Bulletin n°12

Veille thermique
Période : novembre 2023

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

D. Marchand, C. Gauvin and M. A. Landry-Duval.

Contraintes thermophysiologiques associées aux vêtements individuels de protection des pompiers : impact et efficacité des membranes barrières et des designs du vêtement.

Rapports scientifiques. Montréal (Canada): Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST); 2023.

https://www.irsst.qc.ca/publications-et-outils/publication/i/101193/n/contraintes-thermophysiologiques-vetements-protection-pompiers-membranes-barrieres-design

L'objectif de cette étude était d'évaluer la réponse physiologique au port de vêtements individuels de protection (VIP) pour les pompiers, munis de deux membranes barrières humidifuges, dont l'une, ayant des propriétés de perméabilité à la vapeur d'eau et de transfert de chaleur améliorées. Ce nouveau concept est basé sur de nouvelles technologies ayant le potentiel de réduire les contraintes thermophysiologiques des pompiers. Dix participants ont réalisé des tests de marche à 5 km/h sur un tapis roulant dans une chambre climatique où la température (35°C) et l'humidité relative (50 %) étaient contrôlées. Les principaux résultats suggèrent que la membrane barrière de nouvelle génération (M2) obtient une perception psychophysique de l'effort moins élevée que l'autre membrane pour les 20 dernières minutes du test. Les modifications de design du modèle Innovateur ne permettent pas de diminuer les contraintes physiologiques à l'effort et il cause un inconfort pour le cou et les hanches lors de la flexion du tronc. En présence du support de l'appareil de protection respiratoire autonome, le nouveau système d'aération dans la zone dorsale ne réduit pas les contraintes thermophysiologiques dans une situation d'effort prolongé de 45 minutes. Les résultats de cette recherche démontrent l'importance d'améliorer l'efficacité des matériaux qui composent les VIP. En effet, malgré un effort physique relativement bas imposé par la pente et la vitesse du tapis roulant, aucune des conditions évaluées ne permet une stabilisation des variables associées au processus de thermorégulation. La température interne du corps et la fréquence cardiaque augmentent progressivement durant toute la durée du test.

R. Wibowo, V. Do, C. Quartucci, D. Koller, H. A. M. Daanen, D. Nowak, S. Bose-O'Reilly and S. Rakete.

Effects of heat and personal protective equipment on thermal strain in healthcare workers: part B-application of wearable sensors to observe heat strain among healthcare workers under controlled conditions.

INTERNATIONAL ARCHIVES OF OCCUPATIONAL AND ENVIRONMENTAL HEALTH. 2023.

https://doi.org/10.1007/s00420-023-02022-2

As climate change accelerates, healthcare workers (HCW) are expected to be more frequently exposed to heat at work. Heat stress can be exacerbated by physical activity and unfavorable working requirements, such as wearing personal protective equipment (PPE). Thus, understanding its potential negative effects on HCW's health and working performance is becoming crucial. Using wearable sensors, this study investigated the physiological effects of heat stress due to HCW-related activities.MethodsEighteen participants performed four experimental sessions in a controlled climatic environment following a standardized protocol. The conditions were (a) 22 degrees C, (b) 22 degrees C and PPE, (c) 27 degrees C and (d) 27 degrees C and PPE. An ear sensor (body temperature, heart rate) and a skin sensor (skin temperature) were used to record the participants ' physiological parameters. Results: Heat and PPE had a significant effect on the measured physiological parameters. When

wearing PPE, the median participants' body temperature was 0.1 degrees C higher compared to not wearing PPE. At 27 degrees C, the median body temperature was 0.5 degrees C higher than at 22 degrees C. For median skin temperature, wearing PPE resulted in a 0.4 degrees C increase and higher temperatures in a 1.0 degrees C increase. An increase in median heart rate was also observed for PPE (+ 2/min) and heat (+ 3/min). Conclusion: Long-term health and productivity risks can be further aggravated by the predicted temperature rise due to climate change. Further physiological studies with a well-designed intervention are needed to strengthen the evidence for developing comprehensive policies to protect workers in the healthcare sector.

Y. H. Liu, D. L. Wang and J. Li.

Polyimide aerogel/aramid fiber composite with high mechanical strength and thermal insulation for thermal protective clothing.

FRONTIERS IN MATERIALS. 2023;10.

https://doi.org/10.3389/fmats.2023.1224883

Polyimide (PI) aerogel, as a new organic aerogel material, has the excellent thermal properties of polyimide and the characteristic of high thermal insulation of aerogels, and has gained increasing attention. In this work, using PI aerogel as the matrix material and aramid fiber as the reinforcement material, controllable flexible PI aerogel/aramid fiber composite insulation materials were successfully prepared by freeze-drying and soft treatment. This study sought to determine how the mass percentage of PI aerogel affected the microstructure, mechanical characteristics, thermal insulation capabilities, and thermal comfort of clothes in PI aerogel/aramid fiber composites. To achieve this, the preparation process of PI aerogel was optimized, and the effects of different mass fractions of PI aerogel on the properties of the composite material were evaluated. The results demonstrated that increasing the mass fraction of PI aerogel led to improvements in the mechanical properties, flexibility, and heat insulation properties of the composite material. Furthermore, the PI aerogel/aramid fiber composite offered enhanced thermal comfort to the wearer in hot and humid environments, indicating that the composite material is particularly suited for thermal insulation applications.

Travail par fortes chaleurs et périodes de canicule

C. Backes, N. Savic, A. Oppliger, J. Marti, J. Spycher and D. Vernez.

Prévention du stress thermique chez les travailleurs en extérieur.

Archives des Maladies Professionnelles et de l'Environnement. 2023;84(6):101896.

https://doi.org/10.1016/j.admp.2023.101896

Le changement climatique des dernières décennies accroît la fréquence des phénomènes météorologiques extrêmes, tels que les vagues de chaleur et les températures atmosphériques élevées. Des études épidémiologiques ont mis en évidence des liens étroits entre le stress thermique et la morbidité, la mortalité et les pertes de productivité. Le stress thermique n'est pas seulement un danger pour la santé, mais aussi une cause de pertes économiques importantes. Si la mesure et la modélisation du stress thermique sont bien connues, leur mise en œuvre reste complexe et/ou nécessiteuse en ressources. Cette étude a pour but d'identifier les paramètres les plus significatifs pour la détermination du stress thermique, afin de prévenir les situations à risque chez les travailleurs de la construction en plein air durant les épisodes de canicule au moyen d'outils simples à mettre en œuvre. Conclusion : Ce nouvel outil permet de quantifier simplement le nombre d'heures quotidiennes qu'un travailleur en extérieur peut effectuer avant d'être exposé au stress thermique. Cette estimation tient compte des tâches des travailleurs. Les données d'entrée consistent en trois paramètres faciles à collecter sur le terrain et adaptés à des situations spécifiques. En s'inspirant de la norme ISO sur le stress thermique, cet outil permet d'anticiper les changements dans l'organisation du travail pour éviter les risques de stress thermique et les pertes de productivité.

B. M. Varghese, A. Hansen, N. Mann, J. W. Liu, Y. Zhang, T. R. Driscoll, G. G. Morgan, K. Dear, A. Capon, M. Gourley, V. Prescott, V. Dolar and P. Bi.

The burden of occupational injury attributable to high temperatures in Australia, 2014-19: a retrospective observational study.

MEDICAL JOURNAL OF AUSTRALIA. 2023.

https://doi.org/10.5694/mja2.52171

To assess the population health impact of high temperatures on workplace health and safety by estimating the burden of heat-attributable occupational injury in Australia.Study design, settingRetrospective observational study; estimation of burden of occupational injury in Australia attributable to high temperatures during 2014-19, based on Safe Work Australia (work-related traumatic injury fatalities and workers' compensation databases) and Australian Institute of Health and Welfare data (Australian Burden of Disease Study and National Hospital Morbidity databases), and a meta-analysis of climate zone-specific risk data.Main outcome measureBurden of heat-attributable occupational injuries as disability-adjusted life years (DALYs), comprising the numbers of years of life lived with disability (YLDs) and years of life lost (YLLs), nationally, by Koppen-Geiger climate zone, and by state and territory.ResultsDuring 2014-19, an estimated 42 884 years of healthy life were lost to occupational injury, comprising 39 485 YLLs (92.1%) and 3399 YLDs (7.9%), at a rate of 0.80 DALYs per 1000 workers per year. A total of 967 occupational injury-related DALYs were attributable to heat (2.3% of occupational injury-related DALYs), comprising 890 YLLs (92%) and 77 YLDs (8%). By climate zone, the heat-attributable proportion was largest in the tropical Am (12 DALYs; 3.5%) and Aw zones (34 DALYs; 3.5%); by state and territory, the proportion was largest in New South Wales and Queensland (each 2.9%), which also included the largest numbers of heat-attributable occupational injury-related

DALYs (NSW: 379 DALYs, 39% of national total; Queensland: 308 DALYs; 32%).ConclusionAn estimated 2.3% of the occupational injury burden in Australia is attributable to high ambient temperatures. To prevent this burden increasing with global warming, adaptive measures and industry-based policies are needed to safeguard workplace health and safety, particularly in heat-exposed industries, such as agriculture, transport, and construction.

E. M. Patton and M. W. Doyle.

Observed Warming Trends at US Army Basic Combat Training Installations and Implications for Future Recruit Training.

MILITARY MEDICINE. 2023.

https://doi.org/10.1093/milmed/usad425

Army recruits conducting BCT are among the most susceptible population of military personnel to experience exertional heat illness, a concern expected to become increasingly urgent due to steadily rising temperatures. In this study, we provide an empirical analysis of wet bulb globe temperature (WBGT) index trends at U.S. Army BCT installations and quantify the magnitude of these trends. Assuming these warming trends continue, the anticipated effects of increasing temperature trends are discussed in relation to potential impacts on recruit heat illness incidence and training disruption.Materials and Methods We obtained weather data beginning in the early 1960s, including WBGT index measurements derived by the U.S. Air Force 14th Weather Squadron. We apply these datasets to two classifications for high WBGT index days, including one classification accounting for heat illness susceptibility based on prior day heat exposure, to determine when recruits are most at risk of heat illness. The daily likelihood of extreme WBGT index values is described at each installation using a 30-year climatological average. Trends in the WBGT index are evaluated quantitatively during the warm season (May 1-September 30) and full year and compared between decades and by individual BCT classes.Results Trends in the WBGT index have increased at all four BCT installations. Between January 1960 and October 2022, the mean WBGT index value increased most quickly at Ft Jackson, SC (0.272 degrees C decade-1, CI: 0.255-0.289) and least at Ft Moore, GA (0.190 degrees C decade-1, CI: 0.170-0.210). Ft Moore experiences the greatest heat burden, with the daily likelihood of experiencing a "black flag" event (>= 90 degrees F WBGT index) peaking at nearly 50% in late July, while Ft Leonard Wood, MO, experiences the least heat burden. This heat burden is spread unevenly across installations and dependent on BCT class start date. Recruits beginning in mid-June will experience approximately 200 hours of hazardous heat during BCT at Ft Moore, GA; 100 hours at Ft Jackson, SC; 80 hours at Ft Sill, OK; and 61 hours at Ft Leonard Wood, MO.Conclusions Temperatures measured on the WBGT index have steadily increased at US Army basic training installations since at least 1960. In the future, adaptation to the BCT program will be required to maintain rigorous standards without incurring unacceptable risk of recruit heat illness. The analysis provided by this study can help inform medical, training, and policy implementations needed to ensure continued BCT in a warming world.

M. Abbasi, S. Yazdanirad, F. Golbabaei, H. Dehghan and A. Ahmadi.

Validity of ten analytical heat stress indices in predicting the physiological parameters of people under various occupational and meteorological conditions.

INTERNATIONAL JOURNAL OF BIOMETEOROLOGY. 2023.

https://doi.org/10.1007/s00484-023-02580-7

Until now, only a few comprehensive studies have validated analytical heat stress indices in different conditions. The present study aims to investigate the validity of these indicators in predicting the physiological parameters of workers. This cross-sectional study was conducted with 194 male employees working in warm environments. First, demographic information was collected. After participants rested for 30 min, their heart rate and tympanic temperature were measured. The subjects then performed their routine tasks. At the end of 90 min, their heart rate and tympanic temperature were again measured. Additionally, their metabolism rate and clothing thermal insulation were estimated. Environmental parameters were also measured at 30-, 60-, and 90-min time points. Additional information required to compute the indices was recorded. Then, the values of each of the indices were computed. Finally, the validity of the indices was assessed under different conditions. The results indicated that the highest regression coefficients with tympanic temperature were assigned to modified physiologically equivalent temperature (mPET) (0.7515), predicted heat strain (PHS) (0.7201), and predicted mean vote (PMV) (0.7082), index, respectively. Also, the greatest regression coefficients with heart rate belonged to mPET (0.7773), PMV (0.7624), and PHS (0.6479) index, respectively. Based on the results, the highest diagnostic accuracies of receiver operating characteristic (ROC) curves for tympanic temperature were related to indices of mPET, PHS, and PMV with the area under the ROC curve (AUC) of 0.945, 0.931, and 0.930, respectively. Of the studied indices, it was observed that mPET, PHS, PMV, and PPD showed more validity compared to others.

Actualités novembre 2023

- ## Travail par fortes chaleurs et périodes de canicule

58 °C ressentis : le Brésil suffoque sous une canicule record. Liberation.fr, 15 novembre 2023

Le « Lancet Countdown » mesure les effets alarmants du changement climatique sur la santé. Lemonde.fr, 15 novembre 2023

Le réchauffement climatique impacte le bien-être mental des agriculteurs européens. Euronews.com, 27 novembre 2023

Is Heat Illness Regulation On The Horizon? Mondaq.com, 6 novembre 2023

Climate change hits women's health harder. Activists want leaders to address it at COP28, thecanadianpressnews.ca, 14 décembre 2023

- ## Maladies liées à la chaleur

Evaluating changes in firefighter urinary metabolomes after structural fires: an untargeted, high resolution approach. Nature.com, 27 novembre 2023