

Bulletin n°41

Veille thermique

Période : septembre 2026

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.

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INRS-Biblio

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J. Debreu.

Dossier. Face aux risques climatiques, le BTP s'organise.

Prévention BTP. 2026:ill., bibliogr., 6–16.

Ce dossier analyse l'adaptation du secteur du bâtiment et des travaux publics à l'intensification des risques climatiques : fortes chaleurs, canicules, vents violents, pluies, inondations, froid et cyclones. Le changement climatique affecte désormais directement la santé des travailleurs, la sécurité des chantiers et la continuité des activités. La réglementation française a évolué : la canicule a intégré le régime du chômage intempéries et les seuils de vigilance de Météo-France servent désormais de référence, tandis que les employeurs doivent évaluer les risques liés aux ambiances thermiques et en particulier ceux liés aux fortes chaleurs dans le DUERP. Le dossier insiste sur l'anticipation plutôt que sur une gestion ponctuelle des crises : veille météorologique, préparation de la base vie, adaptation des horaires et des tâches, hydratation, pauses à l'ombre, formation des salariés, mise à l'abri des équipes, arrimage des matériels et sécurisation des grues et échafaudages. L'organisation constitue le premier levier de prévention, avant les équipements individuels tels que vêtements anti-UV, casques ventilés ou dispositifs rafraîchissants. Plusieurs témoignages d'entreprises (entreprises de couverture, de maçonnerie, et de plomberie, chauffage et climatisation) montrent comment ces principes sont appliqués concrètement, notamment par le décalage des horaires, le report de certaines opérations ou l'adaptation des équipements. Dans les territoires ultramarins, l'expérience des cyclones a déjà instauré une culture avancée d'anticipation, d'amarrage et de lestage des installations. L'étude Sunshine d'un service de prévention et de santé au travail indique comment deux types d'entreprise (couverture charpente et enrobés VRD (voirie et réseaux divers)) gèrent les risques liés à la chaleur. Enfin, une étude de l'EU-OSHA (Agence européenne pour la sécurité et la santé au travail) portant sur le chantier de 2050 souligne la nécessité de repenser durablement la construction : préfabrication hors site, automatisation, matériaux adaptés au futur climat et intégration de la prévention dès la conception.

EPI, matériaux protecteurs/réchauffants

A. Kumar, S. Alagappan, R. S. Rengasamy and P. Talukdar.

Development of a Numerical model to predict the thermal insulating characteristics of ultra-low density non-woven fabrics used in extreme cold weather clothing.

APPLIED THERMAL ENGINEERING. 2026;307.

<https://doi.org/10.1016/j.applthermaleng.2026.133060>

Ultra-lightweight, high-loft nonwoven fabrics made from hollow polyester fibers are promising thermal insulation materials for extreme cold-weather clothing owing to their low mass, flexibility, and excellent insulation performance. Their highly porous fibrous structure traps large volumes of still air, thereby reducing solid-phase heat conduction. Beyond apparel, such materials also have potential applications in aerospace systems, emergency shelters, and other thermal protection systems requiring lightweight and efficient insulation under severe environmental conditions. In this study, a comprehensive continuum-scale steady-state numerical model was developed to predict the thermal insulation performance of ultra-low-density, high-bulk nonwoven fabrics produced from blends of hollow polyester fibers. The fibrous assembly was represented as a homogeneous porous medium using effective transport properties without resolving individual fibers or pore-scale flow fields. The model incorporates coupled conduction, radiation, and convection within the porous structure. Six nonwoven specimens (S1-S6), each with an areal density of 100 gsm, were fabricated using blends of three hollow polyester fibers with different outer diameters (1.8H, 4H, and 7H). Conduction was modeled using Maxwell-Eucken-based formulations adapted for hollow fibers, while radiative transport was evaluated using Mie-theory-based optical extinction coefficients dependent on fiber diameter, wavelength, and refractive characteristics. Convective transport was estimated from experimentally measured fabric permeability and thickness using an equivalent porous-medium approach. Model predictions were validated against Sweating Guarded Hot Plate (SGHP) measurements conducted in accordance with ISO 11092, showing good agreement for all six investigated fabric configurations. The results from the developed model demonstrate that radiative heat transfer remains important even under room-temperature conditions, in ultra-low-density nonwovens, despite being commonly neglected in textile insulation analysis. For ultra-high porosity fabrics (porosity $\geq 99\%$), heat conduction is governed primarily by stagnant air, whereas radiation contributes approximately 25%-35% of the total heat loss due to reduced optical thickness and increased radiative mean free paths. Simply increasing porosity to suppress conductive heat transfer may therefore not improve insulation, as the accompanying increase in radiative transmission can offset the conductive benefit. Increasing fiber diameter reduced insulation performance by 45%-50%, whereas increasing fiber hollowness improved insulation by 40%-45% through stronger optical attenuation. Natural convection was found to be negligible because the microfibrillar network provides high specific surface area and strong viscous resistance to entrapped air. Lower ambient temperatures also improved insulation performance by 9%-10% owing to reduced radiative conductivity. The proposed model is validated for highly porous hollow polyester nonwoven insulation materials under standardized dry thermal conditions and can be used to analyze the influence of fiber and fabric structural parameters on thermal insulation performance, thereby supporting the design of lightweight insulation layers for extreme cold-weather clothing.

EPI, matériaux protecteurs/refroidissants

C. Feng, R. Cheng, S. Q. Hou, B. Lu, S. N. Ouyang, C. L. Du, P. Ren and S. Gao.

Clothing radiative properties and outdoor thermal comfort in summer: A comparative assessment of Chinese cities using MRT and PET.

CASE STUDIES IN THERMAL ENGINEERING. 2026;86.

<https://doi.org/10.1016/j.csite.2026.108464>

Clothing radiative properties-solar reflectivity (ρ_{sr}) and longwave emissivity (ϵ_{lr})-fundamentally influence thermal comfort in outdoor environments during summer. This study simulated the effect of three clothing fabrics with different radiative properties, namely ordinary yellow fabric (OYF: $\rho_{sr} = 0.67$, $\epsilon_{lr} = 0.89$), ordinary white fabric (OWF: $\rho_{sr} = 0.79$, $\epsilon_{lr} = 0.91$), and radiative cooling fabric (RCF: $\rho_{sr} = 0.98$, $\epsilon_{lr} = 0.96$), on summer outdoor thermal comfort across 34 major Chinese cities during August 2024 using modified calculation methods for mean radiant temperature (MRT) and physiological equivalent temperature (PET). Results demonstrated significant thermal comfort improvements with higher solar reflectivity and longwave emissivity: MRT values decreased from 49.0 degrees C (low reflectivity: OYF) to 42.4 degrees C (moderate reflectivity: OWF) and 31.4 degrees C (RCF: high reflectivity and emissivity), and PET improved from 35.2 degrees C (OYF) to 32.3 degrees C (OWF) and 28.9 degrees C (RCF). The proportion of PET values within the slightly cool to slightly warm range increased from 19.8% (OYF) to 29.1% (OWF) and 40.5% (RCF), and the combined proportion of hot and very hot conditions decreased from 56.6% to 9.6%. Correlation and regression analyses indicated that the difference between the MRT for OYF and RCF was primarily driven by global solar radiation and that for PET reflected the combined effects of solar radiation, ground surface temperature, and relative humidity. These findings provide quantitative guidance for fabric selection under diverse summer climatic conditions.

S. J. Wu, M. Tian, J. N. Wang, Y. Su and J. Li.

Effect of Fabric Stretch on the Thermal Protective Performance of Firefighter Clothing: An Experimental and 3D Numerical Analysis.

FIRE TECHNOLOGY. 2026;62(6).

<https://doi.org/10.1007/s10694-026-02005-y>

During firefighting operations, movements such as bending elbows and knees induce deformation of the outer shell material, affecting the thermal protective performance (TPP) of firefighter clothing. However, the effects of fabric stretching under different thermal environments and the associated microstructural mechanisms remain unclear. To investigate this, experiments were conducted at four stretch levels (0%, 3%, 6%, 12%) under three thermal conditions (8.5 kW/m² radiant heat, 30 kW/m² flame, 84 kW/m² hybrid heat), measuring fabric structural properties and TPP. Results indicated that stretching reduced fabric porosity and slightly increased thickness, with TPP decreasing more noticeably under low-radiation heat. To elucidate the heat transfer mechanisms, a three-dimensional finite element model incorporating yarn geometry and air pores was developed. Simulations revealed that stretch-induced structural changes enhanced the intrinsic thermal insulation performance (TIP) of the fabric. Parametric analyses further showed that increasing surface convection produced only minor changes in thermal resistance, whereas increasing fiber thermal conductivity resulted in a more noticeable reduction. Combined experimental and simulation results demonstrated that changes in TPP

were governed by the competing effects of (i) improved thermal insulation due to increased fabric thickness and (ii) enhanced conductive heat transfer due to increased fiber-sensor contact area. Although stretching increased TIP, the latter effect dominated, resulting in lower TPP values. These findings elucidate the heat transfer mechanisms of stretched fabrics and support TPP evaluation considering fabric deformation. They also provide practical guidance for the design of firefighting suits with adequate ease allowances in body regions undergoing substantial movement, thereby improving firefighter thermal protection and safety.

F. Wang, G. Y. Zhang, X. H. Zhang, L. L. Shang, B. J. Sun, X. F. Liu, W. J. Guo, J. L. Xu, C. Y. Zhao and Y. F. Wang.

Effect of thermoelectric cooling on the thermal comfort of chemical protective clothing.

BUILDING AND ENVIRONMENT. 2026;305.

<https://doi.org/10.1016/j.buildenv.2026.115198>

Chemical protective clothing (CPC), given its high resistance to heat and moisture transfer, can markedly restrict human heat dissipation and sweat evaporation, thereby inducing severe heat stress. To alleviate the thermal burden on CPC wearers under hot working conditions, this study designed an internal air-circulation device based on thermoelectric cooling and experimentally investigated its effectiveness in mitigating the overall heat stress of wearers; human subject experiments were conducted in a constant temperature and humidity chamber (ambient temperatures of 30, 32, and 34 degrees C, with a relative humidity of 50 %). The temperature and humidity of the microclimate inside the CPC and various physiological parameters of the participants were continuously monitored, and overall thermal comfort was comprehensively evaluated by combining these data with subjective questionnaires conducted periodically throughout the experiments. Results showed that the device reduced the microclimate temperature by up to 1.0 degrees C and the microclimate relative humidity by 15.2 %-19.2 %. Additionally, the participants' mean skin temperature, core temperature, heart rate, and total sweat loss were all significantly reduced, with the maximum reductions reaching 0.6 degrees C, 0.36 degrees C, 20 bpm, and 0.25 kg, respectively. Consequently, the device simultaneously improved the thermal sensation, humidity sensation, and thermal comfort scores, with maximum improvements of 1.14, 1.01, and 0.64, respectively. The device produced more pronounced improvements in the core trunk region, with the chest and back thermal comfort improving by 0.69 and 0.77 on average, respectively. This study provides experimental evidence for reducing thermal burden and improving thermal comfort among CPC wearers.

K. Kozhabergenova, B. Nurmukhambetova, G. Kasymova, Z. Rakhmanova and M. S. Kalmakhanova.

Heat transfer modeling and experimental analysis of multilayer textile protective clothing under molten metal exposure for metallurgical applications.

JOURNAL OF THE TEXTILE INSTITUTE. 2026.

<https://doi.org/10.1080/00405000.2026.2726580>

Thermal protection performance of multilayer textile clothing packages for metallurgical workers was investigated through mathematical modelling and experimental analysis. A non-stationary Fourier heat conduction model solved by the finite difference method predicted inner surface temperatures below 41 degrees C under 70 degrees C external exposure for 25 min, satisfying the 50 degrees C safety threshold. Experiments using molten tin and lead dripped onto four textile packages at inclination angles of 45 degrees, 75 degrees, and 180 degrees showed that vertical exposure produced the highest

inner surface temperatures (up to 65 degrees C for tin and 81 degrees C for lead), while reduced angles lowered values to 25-37 degrees C. Among tested configurations, the package incorporating a Thermolin (Panox/Kevlar) outer layer with wool cloth and cotton inner layers delivered the best thermal insulation. Results confirm that material composition and inclination angle critically determine protective performance.

F. Wang, J. L. Xu, Y. Tian, G. Y. Zhang, C. Y. Zhao, X. F. Liu, L. L. Shang and B. J. Sun.

Protective clothing microenvironment and local thermal comfort under thermoelectric cooling and dehumidification.

INTERNATIONAL JOURNAL OF REFRIGERATION. 2026;192.

<https://doi.org/10.1016/j.ijrefrig.2026.107110>

Protective clothing restricts convective and evaporative heat dissipation because of its enclosed structure, causing heat and moisture accumulation and reducing wearing comfort. To improve thermal comfort in hot-humid environments, this study developed an air-cooled thermoelectric cooling and dehumidification device, and its performance was evaluated through exercise and seated recovery experiments under different temperature (28 and 30 degrees C) and relative humidity (50% and 70% RH) conditions. Changes in the clothing microenvironment, physiological responses, and subjective perceptions were compared between the control (CON) and cooling (COOL) conditions, and responses were also examined separately in male and female participants. Compared with CON, COOL reduced the microenvironment temperature by 0.51 degrees C during exercise and 0.80 degrees C during recovery, while microenvironment relative humidity decreased by 10.44% and 11.49%, respectively. Local skin temperatures at the air-supplied regions decreased, with the greatest reduction at the head (1.13 degrees C). Subjective responses generally improved after device activation, with maximum reductions of 1.04 thermal sensation vote (TSV) units and 1.13 humidity sensation vote (HSV) units, and a maximum improvement of 0.93 thermal comfort vote (TCV) units. The back showed the most pronounced subjective improvement; under T28R50 (28 degrees C and 50% RH), TSV and HSV decreased by 0.99 and 0.85, respectively. Both male and female participants benefited from device use. These findings provide quantitative evidence for evaluating and optimizing cooling and dehumidification systems for protective clothing.

Z. T. He, G. Y. Liu and Y. J. Liu.

Recent advances in aramid-based multilayer composites for thermal-moisture comfort regulation in firefighter protective clothing.

COMPOSITE STRUCTURES. 2026;398.

<https://doi.org/10.1016/j.compstruct.2026.120940>

Firefighters operating in high-temperature and high-intensity environments are vulnerable to heat stress caused by metabolic heat, sweat accumulation, and deterioration of the clothing microclimate. Aramid fibres are widely used in firefighting suits because of their excellent flame resistance, thermal stability, and mechanical strength; however, their hydrophobicity and low moisture regain restrict liquid sweat transport and water vapour release. This review examines the structural evolution of aramid-based firefighting materials and critically summarises single-component, binary, and multi-component composite systems. It analyses how moisture-wicking fibres, breathable membranes, phase-change materials, air-spacer structures, and aerogels regulate liquid water transport, vapour diffusion, latent heat buffering, and sensible heat insulation, while comparing key indicators including

TPP, Rct, and Ret. Existing studies show that these strategies regulate heat and moisture transfer through different mechanisms, but their overall performance depends on interfacial compatibility, pore continuity, structural configuration, and service ageing. Future research should emphasise dynamic heat-moisture testing, full-garment and human-subject evaluation, and performance retention after thermal, hydrothermal, mechanical, and laundering ageing. This paper identifies material- and interface-level design considerations for improving heat and moisture management while preserving thermal protection.

T. Das, A. Das and R. Alagirusamy.

Silica aerogel-embedded thermal liner: fabrication, properties, and potential for extreme heat protective clothing.

INDIAN JOURNAL OF FIBRE & TEXTILE RESEARCH. 2026;51(3):411–22.

<https://doi.org/10.56042/ijftr.v51i3.18683>

Silica aerogel was developed in situ aramid needle punched nonwoven thermal liner via sol-gel process followed by ambient pressure drying technique using tetraethoxysilane (TEOS) as a precursor. The thermal liner was augmented with silica aerogel at three different add-on percentages relative to the weight of the nonwoven fabric. This incorporation aimed to investigate the influence of the aerogel add-on percentage on the thermal protective performance of the tested thermal liner. The wet gel surface was modified through a silylation process, varying concentrations of silylating agent, trimethylchlorosilane (TMCS), in hexane. The characterization of the aerogel-embedded thermal liner samples encompassed evaluations of thickness, air permeability, thermal conductivity, thermal stability (measured by TGA), and examination through Fourier-transform infrared spectroscopy (FTIR) and Scanning Electron Microscopy. The heat transfer index (HTI24) was measured for every sample under radiant and flame heat exposure. An investigation using Analysis of Variance was carried out to evaluate how the percentage of aerogel add-on and concentrations of silylating agent affect the HTI24 heat transfer index (HTI24) of the aerogel-embedded thermal line. Aerogel embedded thermal liner, irrespective of aerogel add-on percentages and TMCS concentrations, provides higher protection under both radiant and flame exposure than non-aerogel nonwoven thermal liner. Both aerogel add-on percentage and TMCS concentration positively impact the HTI24 value for both radiant and flame heat exposure. Higher protection against radiant and flame heat exposure makes aerogel-embedded thermal liners more suitable for extreme heat-protective clothing.

Maladies liées à la chaleur

D. Y. Cho, E. H. Choi and S. Lee.

Heat Exposure and Fall Accidents in Construction: Informing Occupational Safety and Health Policy in Korea.

SAFETY AND HEALTH AT WORK. 2026;17(3):365–74.

<https://doi.org/10.1016/j.shaw.2026.04.004>

Background: As the frequency and intensity of heat waves increase due to climate change, concerns regarding construction worker safety are growing. While research on heat-related illnesses is extensive, studies examining the impact of heat exposure on construction fall accidents & horbar;the leading cause of occupational fatalities & horbar;remain limited. This study investigated the relationship between daily maximum temperature and fall accidents. Methods: We analyzed 42,220 fall accidents reported to the Republic of Korea Occupational Safety and Health Agency between 2015 and 2019. Daily maximum temperature and relative humidity data were linked to accident dates. The association between temperature and fall accidents was examined using negative binomial regression with a segmented term at the identified threshold. Exploratory quadratic and segmented regression models were used to identify the temperature threshold, and stratified analyses were conducted by age group and workplace size. Results: A nonlinear relationship was observed, with fall accidents peaking at approximately 29 degrees C, followed by a plateau. The segmented regression model incorporating a knot at 29 degrees C demonstrated the highest explanatory power ($R^2 = 0.894$). Negative binomial regression confirmed significant over-dispersion ($\alpha = 0.123$) and indicated that each 1 degrees C increase in temperature above 29 degrees C was associated with a 16.7% increase in fall accident counts (incidence rate ratio = 1.167, 95% confidence interval: 1.145 -1.188). This relationship was most pronounced among workers aged 50-59 years ($R^2 = 0.573$) and ≥ 60 years ($R^2 = 0.593$), as well as in workplaces with fewer than 50 employees ($R^2 = 0.589$ -0.595). Conclusion: Construction fall accidents were concentrated around a daily maximum temperature of 29 degrees C, which is lower than the current heatwave advisory threshold (apparent temperature: 33 degrees C). The stronger associations observed among older workers and in small-scale workplaces indicate that prioritized protection for these groups is necessary. (c) 2026 Occupational Safety and Health Research Institute. Published by Elsevier B.V. on behalf of Institute, Occupational Safety and Health Research Institute, Korea Occupational Safety and Health Agency.

E. J. Z. Robinson, C. Howarth, Y. X. Zhou and S. Dasgupta.

Heat, health, and adaptation in the UK labour force.

CLIMATIC CHANGE. 2026;179(9).

<https://doi.org/10.1007/s10584-026-04278-2>

Climate change is already having a measurable impact on labour forces across the globe, with far reaching implications for economic growth, worker health and productivity, firm profitability, poverty and inequality, and food security, to name but a few. This study quantifies UK workers' perceptions of the impacts of heat on their health and the extent to which and how adaptation measures reduce the negative impacts of extreme heat. We collected data during the UK 2024 and 2025 summers, just after periods of anomalous heat, surveying over 2,000 people each year in the UK labour force when their recollection of the heat episode was fresh in their memories. Using microeconomic analysis and controlling for a rich set of demographic, occupational, and adaptation covariates, our results clearly

show that workers perceive their health to be harmed by anomalously high temperatures, and both workers and employers rely on a wide range of adaptation measures to protect their health. However, these measures are only partially effective. For example, a 1 C positive temperature anomaly from the long-term average on average increased the probability of a worker reducing their hours by 9.9% and their effort by 9.5%; but for those workers who received advanced alerts of heat episodes, those probabilities are 6.2% and 6.7%, respectively. Advanced heat alerts also reduced the probability of workers reporting adverse health effects by approximately 5%-points.

M. C. Morrissey, J. K. W. Lee, I. Rollo and Y. Pitsiladis.

Leveraging wearables to safeguard workers in a hotter climate.

FRONTIERS IN PUBLIC HEALTH. 2026;14.

<https://doi.org/10.3389/fpubh.2026.1867796>

Rises in global temperatures have threatened the health, safety, and productivity of workers who perform physically demanding work. Traditionally, occupational heat illness prevention plan have relied on environmental monitoring and administrative controls, however, these approaches do not account for the considerable intra- and inter-variability in physiological responses to extreme heat. In contrast, elite sport has served as a valuable test bed for investigating thermoregulation, exertional heat illness, and the feasibility of real-time physiological monitoring. Experiences from recent Olympic Games have demonstrated that integrated environmental and physiological monitoring systems can operate at scale under extreme heat conditions, while also highlighting important technological, operational, and governance limitations. Translating these advances to occupational settings presents both opportunities and challenges because workers differ substantially from athletes in age, health status, heat acclimatisation, work demands, exposure duration, and access to medical oversight. Furthermore, implementation is complicated by concerns regarding data governance, privacy, informed consent, device validity, interpretation of physiological information, and the use of physiological thresholds to guide workplace decisions. This commentary examines lessons learned from elite sport and discusses their application to occupational heatsafety programs. We propose a tiered adoption framework that aligns physiological monitoring complexity with organizational capacity, technical expertise, and governance requirements, ranging from foundational heat-safety practices to advanced multimodal physiological monitoring under professional oversight. Physiological monitoring should complement, but not replace, established heat-stress prevention strategies and be implemented within clearly defined operational and ethical boundaries. Future research should focus on validating wearable technologies in occupational environments, developing individualized decision frameworks, and establishing governance structures that support responsible implementation.

T. Stothers, T. D. Gibbons, K. N. Thomas, E. Jones, H. A. Campbell and J. D. Cotter.

No evidence of higher peak heat tolerance in the afternoon or with opportunity for thermal behaviour during low-intensity work in uncompensable heat.

EXPERIMENTAL PHYSIOLOGY. 2026.

<https://doi.org/10.1113/EP092803>

Heat tolerance is known to be limited by high brain temperature, but most findings pertain to strenuous exercise following artificially altered baseline temperature or with limited opportunity for behaviour. Therefore, we investigated the hypotheses that thermal perceptions, hyperventilation and cerebrovascular responses would be exacerbated in: (1) the afternoon relative to morning; and (2) the

absence of opportunity for behavioural thermoregulation. Thirteen habitually active participants (seven females) cycled at 25% peak power wearing a water-perfused suit (similar to 48 degrees C) until volitional tolerance on three occasions, once in the morning (AM) and twice in the afternoon (PM), with or without access to face fanning with mist (similar to 1.7 m/s). Heating took similar to 2 h. Core temperature (T-c) was 0.35 degrees C lower in AM at baseline (95% confidence interval: -0.55 degrees C, -0.16 degrees C; $P < 0.001$, Hedges' $g = 1.673$) but not at tolerance (39.10 degrees C +/- 0.71 degrees C vs. 39.11 degrees C +/- 0.50 degrees C; $P = 0.947$, $g = 0.024$), hence the rise was greater (95% confidence interval: 0.00 degrees C, 0.80 degrees C; $P = 0.047$, $g = 0.651$). The fan did not confer higher T-c tolerance (95% confidence interval: -0.44 degrees C, 0.24 degrees C; $P = 0.764$, $g = 0.050$). The modelled T-c thresholds for heat discomfort and hyperventilation were similar to 0.23 degrees C lower in AM, but sensitivities did not differ reliably or with fan availability ($P \geq 0.098$). Internal carotid artery flow was similar across time of day ($P = 0.904$) and showed little effect of heating. Changes in estimated intracranial pressure did not differ reliably between conditions. In conclusion, thermal reserve was smaller in PM by virtue of higher baseline, and psychophysical, ventilatory and cerebrovascular responses were not reliably different. For most individuals, an opportunity for behaviour did not improve discomfort, hyperventilation or tolerance.

Outils et capteurs de mesure

Y. H. Wei, T. Wang, J. B. Yan, Y. H. Bao, Z. Y. Ma, L. Y. Ma, X. M. Guo and J. Z. Zhao.

Personalized Skin Temperature Benchmark via Wireless Wearable Sensor for Assessing Peripheral Thermoregulation.

ADVANCED MATERIALS TECHNOLOGIES. 2026.

<https://doi.org/10.1002/admt.71303>

Hypothermia constitutes a substantial risk in outdoor and occupational environments. However, conventional assessment methods rely on population-based statistical norms, which often fail to account for interindividual variability. This study proposes the concept of a personalized skin temperature benchmark, defined as an individual-specific database of skin temperature acquired from multiple body sites and associated with health status as well as environmental conditions. To realize this concept, a custom-designed wireless wearable flexible temperature sensor was developed, enabling comfortable and continuous monitoring at the wrist, forehead, and chest. Data were collected from two healthy male subjects by systematically varying physical activity level and clothing insulation index, while simultaneously measuring apparent temperature (which depends on ambient temperature, humidity, and wind speed). The results revealed significant differences in skin temperature benchmarks between the two individuals. A key parameter (skin heat loss) is introduced to quantify peripheral thermoregulation, with its values serving as a personalized indicator, and peripheral thermoregulation classification requires further validation. A critical step toward non-invasive early warning of hypothermia lies in establishing reliable skin-core temperature calibration, yet this remains an open challenge.

X. B. Xu, H. Du, H. X. Gao, I. Q. Shah and A. Ghahramani.

Physiological dynamics of fan-assisted cooling during transient heat-stress recovery: Evidence from skin temperature, core body temperature, and heat storage.

ENERGY AND BUILDINGS. 2026;371.

<https://doi.org/10.1016/j.enbuild.2026.118228>

Occupants often enter indoor spaces with residual heat load after commuting or brief outdoor activity, creating a transient recovery demand that differs from steady-state thermal comfort. This study examined the thermophysiological dynamics of fan-assisted cooling during transient heat-stress recovery. Twenty young subjects completed 10 min of step exercise at 29 degrees C to simulate commuting-induced heat exposure, followed by 50 min of seated recovery under five conditions: 29 degrees C without fan, 24.5 degrees C without fan, and 27 degrees C with a directional, ceiling, or desk fan. Mean skin temperature and core body temperature were continuously monitored, and body heat storage was calculated to characterize recovery dynamics. Under the 29 degrees C no-fan condition, mean skin temperature, core body temperature, and body heat storage remained 0.17 degrees C, 0.12 degrees C, and 0.45 kJ/kg above their initial values at the end of recovery, indicating insufficient passive heat dissipation. In contrast, the 24.5 degrees C no-fan and fan-assisted conditions promoted heat dissipation, with the directional fan achieving the largest reduction in body heat storage (-0.97 kJ/kg), followed by the 24.5 degrees C no-fan condition (-0.84 kJ/kg), ceiling fan (-0.63 kJ/kg), and desk fan (-0.30 kJ/kg). Core body temperature showed small between-condition differences, suggesting that the cooling benefits were more clearly reflected in faster skin cooling and reduced residual body heat storage. Cooling produced a pronounced temporal separation between skin and core responses: under

the four cooling conditions, mean skin temperature peaked 6.30-7.79 min earlier than core body temperature, compared with 2.05 min under the 29 degrees C no-fan condition. These findings indicate that fan-assisted cooling during transient heat-stress recovery cannot be fully evaluated using nominal air speed or SET-equivalent conditions alone; airflow delivery pattern, body-surface coverage, and heat-storage dynamics should also be considered when designing low-energy cooling strategies for occupants with residual thermal burden.

A. T. Ky, E. C. Lee, J. J. S. Rolloque, H. Y. Luk, J. Blinch and Y. Sekiguchi.

A randomized trial on thirst satiation during exercise in the heat: Effects on thermal strain, perceived concentration, and executive function.

NUTRITION AND HEALTH. 2026.

<https://doi.org/10.1177/02601060261486093>

Oral rehydration reduces thirst sensation, which potentially influences cognitive performance. Aim This study examines whether thirst influences cognitive performance between intravenous and oral rehydration. Methods Twelve men cycled for 90 min at 55% VO₂max in 35 degrees C and 30% r.h, followed by a 12 km cycling time trial. Two experimental trials were conducted: participants consumed 25 mL of water every 5 min (low thirst: LT) or were infused with 25 mL of isotonic saline every 5 min via intravenous tube (high thirst: HT). Thirst was measured every 5 min with visual analog scales. The Environmental Symptoms Questionnaire (ESQ), Profile of Mood States (POMS), a modified flanker task, body mass, and urine specific gravity (USG) were recorded before and the end of each trial. Summary There were no significant differences in body mass loss and USG ($p \geq 0.14$), demonstrating similar hydration states. Thirst was higher in HT compared to LT after 15 min and throughout the 90 min and 12 km time trial ($p = 0.006$). Participants reported feeling performance decrements (mean $\pm$ SD; HT: 3.7 ± 0.2 , LT: 3.1 ± 0.3 , $p = 0.012$), difficulty concentrating (HT: 1.8 ± 0.2 , LT: 1.4 ± 0.1 , $p = 0.032$), and an overall heightened subjective thermal strain (total ESQ, HT: 27.3 ± 1.1 , LT: 24.8 ± 1.0 , $p < 0.045$) during HT trials compared to LT for the ESQ. No significant differences were observed in the flanker task and POMS between trials ($p > 0.05$). Thirst may not affect executive function performance, though it may increase subjective thermal strain during exercise in the heat. This study suggests that strategies for mitigating thirst are as important as maintaining hydration status to maintain concentration and subjective thermal strain.

Travail par fortes chaleurs et périodes de canicule

H. Mun, J. Jeong, L. Kumi, J. Jeong, M. Kim and M. W. Song.

Data-driven framework for calibrated thermal comfort assessment and thermal sensation prediction of construction workers during summer.

ENGINEERING CONSTRUCTION AND ARCHITECTURAL MANAGEMENT. 2026.

<https://doi.org/10.1108/ECAM-01-2026-0060>

Purpose Construction workers are highly vulnerable to summer heat stress, yet thermal comfort assessment is often constrained by limited site-specific meteorological data. This study aims to develop a calibration framework that adjusts publicly available meteorological data to approximate on-site conditions and to evaluate thermal comfort indices for predicting workers' thermal sensation. *Design/methodology/approach* Field data were collected from 341 construction workers at a residential site in South Korea during summer. Personal characteristics, subjective thermal responses, and environmental parameters were obtained through surveys and measurements. Public meteorological data were calibrated using linear regression, and the Physiological Equivalent Temperature (PET) and Universal Thermal Climate Index (UTCI) were calculated using public, calibrated, and field datasets. Machine learning regression models were applied to predict Mean Thermal Sensation Vote. *Findings* Calibration significantly improved agreement with field measurements, reducing RMSE from 1.61 degrees C to 0.84 degrees C for air temperature, from 8.05% to 3.18% for relative humidity, and from 1.28 m/s to 0.50 m/s for wind speed, with the largest improvement observed for humidity. Decision Tree Regression showed the highest explanatory power ($R^2 = 0.82$ for PET; $R^2 = 0.86$ for UTCI). UTCI outperformed PET, reflecting greater sensitivity to humidity and wind effects. *Originality/value* The study presents a low-cost, scalable framework enabling reliable, site-specific thermal comfort assessment using calibrated public data, supporting improved heat risk management in construction under climate change.

J. Kim.

Heatwave and Limited Compensating Wage Adjustment: Evidence from South Korea's Construction Sector.

ENVIRONMENTAL & RESOURCE ECONOMICS. 2026;89(10).

<https://doi.org/10.1007/s10640-026-01119-9>

Extreme heat has emerged as an important occupational risk under climate change, particularly for workers engaged in physically demanding outdoor labor. This paper examines whether cumulative heatwave exposure is associated with working-environment satisfaction and wage responses within a compensating wage differentials framework in South Korea's construction sector. We combine panel data from the Korean Labor and Income Panel Study (2001-2022) with regional weather observations across 16 areas. Cumulative heatwave exposure is measured as the number of days with daily maximum temperature at or above 35 degrees C during the 30 days preceding each interview. We estimate mixed-effects ordered probit models for working-environment satisfaction and individual fixed-effects models for real hourly wages. The results indicate an asymmetry between working-environment satisfaction and wage adjustment. Cumulative heatwave exposure is associated with lower working-environment satisfaction among day laborers, while corresponding wage adjustment remains statistically insignificant. Overall, the findings are broadly consistent with limited compensating wage adjustment under cumulative heatwave exposure in relatively weakly protected

segments of the construction labor market. The results further suggest that market-based wage adjustment alone may be insufficient to fully offset heat-related deterioration in perceived working conditions among vulnerable construction workers.

G. P. Kenny, G. Bourgois, S. M. Taggart, K. E. McCormick, J. J. McCormick, L. G. Ioannou and F. K. O'Connor.

Initial Stay Time and Work-Rest Scheduling During Consecutive Heavy-Intensity Workdays in Hot Environments in Young and Older Males.

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE. 2026.

<https://doi.org/10.1002/ajim.70138>

This study examined initial stay times (IST), defined as the duration of uninterrupted work before core temperature approaches recommended safety limits (38.0 degrees C, similar to 1.0 degrees C above baseline), and the efficacy of work-rest cycles during repeated heavy work across consecutive workdays in young and older males. Methods Twenty-one active, non-heat-acclimated males (10 young: 22 [20-25] y; 11 older: 67 [63-68] y) completed a 1.5-day work protocol wearing coveralls (similar to 1 Clo). Participants performed treadmill walking at similar to 260 W & centerdot;m(-2) in 26 degrees C WBGT during morning (AM1) and afternoon (PM1) bouts on Day 1, separated by a 1-h lunch break, followed by a morning bout (AM2) on Day 2. Results After reaching IST, ACGIH-recommended work-rest cycles (30-min work/30-min rest) were implemented for up to 240 min while core temperature was monitored. IST was shorter during PM1 than AM1, reflecting elevated baseline core temperatures entering the afternoon work period (median [Q1, Q3]: AM1: 61 [44, 75] min; PM1: 29 [24, 34] min). Following overnight recovery, IST returned to morning baseline values on Day 2 (AM2: 62 [47, 111] min). Age did not significantly influence IST across work periods. After reaching IST, prescribed work-rest cycles maintained core temperature near safety limits (≤ 38.1 degrees C) across work periods, although older males exhibited slightly higher peak values. Conclusion We show that the duration of the initial work bout before reaching recommended safety limits is reduced during afternoon work but returns to baseline after overnight recovery. Once implemented, prescribed work-rest cycles effectively regulate thermal strain across work periods in young and older males.

M. H. Li, S. S. Du, R. Xu, R. Xu, Q. Zu, Z. H. Lv, W. M. Ye, W. Zheng and J. J. Xiang.

Occupational heat exposure, nighttime warming, and eGFR loss in petrochemical workers: a retrospective cohort study with metabolomic evidence.

ENVIRONMENTAL RESEARCH. 2026;308.

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Under the context of climate warming, whether rising nighttime temperatures modify heat-related kidney risks among industrial workers remains unclear. This retrospective cohort study included 2148 petrochemical workers in southeastern China followed from 2013 to 2022. Occupational heat exposure was assessed using the wet-bulb globe temperature (WBGT) index based on workplace monitoring records, and eGFR loss was defined as a $\geq 30\%$ reduction in estimated glomerular filtration rate from baseline. Nighttime temperature was derived from ERA5-Land hourly temperature data (20:00-07:00). Cox proportional hazards models were used to estimate associations, with interaction analyses evaluating effect modification by nighttime temperature indicators. Serum metabolomics were conducted to explore potential mechanisms. During 11,412 person-years of follow-up, 382 incident cases of eGFR loss were identified. Occupational heat exposure was associated with an increased risk

of eGFR loss (HR = 1.44, 95% CI: 1.16-1.79; P = 0.001). Over the past three decades (1993-2022), nighttime temperature in the study region increased at a rate of 0.405 degrees C per decade. The association between occupational heat exposure and eGFR loss was stronger at higher nighttime warming rates (P for interaction < 0.001) and higher nighttime temperatures (P for interaction = 0.012). Metabolomic analyses revealed alterations in amino acid metabolism, energy metabolism, and tryptophan-related pathways. These findings suggest that occupational heat exposure was associated with an increased risk of eGFR loss, and this association may be amplified under warmer nighttime conditions. Impaired nocturnal thermal recovery and related metabolic disturbances may contribute to heat-related renal injury.

R. Fortunato, M. S. Ragettli, T. Gerosa, J. Dratva and I. Baumann.

Occupational heat strain among home health care workers: a cross-sectional study.

BMC PUBLIC HEALTH. 2026;26(1).

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Extreme heat events affect workers' health. Home health care workers face physically strenuous tasks, mobility demands, and increased workloads during heat events. Yet little is known about the extent of heat strain and the specific symptoms they experience. This study aims to examine how home health care workers in Switzerland perceive heat exposure at work and what heat-related symptoms they experience. We examine which factors are associated with perceived heat strain. Methods We conducted an anonymous online cross-sectional survey of home health care workers (N = 359) in north-eastern and Southern Switzerland, two climatically distinct regions. Using items from previous studies on occupational heat strain, we assessed perceived heat strain, heat-related symptoms and a set of independent variables. Differences were tested using Mann-Whitney U and chi-square tests, followed by ordinal logistic regression to identify associations and regional moderation effects. Results Substantial perceived heat strain was reported by 86% of participants. Higher levels of perceived heat strain were significantly associated with increased workload (OR 14.06, 95% CI 7.12-28.85), heat-related symptoms (OR 5.27, 2.20-12.88), constrained hydration (OR 2.59, 1.35-5.02), working in southern Switzerland (OR 3.98, 2.11-7.61), and seeking cool environments to rest (OR 3.78, 1.55-9.60). Conclusions Home health care workers reported substantial perceived heat strain at work, particularly when workload increased or hydration was constrained. Regional differences were evident, with stronger heat strain in southern Switzerland. Findings highlight the need to develop heat-protection measures tailored to workplace characteristics-such as workload, constrained hydration, and geographical region-to strengthen climate resilience in this essential and understudied workforce.

Actualités septembre 2026

• Travail par fortes chaleurs et périodes de canicule

Des climats et des heures adaptées. La Nouvelle République du Centre-Ouest (presse, p. 2), 5 septembre 2026

« Pantalon et chemise, ça n'est pas possible » : après cinq canicules, ces conducteurs de bus souffrent toujours. Leparisien.fr, 6 septembre 2026

« J'ai relevé 67 degrés sur le bitume » : quand les canicules à répétition forcent les entreprises à s'adapter pour protéger leurs salariés. Challenges.fr, 7 septembre 2026

Cols secs, cols humides : quand la chaleur redessine le travail (et nos inégalités). Leaders.com.tn, 9 septembre 2026

« Une réponse au changement climatique » : face à des chaleurs torrides, le Portugal expérimente les vendanges de nuit. Avis-vin.lefigaro.fr, 10 septembre 2026

CHALEUR AU TRAVAIL Jean-Pierre Farandou à la recherche de la recette madrilène. Liberation.fr, 11 septembre 2026

Ils racontent leur été de travail dans la fournaise. Var Matin (presse, p. TOUL3), 18 septembre 2026

Face à la canicule meurtrière, les hôpitaux ont géré avec les moyens du bord. Lesoir.be, 22 septembre 2026

Fortes chaleurs au travail la MNT veut inscrire la protection des agents territoriaux dans la durée. Riskassur-hebdo.com, 22 septembre 2026

L'air intérieur industriel est 3 à 10 fois plus pollué que l'extérieur. Santematin.fr, 22 septembre 2026

Texas workers face life-or-death heat risks as workplace protections lag. Houstonchronicle.com, 17 septembre 2026

'Your body fights to stay cool': workers toil in record heat as federal rule frozen. Theguardian.com, 25 septembre 2026

• Maladies liées à la chaleur

Si le retour au travail vous pèse après un été de mégafeux, vous êtes peut-être atteint de « worry burn-out ». Lemonde.fr, 3 septembre 2026

Canicules : 84,4 % des salariés épuisés par les vagues de chaleur, selon la CGT. Humanite.fr, 4 septembre 2026

Changement climatique et santé au travail : nouveau risque ? Lassuranceenmouvement.com, 7 septembre 2026

L'impossible calcul du nombre de morts. Liberation.fr, 11 septembre 2026

9 salariés sur 10 affectés : voici comment la canicule de cet été a fait grimper l'anxiété ! Passeportsante.net, 11 septembre 2026

Onze vies emportées par la chaleur. Lemonde.fr, 18 septembre 2026

La France est le pays d'Europe où le plus de personnes décèdent au travail et c'est de pire en pire pour les Françaises. Science-et-vie.com, 23 septembre 2026

Canicule : les effets à retardement se font toujours sentir sur les travailleurs. Humanite.fr, 26 septembre 2026

- **Outils et capteurs de mesure**

IFA 2026 : le bracelet Speediance veut mesurer la température corporelle interne, pas seulement celle de la peau. Watchgeneration.fr, 6 septembre 2026

- **EPI, matériaux protecteurs/refroidissants**

Hydration Backpacks Help Workers to Beat the Heat. Tdworld.com, 2 septembre 2026