Bulletin n°22

Veille thermique
Période : septembre 2024

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.

Sommaire :

EPI, matériaux protecteurs/refroidissants

Ambiance chaude

Z. H. Gu, Y. Su, Y. W. Fan, M. Tian and J. Li.

Analyzing thermal-moisture comfort and thermal protective performance of phase change materials dripped protective clothing.

FIRE AND MATERIALS. 2024.

https://doi.org/10.1002/fam.3239

The objective of the study was to alleviate the thermal-moisture comfort (TMC) of phase change material (PCM) thermal protective clothing, while simultaneously enhancing thermal protective performance (TPP) by a drip molding process. Nine types of PCM dripped fabrics were prepared by the drip molding process and served as comfort layers of thermal protective clothing. The TMC and TPP of the fabric systems were measured. A new method was proposed to balance the TMC and TPP of thermal protective clothing. The results demonstrated that the drip molding process marginally weakened the TMC while substantially enhancing the TPP of fabric systems. But the TMCs of the PCM dripped fabrics were far larger than the PCM coated fabric. Specifically, an increase in droplet diameter led to a decline in TMC and an improvement in TPP, whereas an increase in droplet interval resulted in an enhancement in TMC and a decrease in TPP. The findings obtained in this study can be used to engineer fabric systems that provide better protection for heat stress and skin burns.

H. S. Lopes, P. C. Remoaldo, V. Ribeiro, J. Martin-Vide and I. Ribeiro.

Clothing and Outdoor Thermal Comfort (OTC) in tourist environments: a case study from Porto (Portugal).

INTERNATIONAL JOURNAL OF BIOMETEOROLOGY. 2024.

https://doi.org/10.1007/s00484-024-02753-y

This study focuses on assessing tourists' perception of bioclimatic comfort in the urban context of Porto, Portugal, specifically in the areas of Avenida dos Aliados and Praca da Liberdade. The study examines the relationship between meteorological conditions, tourists' clothing choices, and their physical activity levels. The study integrates microclimatic measurements and questionnaire surveys carried out during the summers of 2019 and 2020, and the winter of 2019-2020. A comprehensive questionnaire following international standards was administered to a representative sample of 563 tourists. The results show significant variations in mean air temperature (AT), wind speed (W chi), relative humidity (RH), global radiation (G(RAD)), and total mean radiant temperature (T-MRT) over the study periods. The assessment of Outdoor Thermal Comfort (OTC) is based on ASHRAE 55 standards, using the Thermal Sensation Vote (TSV) scale and the tourists' opinions on their thermal preferences. Clothing choices are found to be influenced by AT, with tourists choosing lighter clothing in warmer conditions. Gender and age differences in clothing insulation (Icl) are identified, suggesting potential differences in OTC perception. AT varied significantly, with an inflection point in clothing choices at 21.7 degrees C and a correlation between AT and reduction in clothing layers ($r(2) = 0.846$; $p < 0.05$). The study also observes seasonal variations in physical activity levels of tourists, with higher activity levels in summer due to milder weather (110.0 W.m(-2)). More thermally comfortable environments tend to promote a sense of well-being among visitors, which directly affects their satisfaction during their stay in the city.

When tourists feel comfortable with the thermal conditions of the urban environment, they are more likely to explore and enjoy local attractions for longer periods of time, thereby enhancing their cultural and leisure experiences. Women tend to wear fewer layers of clothing than men in summer, reflecting potential differences in OTC perception. Results align with previous studies, indicating the impact of clothing insulation of individual subject (Icl) on OTC varies across locations and cultures.

A. Vartanian.

Passively cooling power equipment.

NATURE REVIEWS MATERIALS. 2024.

https://doi.org/10.1038/s41578-024-00738-2

An article in Advanced Materials designs a sorbent-based cooling system that can dissipate the heat produced by heavy-load power equipment.

M. O. Aijaz, U. A. Samad, I. A. Alnaser, M. I. H. Siddiqui, A. K. Assaifan and M. R. Karim.

PBAT/PLA-Based Electrospun Nanofibrous Protective Clothes with Superhydrophobicity, Permeability, and Thermal Insulation Characteristics for Individuals with Disabilities.

POLYMERS. 2024;16(17).

https://doi.org/10.3390/polym16172469

This study presents the development of multifunctional protective clothing for disabled individuals using PBAT/PLA biopolymeric-based electrospun nanofibrous membranes. The fabric consists of a superhydrophobic electrospun nanofibrous cloth reinforced with silica nanoparticles. The resulting nanofiber membranes were characterized using FE-SEM, a CA goniometer, breathability and hydrostatic pressure resistance tests, UV-vis spectroscopy, thermal infrared photography, tensile tests, and nanoindentation. The results demonstrated the integration of superhydrophobicity, breathability, and mechanical improvements in the protective clothing. The nanofibrous porous structure of the fabric allowed breathability, while the silica nanoparticles acted as an effective infrared reflector to keep the wearer cool on hot days. The fabric's multifunctional properties make it suitable for various products, such as outdoor clothing and accessories for individuals with disabilities. This study highlights the importance of selecting appropriate textiles for protective clothing and the challenges faced by disabled individuals in terms of mobility, eating, and dressing. The innovative and purposeful design of this multifunctional protective clothing aimed to enrich the lives of individuals with disabilities.

S. Y. Zhang, K. Ma, L. J. Wang, Z. M. Zhang, X. Y. Ye, J. Z. Zhang and H. H. Li.

Prediction of thermal protection performance and empirical study of flame-retardant cotton based on a combined model.

FRONTIERS IN MATERIALS. 2024;11.

https://doi.org/10.3389/fmats.2024.1454935

Thermal protection performance (TPP) is an important index to evaluate the performance of firefighting clothing. The purpose of this work is to build a model to predict the TPP values of fabrics with fewer variables. Two properties of flame-retardant cotton were tested with TPP values under different air

gaps, and the correlations between these properties were also analyzed. A combined model was established by integrating multivariate nonlinear regression model and gradient boosting regression tree model. Then the combined model was compared with these two single models. The results showed that the correlation coefficients between gram weight and thickness of fabric and TPP value were 0.833 and 0.837, respectively, indicating a strong correlation. The correlation coefficient between air gap and TPP value was 0.304, indicating a weak correlation. In predicting the thermal protective performance of flame-retardant cotton, this study employed a multivariate nonlinear regression model, a Gradient Boosting Regression Tree (GBRT) model, and a combined model. After comparing various evaluation metrics, it was finally decided to adopt the combined model for predicting the thermal protective performance values of flame-retardant cotton. This method improved the prediction accuracy of thermal protective performance, facilitating the promotion and application of the combined model. Furthermore, when exploring the thermal protective performance of flame-retardant cotton, the use of fewer variables to establish the prediction model can not only significantly simplify the complex structure of the model but also greatly enhance the analysis efficiency, ensuring the efficiency and precision of the research process.

F. Mansouri, M. T. Nia, R. Villar, S. M. Cornish and G. G. Giesbrecht.

Upper- vs. Whole-Body Cooling During Exercise with Thermal Protective Clothing in the Heat.

AEROSPACE MEDICINE AND HUMAN PERFORMANCE. 2024;95(9):659-66.

https://doi.org/10.3357/AMHP.6434.2024

INTRODUCTION: Firefighters operating in hot environments face challenges from protective garments that restrict heat dissipation, resulting in increased core temperature, thermal discomfort, and performance decline. Cooling vests represent a viable solution. The study aim was to compare effectiveness of the same amount of cooling power to the upper body (UB) or whole body (WB) in alleviating thermoregulatory and physiological stress, enhancing cognitive function, and reducing ratings of thermal discomfort and exertion, during 60 min of exercise in a hot environment (40 degrees C, 40% relative humidity) while wearing firefighter turnout gear. METHODS: Eight healthy individuals (27.5 +/- 3 y) participated in three conditions with either no cooling (Control) or active cooling with a liquid perfused shirt (UB cooling), or with a liquid perfused shirt and pants (WB cooling). In each trial, subjects performed three sets of 15 min of stepping (20 steps & sdot; min-1) and 5 min of rest. RESULTS: Both cooling strategies were beneficial compared to having no cooling at all. Subjects could only complete two exercise bouts during Control, but they completed all three bouts with active cooling. WB cooling provided an advantage over UB cooling for core and skin temperature, and thermal comfort and sensation. The advantage in minimizing the increase in core temperature was only evident during the third exercise bout. DISCUSSION: Active cooling is advantageous under these conditions. WB cooling provided some benefits vs UB cooling during heavy intensity exercise; however, it is uncertain whether these benefits would be observed during light-to-moderate exercise, which more likely reflects an actual firefighting scenario.

Ambiance froide

Mishra, R. Kumari, V. Baheti and R. S. Rengasamy.

Experimental Investigation of the Influence of Structural Parameters on the Radiative Transmittance of Goose-Down Polyester Nonwovens for Cold Weather Clothing.

FIBERS AND POLYMERS. 2024.

https://doi.org/10.1007/s12221-024-00709-y

The lower effective thermal conductivity of goose down fibres provides an excellent thermal insulator property, which is mainly assumed due to its air-entrapping ability and thus lower diffusive thermal conductivity. Although the effective thermal conductivity of a porous medium is a combination of both diffuse and radiative thermal conductivity, using an alternate approach, the present work attempted to quantify the influence of structural parameters on radiative transmittance, which is directly related to radiative conductivity that affect the overall effective thermal conductivity. A Box-Behnken design was used to study the effect of areal density, thickness of nonwovens, and blend proportion of the goose down fibres in non-wovens on the radiative transmittance. It was found that radiative transmittance does not decrease linearly with an increase in areal density. Also, the model predicted an interaction factor among the thickness of the nonwoven and the blend proportion of the goose down fibers; with an increase in thickness, radiative transmittance showed a decreasing trend; with an increase in goose down blend proportion, radiative transmittance decreased, but the extent of reduction was different for different levels of thickness. So, it was found that the multidirectional orientation of goose down fibres along with their fine barbules are the major factors that contributed to their lower radiative transmittance properties.

P. Wang, G. F. Sun, S. C. Hua, W. Yu, C. Z. Meng, Q. Han, J. Kim, S. J. Guo, G. Z. Shen and Y. Li.

Multifunctional all-nanofiber cloth integrating personal health monitoring and thermal regulation capabilities.

INFOMAT. 2024.

https://doi.org/10.1002/inf2.12629

Frequent heat waves and cold spells pose threats to human survival. Herein, we develop a multifunctional all-nanofiber cloth with physiological signal monitoring and personal thermal management capabilities through facile fiber electrospinning and ink printing techniques. The double-sided fabric mat of a thick carbon nanotube network with high solar absorption on top of a thermoplastic polyurethane nanofiber substrate with high solar reflectivity and mid-infrared emissivity offers a contrary thermal management effect of heating or cooling by opposite wearing mode. The integrated fabric strain and temperature sensors for health status evaluation through monitoring physiological signals of respiration and body temperature. By wearing a T-shirt tailored by the developed electronic cloth, the wearer's skin temperature can be actively regulated with cooling by 5.4 degrees C and warming by 3.0 degrees C in hot and cold environments compared to normal clothing, respectively. This platform can inspire further studies in wearable multifunctional permeable electronics.image We develope a multifunctional all-nanofiber cloth with physiological signal monitoring and personal thermal management capabilities through facile fiber electrospinning and ink printing techniques.

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

Self-assessed threshold for cold temperatures and thermal insulation of clothing among poultry workers.

SCIENTIFIC REPORTS. 2024;14(1).

https://doi.org/10.1038/s41598-024-71393-4

The association between self-assessed cold threshold (CT) and thermal insulation of clothing (I-cl) was analysed in 283 poultry workers in Thailand. The mean CT was 13.5 degrees C (range - 28-29) and the mean I-cl was 1.23 clo (range 0.35-2.21). The adjusted CT remained unchanged at low I(cl)s (0.35 through 1.25 clo) but was estimated to increase by 14.8 degrees C at high I(cl)s (1.25 through 2.21 clo). Overall, CT was higher by 2.4 degrees C (95% confidence interval [CI] 0.3-3.8) at high (>= 1.25 clo) than that at low (< 1.25 clo) I-cl, but this difference was modified by personal and work-related factors. The difference was 2.6 degrees C (CI 0.5-4.6) for older (30-57 y) compared to younger (18-29 y) participants, with an excess of 7.3 degrees C (CI 5.6-9.0) for low vs high educated participants, 2.6 degrees C (CI 0.5-4.8) for those doing heavy vs light work, 7.4 degrees C (CI 3.7-11.0) for alcohol consumers vs others, and 3.4 degrees C (CI 0.6-6.3) for smokers vs non-smokers. The differences were independent of personal characteristics and worksite physical conditions and were interpreted as increased cold sensitivity among subgroups with lesser stamina and poorer health. Sensitive worker subgroups should be identified, and their need for cold protection should be reviewed.

Maladies liées à la chaleur

N. B. Morris, N. Ravanelli and G. K. Chaseling.

The effect of alcohol consumption on human physiological and perceptual responses to heat stress: a systematic scoping review.

ENVIRONMENTAL HEALTH. 2024;23(1).

https://doi.org/10.1186/s12940-024-01113-y

Background Ethyl alcohol (ethanol) consumption is ostensibly known to increase the risk of morbidity and mortality during hot weather and heatwaves. However, how alcohol independently alters physiological, perceptual, and behavioral responses to heat stress remains poorly understood. Therefore, we conducted a systematic scoping review to understand how alcohol consumption affects thermoregulatory responses to the heat. Methods We searched five databases employing the following eligibility criteria, studies must have: 1) involved the oral consumption of ethanol, 2) employed a randomized or crossover-control study design with a control trial consisting of a volume-matched, non-alcoholic beverage, 3) been conducted in healthy adult humans, 4) reported thermophysiological, perceptual, hydration status markers, and/or behavioral outcomes, 5) been published in English, 6) been conducted in air or water at temperatures of > 28 degrees C, 7) involved passive rest or exercise, and 8) been published before October 4th, 2023. Results After removing duplicates, 7256 titles were screened, 29 papers were assessed for eligibility and 8 papers were included in the final review. Across the 8 studies, there were a total of 93 participants (93 male/0 female), the average time of heat exposure was 70 min and average alcohol dose was 0.68 g<middle dot>kg1. There were 23 unique outcome variables analyzed from the studies. The physiological marker most influenced by alcohol was core temperature (lowered with alcohol consumption in 3/4 studies). Additionally, skin blood flow was increased with alcohol consumption in the one study that measured it. Typical markers of dehydration, such as increased urine volume (1/3 studies), mass loss (1/3 studies) and decreased plasma volume (0/2 studies) were not consistently observed in these studies, except for in the study with the highest alcohol dose. Conclusion The effect of alcohol consumption on thermoregulatory responses is understudied, and is limited by moderate doses of alcohol consumption, short durations of heat exposure, and only conducted in young-healthy males. Contrary to current heat-health advice, the available literature suggests that alcohol consumption does not seem to impair physiological responses to heat in young healthy males.

S. Wuellner, K. Turner and J. T. Spector.

Emergency department visits for heat-related illness among workers: Occupational health surveillance using Washington syndromic surveillance data.

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE. 2024.

https://doi.org/10.1002/ajim.23650

Background: Information on worker occupation and industry is critical to understanding the occupational risks of heat-related illness (HRI), yet few syndromic surveillance systems capture these key data elements. This study evaluates the work data reported through Washington syndromic surveillance for its utility in characterizing HRI ED visits by industry and occupation.Methods: Standard industry and occupation codes were assigned to employer name and occupation descriptions reported in Washington ED visit records maintained within the state's syndromic surveillance system, for visits involving HRI in 2020-2022. HRI ED visits involving workplace heat exposure were identified based on

discharge diagnoses or on keywords in the triage note or chief complaint fields. HRI ED visits were summarized by patient characteristics, and visit rates were calculated by industry and occupation. Results: Employer name or occupation descriptions were reported in 21.5% of HRI ED records among patients age 16 and older, and in 41.2% of records with mention of heat exposure at work. Twice as many records were classified for industry as for occupation. Agriculture, forestry, fishing, and hunting and transportation and warehousing had the highest rates of HRI ED visits. Specific industries with the highest rates included support activities for agriculture and forestry, the postal service, and fruit and vegetable preserving and specialty food manufacturing. Conclusion: Syndromic surveillance data are a valuable source of occupational health surveillance information when work characteristics are reported, enhancing our understanding of the occupational risks of injuries and illnesses.

X. Y. Yang, C. Shen, I. Ullah, J. Curio and D. L. Chen.

Evaluating heat stress and occupational risks in the Southern Himalayas under current and future climates.

NPJ CLIMATE AND ATMOSPHERIC SCIENCE. 2024;7(1).

https://doi.org/10.1038/s41612-024-00764-5

The southern Himalayas, characterized by its dense population and hot, humid summers, are confronted with some of the world's most severe heat stress risks. This study uses the hourly ERA5 dataset (1979-2022) and CMIP6 projections (2005-2100) to evaluate past and future heat stress based on the Wet Bulb Globe Temperature (WBGT). This has significant implications for the management of occupational workloads in the southern Himalayas. Heat stress levels are classified into 6 categories (0 to 5) using WBGT threshold intervals of 23 degrees C, 25 degrees C, 28 degrees C, 30 degrees C, and 33 degrees C. With heat stress surpassing level 3 for almost half of the time, people are constrained to engage in less than moderate workloads to ensure their health remains uncompromised. Flow-analogous algorithm is employed to contextualize the unprecedented heat stress case in the summer of 2020 and the associated atmospheric circulation patterns from historical and future perspectives. The results show that over 80% of the time in 2020, heat stress levels were at 3 and 4. The identified circulation pattern explains 27.6% of the extreme intensity, and such an extreme would have been nearly impossible in pre-21st-century climate conditions under the identified pattern. Future projections under SSP2-4.5 and SSP5-8.5 scenarios indicate that heat stress similar to what was experienced in 2020 will likely become a common occurrence across the southern Himalayas. Under a similar circulation pattern, the heat stress levels by the end of the 21st century would be elevated by at least one category compared to the climatic baseline in over 70% of the region, leading to an additional 120.5 (420.1) million daily population exposed to the highest heat stress level under the SSP2-4.5 (SSP5-8.5) scenario.

P. M. Graffy, A. Sunderraj, M. A. Visa, C. H. Miller, B. W. Barrett, S. Rao, S. F. Camilleri, R. D. Harp, C. X. Li, A. Brenneman, J. Chan, A. Kho, N. Allen and D. E. Horton.

Methodological Approaches for Measuring the Association Between Heat Exposure and Health Outcomes: A Comprehensive Global Scoping Review.

GEOHEALTH. 2024;8(9).

https://doi.org/10.1029/2024GH001071

Objective: To synthesize the methodologies of studies that evaluate the impacts of heat exposure on morbidity and mortality. Methods: Embase, MEDLINE, Web of Science, and Scopus were searched from

date of inception until 1 March 2023 for English language literature on heat exposure and health outcomes. Records were collated, deduplicated and screened, and full texts were reviewed for inclusion and data abstraction. Eligibility for inclusion was determined as any article with climate-related heat exposure and an associated morbidity/mortality outcome. Results: Of 13,136 records initially identified, 237 articles were selected for analysis. The scope of research represented 43 countries, with most studies conducted in China (62), the USA (44), and Australia (16). Across all studies, there were 141 unique climate data sources, no standard threshold for extreme heat, and 200 unique health outcome data sources. The distributed lag non-linear model (DLNM) was the most common analytic method (48.1% of studies) and had high usage rates in China (68.9%) and the USA (31.8%); Australia frequently used conditional logistic regression (50%). Conditional logistic regression was most prevalent in case-control studies (5 of 8 studies, 62.5%) and in case-crossover studies (29 of 70, 41.4%). DLNMs were most common in time series studies (64 of 111, 57.7%) and ecological studies (13 of 20, 65.0%). Conclusions: This review underscores the heterogeneity of methods in heat impact studies across diverse settings and provides a resource for future researchers. Underrepresentation of certain countries, health outcomes, and limited data access were identified as potential barriers. Climate change and global warming are major threats to public health, leading to increased illness and death worldwide due to rising temperatures. Heatwaves are becoming more frequent and severe, causing various health problems, particularly affecting low-income and minority communities. Studying the link between heat and health requires diverse methods due to regional differences. Different study designs and analytical techniques have been used, but there is no consensus on the best approach. Factors like heat severity, duration, air quality, and humidity must be considered. However, defining extreme heat and determining the best metric for heat exposure remain debated. With climate change worsening, understanding previous research on heat-related health impacts is crucial for future policies and adaptation strategies. This scoping review aims to address gaps in knowledge by examining the range of epidemiological approaches used to study the effects of extreme heat on health outcomes. Distributed lag non-linear models were widely used across various health outcomes and study designs, especially in time series studies There were disparities in research focus across different regions with regions like Africa and Oceania being underrepresented Access to public health data and standardized definitions for extreme heat remain significant challenges in heat impact studies.

C. Brimicombe, C. Gao and I. M. Otto.

Vulnerable to heat stress: gaps in international standard metric thresholds.

INTERNATIONAL JOURNAL OF BIOMETEOROLOGY. 2024.

https://doi.org/10.1007/s00484-024-02783-6

Exposure time to heat is increasing with climate change. Heat exposure thresholds are important to inform heat early warning systems, and legislation and guidance for safety in the workplace. It has already been stated that thresholds can be lower for vulnerable groups, including the elderly, pregnant women, children, and those with pre-existing medical conditions due to their reduced ability to thermoregulate their temperature or apply cooling strategies. However, the Wet Bulb Globe Temperature (WBGT) proposed by the international standard organisation (ISO 7243:2017), only takes into account thresholds based on acclimatization status. Therefore in this study we carried out a PRISMA systematic keyword search of "Wet Bulb Globe Temperature" of the Scopus abstract and citation database in August 2023 and a meta-analysis of text extracted from the identified 913 international studies published between December 1957 and July 2023, to investigate heat stress thresholds for different population groups. We find that different thresholds are considered as an indication of heat stress for different population groups. However, critical gaps were identified for the most vulnerable populations, and there are lower numbers of studies on women. Most studies researched adult populations between the ages of 18 and 55 (n = 491), failing to include the youngest

and oldest members of society. Based on these findings, we call for targeted investigations to inform effective heat action policies and set early warning thresholds to ensure the safety and wellbeing of the entire population.

Outils et capteurs de mesure

G. Singh, K. J. M. Bennett, H. McGuigan, S. G. Goddard and C. J. Stevens.

The Effect of a Synthetic-Grass Sport Surface on Physiology and Perception During Intermittent Exercise in Hot Conditions.

INTERNATIONAL JOURNAL OF SPORTS PHYSIOLOGY AND PERFORMANCE. 2024.

https://doi.org/10.1123/ijspp.2024-0095

Purpose: The current study aimed to determine the effect of a synthetic-grass sport surface on core body temperature, skin temperature, heart rate, thermal sensation, thermal comfort, and rating of perceived exertion (RPE) during intermittent exercise in hot conditions. Methods: Using a randomized crossover design, 13 trained/developmental team-sport athletes completed two 50-minute standardized intermittent running protocols on a synthetic and a natural-grass surface, on separate days (control-condition air temperature 32.6 degrees C [1.3 degrees C], relative humidity 43.2% [5.3%]). Results: Final skin temperature was significantly higher on synthetic compared with natural grass at the calf (40.1 degrees C [2.5 degrees C] vs 33.4 degrees C [0.6 degrees C]; P < .001), shoulder (36.6 degrees C [1.7 degrees C] vs 33.7 degrees C [0.7 degrees C]; P < .001), and chest (33.2 degrees C [1.1 degrees C] vs 31.8 degrees C [1.2 degrees C]; P = .02). Thermal sensation (median: 2.3; interquartile range [0.5] vs 2.2 [0.5], P = .03) and sweat rate (1.5 [0.4] L<middle dot>h(-1) vs 1.2 [0.3] L<middle dot>h(-1); P = .02) were also significantly higher on synthetic grass. While final core body temperature was significantly higher on the natural than synthetic grass (38.4 degrees C [0.3 degrees C] vs 38.2 degrees C [0.4 degrees C]), there were no significant differences in delta core temperature, as well as heart rate, thermal comfort, or RPE. Conclusions: Higher skin temperatures, thermal sensation, and sweat rates suggest that exercising on synthetic grass in hot conditions may increase some markers of heat strain during exercise. However, delta core body temperature, heart rate, thermal comfort, and RPE remained unaffected.

E. Stefanelli, M. Sperduti, F. Cordella, N. L. Tagliamonte and L. Zollo.

Performance Assessment of Thermal Sensors for Hand Prostheses.

IEEE SENSORS JOURNAL. 2024;24(17):27559-69.

https://doi.org/10.1109/JSEN.2024.3431274

Amputees using prostheses have a loss of somatosensory functions that should be restored to ensure a more stable grasp, slippage prevention, and protection from unbearable stimuli. Several studies show the necessity of integrating temperature sensors in prostheses to restore thermal sensations. The performance of the used sensors is usually not accurately analyzed when integrated into a prosthesis and a systematic testing protocol is generally missed. This study aims to compare systematically and rigorously the performance of commercial temperature sensors when integrated into a prosthetic fingertip. Four thermal sensors were selected. An experimental setup and a systematic testing protocol for sensor assessment were devised. The sensors were inserted into a 3-D printed fingertip and different object temperatures were considered. Moreover, a silicone layer was added to simulate the presence of a cosmetic glove and various object-to-sensor inclination angles were tested to reproduce a realistic contact. The optimal sensor for integration into a prosthetic fingertip was identified through a statistical analysis of the obtained results. The infrared (IR) sensor was selected, as it exhibited an average rise time <0.01 s and of 0.04 +/- 0.2 s, with and without silicone, respectively, and a mean error (ME) of 3.3 C-degrees +/- 5.1 C-degrees and 4 C-degrees +/- 5.4 (degrees) C with and without silicone,

respectively. All the tested sensors encountered a degradation of performance when the fingertip was covered with silicone and positioned at the highest inclination. These observations emphasize the significance of utilizing the presented standardized method, to evaluate the performance of thermal sensors in a realistic environment.

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

Reference-Free Calibration for Wearable Core Body Temperature Sensor Based on Single-Heat-Flux Method.

IEEE SENSORS LETTERS. 2024;8(9).

https://doi.org/10.1109/LSENS.2024.3435965

Core body temperature (CBT) is one of the useful physiological indicators that are linked to physiological changes. Wearable sensors are expected to be developed to monitor CBT easily during activities. A single-heat-flux method is one of the noninvasive techniques that estimate CBT by measuring heat flow changes near the skin with temperature sensors. The method requires calibrating parameters for estimating CBT in advance by comparing them with reference values obtained through another method. The invasive measurement method is generally used to obtain the reference values, which poses a challenge in terms of measurement burden. Here, we propose a new calibration method that does not require acquiring reference values. This method identifies calibration parameters based on the temperature history after the measurement probe is attached. It has been numerically and experimentally confirmed that the estimation accuracy by the method is equivalent to that of a general-purpose electronic thermometer. This outcome decreases the measurement workload in CBT measurement using the single-heat-flux method and significantly enhances its usability.

Travail par fortes chaleurs et périodes de canicule

B. Hanse, S. M. Alam, S. Krishnan, M. Bhattacharjee, A. Sinha, L. Sundareswaran and J. Kalita.

Occupational heat stress and its health impacts- an overview of research status and need for further research in Southeast Asia with special emphasis on mitigation strategies in North East India.

INTERNATIONAL JOURNAL OF BIOMETEOROLOGY. 2024.

https://doi.org/10.1007/s00484-024-02765-8

The Intergovernmental Panel on Climate Change, IPCC predicts that hot seasons will get even hotter due to global climate change. There exists a critical dependence of human metabolic processes on temperature. Changes in thermal balance therefore, have an adverse effect on health because they raise body temperature, cause excessive sweating, and accelerate the rate of dehydration. Different nations and professional groups use different techniques to measure heat strain. This paper aims to review previous research conducted in the area of heat strain due to heat exposure among workers in Southeast Asia and also to profile mitigation strategies in North East India. Studies conducted between the years 2011 to 2023 in the evaluation of the health impacts of occupational heat stress were searched systematically using several sources of databases like PubMed, Google Scholar, Science Direct, Web of Science, Scopus, etc. It was noted that a greater proportion of previous research on evaluating physiological effects was carried out in controlled environments as opposed to real-world field settings. While such studies give us valuable insights into the relationship, applying the same methodology in the workplace may not be feasible. In India, very few research has been carried out on workplace heat stress, and even fewer have been done in North East India using physiological indicators. North East India is also affected by global climate change leading top more hotter days than before. The region of Northeast India, particularly Guwahati (Assam), has recently seen extreme heat waves during the sweltering summer months. With less literature available in this geographical location, studies with actual field-based settings are much needed to understand the occupational health impacts in this region. This review can formulate a suitable methodology for assessing the health impacts in working environment. This can also help the local health professionals to recognize the heat strain parameters that are acceptable worldwide, and use as pertinent indicators to scrutinize worker's health and develop preventive agendas as climate change advances.

E. Patton, W. H. Li, A. Ward and M. Doyle.

Wet bulb globe temperature from climate model outputs: a method for projecting hourly site-specific values and trends.

INTERNATIONAL JOURNAL OF BIOMETEOROLOGY. 2024.

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Increasing temperature will impact future outdoor worker safety but quantifying this impact to develop local adaptations is challenging. Wet bulb globe temperature (WBGT) is the preferred thermal index for regulating outdoor activities in occupational health, athletic, and military settings, but global circulation models (GCMs) have coarse spatiotemporal resolution and do not always provide outputs required to project the full diurnal range of WBGT. This article presents a novel method to project WBGT at local spatial and hourly temporal resolutions without many assumptions inherent in previous research. We calculate sub-daily future WBGT from GCM output and then estimate hourly WBGT based on a site-specific, historical diurnal cycles. We test this method against observations at U.S. Army

installations and find results match closely. We then project hourly WBGT at these locations from January 1, 2025, to December 31, 2100, to quantify trends and estimate future periods exceeding outdoor activity modification thresholds. We find regional patterns affecting WBGT, suggesting accurately projecting WBGT demands a localized approach. Results show increased frequency of hours at high WBGT and, using U.S. military heat thresholds, we estimate impacts to future outdoor labor. By mid-century, some locations are projected to average 20 or more days each summer when outdoor labor will be significantly impacted. The method's fine spatiotemporal resolution enables detailed analysis of WBGT projections, making it useful applied at specific locations of interest.

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