, and a heat-humidity threshold. Results: Crude odds ratios (COR) indicated that workers exposed to high humidity were 2.5 times more likely to experience high PSI (COR = 2.5 [95 % CI: 1.82-3.44]). GLMM results confirmed RH's significant impact on PSI when adjusting for covariates (aOR = 1.6 [95 % CI: 1.24-2.29]). GAM analysis revealed non-linear relationships between air temperature, RH, and PSI. The predictive model derived from the GAM identified a heat-humidity threshold of 32 degrees C and 60 % RH. Discussion: Elevated PSI under high humidity conditions highlights the need for tailored protective measures, such as hydration strategies and adjusted work-rest cycles, to mitigate physiological strain in hot and humid environments. Conclusion: RH significantly exacerbates PSI among outdoor workers. These findings inform workplace safety guidelines, emphasizing the need for more aggressive heat stress management in high-humidity conditions.

M. Li, B. Meng, Y. Geng, F. Tong, Y. N. Gao, N. Yamano, S. Lim, J. Guilhoto, K. Uno and X. H. Chen.

Inequitable distribution of risks associated with occupational heat exposure driven by trade.

NATURE COMMUNICATIONS. 2025;16(1).

https://doi.org/10.1038/s41467-024-55483-5

The exposure to extreme heat at workplaces poses substantial threat to human effort and manual labour. This becomes more prominent due to the global dispersion of labour-intensive production activities via trade. We combine a climate model with an input-output model to quantify the risks associated with trade-related occupational extreme heat exposure. Here we show an 89% surge in trade-related labour exposure to extreme heat, escalating from 221.5 to 419.0 billion person-hours between 1995 and 2020. Lower-middle-income and low-income economies constituted 53.7% and 18.3% of global exposure but only 5.7% and 1.0% of global labour compensation. In countries highly susceptible to extreme heat conditions, workers perform tasks in heated conditions for up to about 50% of their working hours. The disproportionate trade effects in redistributing global benefits and costs leads to the inequality in heat exposure between developed and developing economies. In striving for equitable and safe work conditions, workers vulnerable to heat extremes in developing economies should be protected by climate adaptation infrastructure, given their critical roles in the global production system.

A. Marinaccio, C. Gariazzo, L. Taiano, M. Bonafede, D. Martini, S. D'Amario, F. de'Donato, M. Morabito and G. Worklimate Working.

Climate change and occupational health and safety. Risk of injuries , productivity loss and the co-benefits perspective.

ENVIRONMENTAL RESEARCH. 2025;269.

https://doi.org/10.1016/j.envres.2025.120844

Background: Climate change is a fundamental threat to human health and outdoor workers are one of the most vulnerable population subgroups. Increasing heat stress and heatwaves are directly associated with the health and safety of workers for a large spectrum of occupations. Heat stress negatively affects labour supply, productivity, and workability. Objectives: The aims of this study are to estimate the risk of work-related injuries for extreme temperature outdoor exposure in Italy, to evaluate the loss in productivity and the associated insurance costs for supporting the co-benefits analysis of the adaptation measures. Methods: The relationship between air temperature and occupational injuries (in the period 2014-19) was evaluated using a time-series approach, by means of a specific over-dispersed Poisson generalized linear regression model, applied to compensation data. To assess the effect of temperature on workability, the wet bulb global temperature (WBGT) was estimated by different levels of humidity and vapor pressure. The costs of injuries have been estimated according to the potential consequences in terms of paid insurance premium and including all management and human resources costs. Results: We estimated 25,632 (95%CI 22,353-28,862) occupational injuries in Italy attributed to heat (between 75 degrees and 99 degrees percentiles) in the period 2014-2019, which corresponds to an average of 4272 cases for year. A decrease in productivity of about 6.5% was estimated for workers engaged in physical activities requiring high metabolic rates for every unit degree increase in temperature between 19.6 C degrees and 31.8 C degrees. The overall compensation costs associated to extreme heat exposure have been estimated to more than 292 million euros between 2014 and 2019, almost equal to 49 million euros per year. Discussion: Prevention measures and adaptation strategies for contrasting the occupational exposure to extreme temperatures can help contain both the risk of injury and, productivity loss, in a co-benefits perspective.

S. C. Msibi, S. Naidoo, K. Jakobsson, J. Glaser, B. Skinner and R. N. Naidoo.

Work and work exposures in sugarcane farming in Eswatini, Southern Africa.

INTERNATIONAL ARCHIVES OF OCCUPATIONAL AND ENVIRONMENTAL HEALTH. 2025.

https://doi.org/10.1007/s00420-025-02140-z

ObjectiveTo describe work practices and exposures among sugarcane farm workers on smallholder cooperatives in eSwatini, being subcontracted (cane cutters) or directly employed (pesticide applicators).MethodsData were collected at mid-harvest using repeated field observations and wet bulb globe temperature (WBGT) measurements. Questionnaires were administered to 267 sugarcane cutters and 125 pesticide applicators. Individual work output was defined as the length of the row of sugarcane cut over the workday, which also determined the monthly remuneration. The Quick Exposure Check was used to assess exposure to musculoskeletal risks. Pesticide handling practices were described with a focus on personal protection safety practices. Additionally, heart rate was measured in 20 pesticide workers for estimation of workload and core temperature.ResultsSugarcane sites generally had no provision for rest in shade. Few workers were provided with drinking water and thus used personal containers or took water from the irrigation system. The mean water intake over the workday was as low as 1.4 L. Most workers (87%) described their work as physically demanding. For workers with a high workload (cane cutters), the observed daily average maximum WBGT of 28.6 degrees C was above the NIOSH recommended exposure limit (REL) of 26 degrees C. Pesticide applicators had a moderate workload. A minority of the applicators had access to proper personal protective equipment such as air respirators (4%), chemical gloves (17%), and chemical overalls (21%); still, their protective clothing hindered heat dissipation and thus increased heat stress.ConclusionWorkplace interventions are needed to protect workers' health and safety.

M. J. Nodoushan, A. Jafari, M. J. Zaveh, N. Nasirzadeh and F. Golbabaei.

Association between climate change and impacts of heat stress among mining employees: a systematic review and meta-analysis.

JOURNAL OF PUBLIC HEALTH-HEIDELBERG. 2025.

https://doi.org/10.1007/s10389-025-02443-y

AimClimate change and global warming have caused concerns about the health of employees. There is evidence that global warming and heat stress threaten the health of mining employees due to the nature of the work. The aim of the present study was to summarize the existing knowledge regarding health effects related to climate change and heat stress, associated risk factors, control strategies, and research gaps for future studies in mining.Subject and methodsA search was performed in Scopus, PubMed, and Web of Science databases. Keywords reflecting climate change, heat stress, and the mining environment were used. We performed a random-effects meta-analysis to calculate pooled event rates for health outcomes.ResultsA total of 15 studies meeting the eligibility criteria were included in the review, of which seven were qualified to be included in the meta-analysis. The pooled results indicate that 22.8% of mining employees were affected by climate change and heat stress. For health effects, weakness and vomiting have the highest and the lowest frequency among exposed people, respectively (41.2% and 8.9%). Risk factors such as age, gender, BMI, degree of acclimatization, education, history of chronic disease, fitness, PPE, workload, and task were identified.ConclusionsRegarding the prediction of the global temperature increase and its effect on heat stress, it is necessary to adopt appropriate policies, occupational health interventions, and implement appropriate strategies. In this regard, measures such as work-rest programs, sufficient hydration, provision of shade, and engineering controls have been suggested.

S. R. Notley, R. D. Meade, D. P. Looney, C. L. Chapman, A. W. Potter, A. Fogarty, T. Howlader, L. C. Main, K. E. Friedl and G. P. Kenny.

Physiological monitoring for occupational heat stress management: recent advancements and remaining challenges.

APPLIED PHYSIOLOGY NUTRITION AND METABOLISM. 2025;50:1-14.

https://doi.org/10.1139/apnm-2024-0395

Occupational heat stress poses a major threat to worker health and safety that is projected to worsen with global warming. To manage these adverse effects, most industries rely on administrative controls (stay times and work-to-rest allocations) that are designed to limit the rise in body core temperature in the "average" individual. However, due to the extensive inter- and intra-individual variation in thermoregulatory function, these administrative controls will result in some individuals having their work rate and productivity unnecessarily restricted (false positives), while others may be subject to rises in heat strain that compromise health (false negatives). Physiological monitoring has long been touted as a more effective approach for individualized protection from excessive heat stress. This has led to extensive interest in the use of wearable technology for heat stress management from both the scientific community and manufacturers of wearable devices, which has accelerated in the past decade. In this review, we evaluate the merits of the recent and emerging approaches to manage occupational heat strain with wearable physiological monitors. Against this background, we then describe the issues that we perceive to be unresolved regarding the use of wearable heat strain monitors and the research efforts needed to address those issues. Particular emphasis is directed to the efficacy of existing physiological indicators of heat strain, how to define upper limits for those indicators and the efforts required to rigorously validate emerging wearable heat strain monitoring devices.

S. P. Parajuli, T. Biggs, N. L. Galvez, P. Quintana, H. Ciborowski, F. De Sales, M. A. Z. Perez, C. Jones, C. Thompson, S. Hurtado-Gonzalez, S. Madonia and S. S. P. Shen.

Heat-related rest-break recommendations for farmworkers in California based on wet-bulb globe temperature.

COMMUNICATIONS EARTH & ENVIRONMENT. 2025;6(1).

https://doi.org/10.1038/s43247-025-02327-9

Extreme heat is a global public health concern that is becoming more frequent and severe in recent periods. Translating Earth science data into policy-relevant metrics, such as rest breaks, is challenging but needed to protect outdoor workers from heat stress. Here, we determine rest-break requirements for the farmworkers of the Imperial and Coachella Valleys in southern California, which have a high poverty rate and the highest heat-illness rates in California. We used high-resolution outputs from a validated Weather Research and Forecasting Model (WRF) at 1-km grid resolution that includes irrigation, a key modulator of heat stress in the study region. We calculated exceedances of heat stress indicators under three existing policy guidelines that use wet-bulb globe temperature (WBGT), heat index (HI), or dry-bulb temperature (DBT), and translated them into rest breaks needed for farmworker safety. WBGT-based rest minutes are most sensitive to the spatiotemporal variation in heat exposure compared to DBT or HI and vary with acclimatization status, season, and work shifts. Recommended rest breaks to protect farmworkers from heat stress range from 2 to 32 min per work-hour between April and August. Although results are specific to California, our method is adaptable for calculating region-specific rest break requirements worldwide.

P. Saberi and J. Green-McKenzie.

Interactive Workshop on Identifying Health Effects of Climate Change in the Clinical Setting: An Occupational and Environmental Health Solution.

JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL MEDICINE. 2025;67(5):330-2.

https://doi.org/10.1097/JOM.0000000000003331

Objective The aim of the study was to provide clinicians an occupational framework to assess climate-related health conditions, determine at-risk workers, and devise solutions. Methods An interactive workshop was presented at the 2022 American Occupational Health Conference. Six climactic events related to occupational health were chosen with corresponding cases from National Institute of Environmental Health Sciences. Participants answered and discussed scripted questions. A 5-point Likert scale utilized by the American Occupational Health Conference evaluated the workshop's quality and utility, and the audience's ability to apply the knowledge. Results Sixty-one (N = 66) participants ranked the workshop highly (4.4-4.6/5). Most participants (90%) reported incorporation of practical knowledge gained, increased advocacy capacity, and ability to teach about the issue. Conclusions Successful integration of engaging interactive sessions in clinician education on climate change and health is critical as climactic conditions can increase patient vulnerability in their role as workers.

J. W. Specht, S. A. Garcia, E. Tourula, M. J. Hite, C. Walker, H. A. Yoder, D. H. Wegman, J. Glaser, Z. J. Schlader and F. T. Amorim.

Heat stress and strain in commercial construction workers in the summer: A pilot study.

JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL HYGIENE. 2025.

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Construction workers are 13 times more likely to die from heat-related illnesses than workers in other job industries. This elevated risk is attributed to excessive heat stress from environmental exposure, metabolic heat generated from physical labor, and the insulating effects of protective clothing. Levels of heat stress may vary across job types, reflecting the diversity of tasks performed and the work environment. Despite elevated risks, heat strain assessed by core temperature (Tcore) in construction workers during summertime in the United States has not been evaluated previously. Thirty-two construction workers (three females) were monitored over 3 summer workdays. Participants were categorized by job type (carpenter, concrete, laborer, roofer) and work environment (covered, uncovered). Heat index (HI), heart rate (HR), and Tcore were measured throughout the workday, while hydration was assessed through pre- and post-shift measurements of urine specific gravity (USG). Peak HI over the 3 days was 27.3, 35.2, and 33.7 degrees C, indicating the potential for low to moderate heat stress. Roofers experienced a higher peak HI compared to other job types ($p < 0.01$), but no differences were observed between workers in covered (28.8 +/- 3.7 degrees C) and uncovered (32.1 +/- 4.2 degrees C) areas ($p = 0.37$). The estimated peak metabolic rate was higher in workers in uncovered areas (868 +/- 238 W) compared to covered (632 +/- 130 W) ($p < 0.01$), with no differences among job types ($p = 0.23$). Forty-three percent of workers had Tcore exceeding 38.0 degrees C, with 4% exceeding 38.5 degrees C. Based on USG, 63% of workers began work dehydrated (1.022 +/- 0.005), but urine did not become more concentrated during the workday (post-shift USG; 1.022 +/- 0.007) ($p = 0.78$). Forward stepwise regression identified that peak metabolic rate plus post-shift USG were the combined variables most associated with peak Tcore ($r(2) = 0.55$, $p < 0.01$). Construction workers, even in low to moderate environmental heat exposure, experienced significant heat strain, primarily due to an elevated metabolic rate. Environmental heat exposure and metabolic rate vary by job type and work environment.

M. Sugiuchi, S. Arata, T. Ikaga, Y. Shiraishi, T. Hayashi, J. Nakano, S. Ando and S. Kawakubo.

Analyzing multiple elements of physical office environment for maximizing perceived work efficiency: Insights from surveys of 58 offices during summer.

BUILDING AND ENVIRONMENT. 2025;267.

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Worker performance is affected by environmental stimuli in the office. Therefore, it is important to analyze the relationship between workers and multiple environment elements simultaneously in order to understand the relationship between the office environment and worker performance. In addition, surveying a large sample of offices simultaneously is desirable to obtain more practical insights. Therefore, this study surveyed multiple elements of the physical office environment related to worker performance in a large sample of offices. The elements of the physical office environment surveyed were air temperature, relative humidity, CO2 concentration, and sound pressure level during the summer. Along with measurements from 58 offices across 29 buildings in Tokyo, Japan, 947 responses to a questionnaire survey of workers conducted to evaluate work performance were analyzed to elucidate the relationship between these elements of the physical office environment and perceived work efficiency. The analysis showed that air temperature was more related to worker performance than to the other elements. In addition, 25 degrees C air temperature group was observed to be associated with high worker performance, with worker performance being lowest in the 27 degrees C group. This finding is expected to provide insight into indoor environments that can effectively enhance office worker performance.

T. Tantipanjaporn, A. Povey, H. A. Shiels and M. van Tongeren.

High levels of heat stress among sugarcane workers in Thailand.

ANNALS OF WORK EXPOSURES AND HEALTH. 2025;69(4):401-14.

https://doi.org/10.1093/annweh/wxaf002

Objectives With continued global warming, the effects of elevated temperatures on the health of agricultural workers are a particular concern. This study characterized the levels of heat stress in Thai sugarcane workers and investigated whether season and harvesting method were associated with it.Methods Three hundred sugarcane workers in Nakhon Sawan Province, Thailand, were recruited, and information on demographics, working conditions, and clothing characteristics was collected from participants during the cooler months (n = 152 participants, mid-January to mid-February) and hotter month (n = 148, March). Heat stress was measured using the Wet Bulb Globe Temperature (WBGT) index, and the WBGT instruments were operated for a full work shift in the sugarcane fields where the participants worked. One-hour time weighted average (TWA) effective WBGT (WBGTeff-1hrTWA) estimates were determined for different times of the day based on the measured WBGT and clothing adjustment factor.Results The average WBGTeff-1hrTWA in the cooler months ranged from 22.5 degrees C during the early morning to 31.3 degrees C during the hottest time of the day, and for the hotter month, it ranged from 25.4 degrees C to 33.9 degrees C, respectively. The measured WBGT, natural wet-bulb temperature (Tnwb), dry-bulb temperature (Tdb), globe temperature (Tg), air velocity (Av), and absolute water vapor pressure (ea) were all statistically significantly higher in the hotter month than in the cooler months. Harvesting during the hotter month and harvesting burnt sugarcane were significantly associated with increased effective WBGT. The harvesters' heat stress in both seasons exceeded the American Conference of Governmental Industrial Hygienists - Threshold limit value for 72.7% of the working time in the cooler months and 90.9% in the hotter month.Conclusions The heat

stress in Thai sugarcane workers was high in both seasons, particularly in the hotter month and when harvesting burnt sugarcane. This results in a very high risk of developing heat-related health effects, and measures are needed to reduce heat stress. Heat stress in agricultural and other outdoor work in tropical climates is an immediate and growing problem.

J. H. Yang, Y. Zhao, T. Y. Guo, X. Zhang, Z. S. Fang and P. H. Wu.

Investigation of the physiological response and thermal adaption of environmental sanitation workers in outdoor spaces: A case study in summer.

THERMAL SCIENCE AND ENGINEERING PROGRESS. 2025;61.

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The continuous rise in global temperatures has deteriorated the quality of urban environments. Sanitation workers in hot outdoor conditions may face heat-related risks, especially in South China where summers are hot and humid. Therefore, establishing a relationship between sanitation workers' physiological indicators and outdoor thermal environments is necessary to accurately predict and assess their heat safety in high-temperature working environments. We conducted a field investigation of thermal and physiological parameters in the campus of Guangzhou University and a total of 969 questionnaires (male) were collected. Through the regression equations, the relationships between sanitation workers' health risks, thermal parameters, and thermal indices were analyzed. The results indicated that sanitation workers had a higher tolerance to the thermal environment at rest than when they were working. The unacceptable T-a (air temperature) and T-mrt (mean radiant temperature) during work was 31.5 and 41.3 degrees C, respectively. Except for the blood oxygen level (SpO(2)), both the heart rate (HR) and auditory canal temperature (T-ac) increased with increasing T-a. Compared with PET (physiological equivalent temperature), UTCI (universal thermal climate index) is better in predicting HR levels. For instance, sanitation works' HR level may be 95 beats/min. When PET exceeded 53.0 degrees C or UTCI exceeded 47.1 degrees C, sanitation workers felt extremely hot. Additionally, when the MTSV (mean thermal sensation vote) was close to 3 (indicating feeling hot) and the physiological strain index was > 7, sanitation workers faced a heat risk. Therefore, the findings indicate that management authorities should consider both T-a and UTCI to provide appropriate guidance to sanitation workers during their work period to ensure occupational safety and prevent heat-related incidents.

Actualités janvier-mai 2025

- **Travail par fortes chaleurs et périodes de canicule FR**

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- **Travail dans une ambiance thermique extrême**

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