Climate Change and Health: The Physiological Society's Key Recommendations for COP29

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The Physiological Society

Physiology, Climate Change, and Health

Physiology is an essential part of the health response to climate change as it helps us understand the consequences of extreme temperatures and other consequences of the climate emergency on the human body. As the science of how the body works, physiology explains the impact of climate change on our health and productivity, and therefore, the very future of our species. Physiologists use their specific expertise to understand how humans respond and cope with extreme temperatures and climatic events to develop proposals for physiological, behavioural, infrastructure, and technological adaptation which can also inform public health guidance.

Climate Change and COP29

As part of the Paris Agreement, governments around the world have committed to "limit global warming to 1.5°C above pre-industrial levels".[1] Putting to one side the urgent decarbonisation efforts required to meet this ambition by 2030, this average temperature goal obscures the extreme variations of temperature throughout the year and across the globe that are associated with it. Missing this target will have a significant impact on the UK population's health and wellbeing as well as lives and livelihoods.

The 29th Conference of the Parties (COP) to the UN Framework Convention on Climate Change (COP29), is taking place in Baku, the Republic of Azerbaijan, from 11 to 22 November 2024. As global temperatures and extreme weather events hit record highs and affect millions of people, it is vital that leaders from governments around the world, business, and civil society come together to advance concrete solutions to tackle the climate crisis.

Health at COP29

Every year the World Health Organization (WHO) in collaboration with the Wellcome Trust and the health community host the Health Pavillion at COP.[2] The Health Pavillion convenes key stakeholders across the global health community to ensure that health and equity are placed at the centre of climate negotiations.

This year, the Pavillion will cover the following topics, among others, to showcase initiatives and solutions to maximise the health benefits of tackling climate change:

- Heat resilience
- Decarbonisation and mitigation
- Healthy workforces
- Nutrition

The full programme of events is available here.

1. https://www.metoffice.gov.uk/about-us/news-and-media/media-centre/weather-and-climate-news/2023/climate-change-drives-uks-first-year-over-10c
2. https://www.who.int/news-room/events/detail/2024/11/11/default-calendar/cop29-health-pavilion

The Physiological Society's Work in Climate Change and Health

The Physiological Society is committed to highlighting the key role of physiological research in delivering on climate change mitigation and adaption goals. From furthering our understanding of adaption to heat and extreme weather, to maximising human health, physiological research is key to the fight against climate change. Since 2021, The Society has been leading efforts to address the health impacts of climate change by holding roundtables with global experts and producing key reports aimed at understanding the pathways linking extreme temperatures and climate change and physical and mental health.[3]

We have called for research focused on understanding the physiological impacts of extreme heat, especially on vulnerable populations and advocated for evidence-based solutions and policies through our *National Heat Resilience Strategy* and *A Roadmap for Global Heat Resilience reports*.[4,5] Furthermore, we also work with multidisciplinary teams and organisations across the global climate and health landscape to highlight the urgent need for low-carbon and low-cost solutions to mitigate, as well as address, the impacts of extreme weather across the population and ensure equitable global access to these strategies.

3. https://www.physoc.org/policy/climate-change-and-health/
4. https://www.physoc.org/policy/climate-change-and-health/heat-resilience-strategy/
5. https://www.physoc.org/policy/climate-change-and-health/roadmap-for-global-heat-resilience/

Timeline of Our Work in Climate and Health

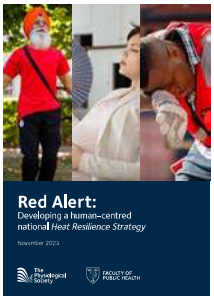
November 2021
'Physiology and Climate Change' report to highlight priority areas related to tackling the impact of climate change on health.

January 2022
Event in the UK Parliament entitled 'Climate change and health: Surviving rising global temperatures.'

January 2022
A roundtable with Wellcome to identify research gaps in rising heat and pregnancy.

July 2022
Event at the Royal Society on the impacts of climate change on health with the Foundation of Science and Technology and Academy of Medical Sciences.

July 2022
An online conference followed by the publication of a report *'The Climate Emergency: Research Gaps and Policy Priorities'*.



November 2023
Publication of report *'Red Alert: Developing a human-centred national Heat Resilience Strategy'*, in partnership with the Faculty of Public Health.

February/May/ August 2024
A workshop with Wellcome on the relationship between climate change, heat, and mental health, follow up report and publication of a joint article in the *Journal of Physiology* and *PLOS Mental Health*.

June 2024
Bringing together over 30 organisations to agree a Roadmap for Global Heat Resilience, launched in Parliament.

July 2024
Launch of the 'Climate and Physiological Resilience Network' to bring together experts working in climate change and health to share research and enhance the resilience of individuals and communities.

"The impact of climate change on health is the biggest global challenge of the 21 Century. The scale of this emergency is so vast a cross border, transdisciplinary approach will be key to tackling climate change."

"It is clear that physiology, physiologists and The Physiological Society all have an important role to play in mitigating climate change, from the micro to the macro level."

Dariel Burdass, Chief Executive, The Physiological Society

"We need to ensure that everybody understands that the climate crisis is a health crisis. Climate change negatively affects population health, and understanding of the body's physiological response to extreme temperatures can maximise the effectiveness of public health interventions at the local and global levels. We must also consider and act upon the inequalities in the distribution of vulnerability across different populations and the world."

Professor Mike Tipton, Extreme Environments Laboratory, University of Portsmouth

Our Key Recommendations for COP29

1

Heat Resilience Plans: Advocate for the prioritisation of health, including mental health and heat resilience in global climate agreements. Prioritising health and enhancing long-term resilience of the population will ensure more people are able to adapt to rising temperatures.

- **Prioritise health and well-being of global populations** by building resilient health systems in countries which are disproportionately burdened by the impact of climate change.
- **Improved heat resilience** by increasing our knowledge base through a greater focus and funding on the research gaps, particularly around vulnerable populations, and ensure that research is translated to action so that local communities can benefit from the research quickly.
- **Promote human-centred design:** Determinants of human thermal comfort and heat illness should be at the heart of designs and interventions to mitigate heat related problems.
- **Ensure a concerted focus on the mental health risks** associated with extreme heat with a focus on regions where most extreme heat events occur and where communities are most vulnerable to its impacts.

2

Heat Resilience Research: Build a global research and policy ecosystem through cross-disciplinary and cross-governmental collaboration. Creating global networks will facilitate the exchange of ideas and best practices in heat resilience.

- **Prioritise strategic research and invest in future development opportunities:** Focus on research that increases population heat resilience, protects vulnerable groups and counties and promotes sustainable practices.
- **Enhanced collaboration and learning from other countries:** Foster cooperation across countries, sectors, and scientific disciplines, incorporating transdisciplinary approaches. Promote knowledge sharing and learning from other countries and cities represented in international heat networks about how to build more heat resilient systems and populations.
- **Increase opportunities to incorporate heat resilience into design:** Foster cooperation among research, health, engineering, planning, and design sectors to integrate consideration around physiological impact of heat into infrastructure projects.
- **Facilitate knowledge sharing:** Establish platforms to share research findings, challenges, and solutions to tackling climate change.
- **Understanding pathways linking heat and mental health:** A better overall understanding of the mechanistic pathways linking heat to poorer mental health would allow for the better prioritisation of research and interventions based on a finite amount of resource being available for this research.
- **Research strategies to integrate mental health measurements into existing physical health studies** on heat and building heat measurements into existing projects looking at mental health problems to bridge the gap between these two areas of research.

3 Healthy Workforces: Protect the workforce to safeguard worker health and productivity in rising temperatures and extreme weather.

There is an urgent need to develop and put in place systems to protect workers.

- **Implement occupational guidelines for those working in high risk settings:** Develop comprehensive guidelines for managing occupational heat exposure, considering factors like temperature, humidity, air flow and pollutants. This should be based on the physical activity level requirements of the role, ability to mitigate exposure to heat and types of Personal Protective Equipment (PPE) worn.
- **Facilitate research in workplaces and working environments:** This will allow better understanding of the physiology of extreme heat and resilience countermeasures on humans in real world settings.

4 Local Decarbonisation, Adaptation and Mitigation: Increase local public awareness on the risks of climate change to health and effective mitigation techniques they can adopt.

Public awareness is key to mitigating climate change at the individual level, whether it is through encouraging active travel (i.e. making journeys in physically active ways) or promoting climate-friendly diets. Local populations must also be educated on how to cope during extreme weather events and what precautionary measures should be taken.

- **Expand public health education:** Implement programs focusing on medium- and long-term behavioural changes such as increased physical activity and better nutrition to improve heat resilience.
- **Advocate for public health measures:** Promote policies such as early warning systems and actionable response plans, that will protect public health as heatwaves become more frequent, intensive and longer.
- **Prioritise green spaces:** Increase the integration of green spaces in urban planning to provide natural cooling areas for the public.
- **Increase public awareness and engagement** on the risks and benefits of heat resilience countermeasures and providing clear and consistent guidance and advice on how to cope with heat stress and reduce cooling demand.

Climate Change and Physiological Research: Case Studies

Heat and Cold Sensitivity in Multiple Sclerosis: A Patient-centred Perspective on Triggers, Symptoms, and Thermal Resilience Practices

The negative effects of heat and cold stress on Multiple Sclerosis (MS) have been known for ~100 years. Yet, we lack patient-centred investigations on temperature sensitivity in persons with MS (pwMS). The aim of this study was therefore to evaluate triggers, symptoms, and thermal resilience practices in the largest international cohort of temperature-sensitive pwMS assessed to date (N= ~800), via a dedicated survey.

Our results indicated that temperature sensitivity varied significantly in pwMS but all participants:

i. experienced hot and cold days as primary triggers.

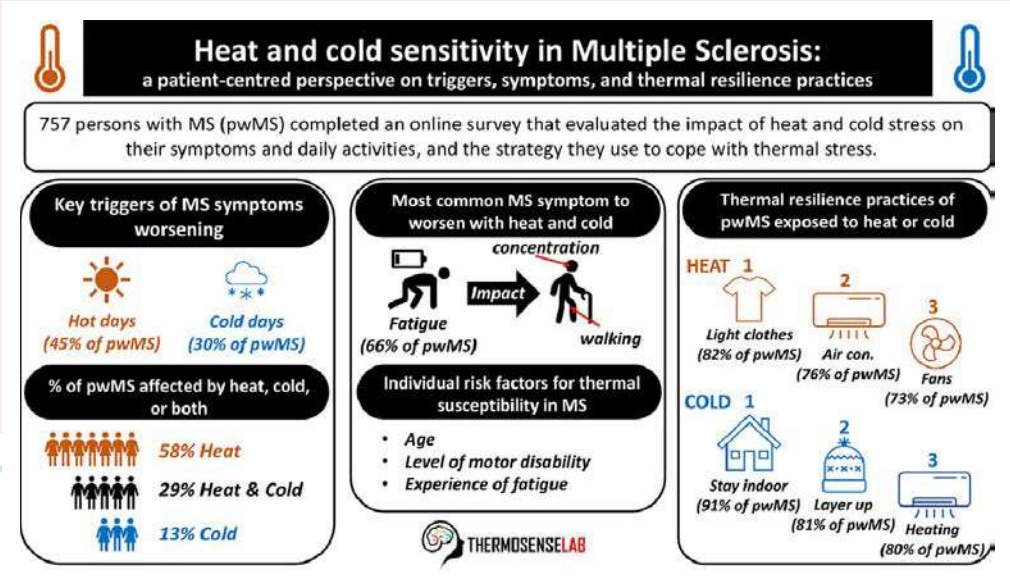
ii. reported fatigue as the most common worsening symptom, impacting walking and concentration.

iii. used air conditioning and changes in clothing insulation as primary thermal resilience practices.

The comprehensive, patient-centred evidence provided by this study on the impact and response to temperature sensitivity could play an important role in the development of individualised healthcare plans as well as of climate & health policies that better accommodate the needs of temperature-sensitive neurological patients.

This translational research has already informed patients' guidance on managing heat intolerance issued by The MS Society UK, the largest MS Charity in the UK, and it has been used by the NIH Disaster Research Response (DR2) Portal to help the research community use similar data collection methods to create larger datasets and to provide a deeper understanding of all of the uncertainties associated with disasters such as heatwaves.

Dr Davide Filingeri and Dr Aikaterini Christogianni, Thermosenselab, Skin Sensing Research Group, School of Health Sciences, University of Southampton (UK)



Using Sports and Exercise Science to Understand Human Thermal Resilience

Excessive heat stress directly compromises human health, safety, and productivity. At the Heat Resilience and Performance Centre, we study the mechanisms of thermal stress on specific outcomes related to health, safety or overall performance and the underlying physiological basis of thermal stress.[6]

We also work closely with other disciplines to better understand common heat-health issues in various contexts, to propose solutions that are more holistic and comprehensive. In proposing these solutions, it is vital we focus on populations that are most vulnerable to the impacts of extreme heat. Looking through the lens of sport, we already have some solutions used by athletes such as conditioning, acclimatisation, the use of cooling and rehydration strategies. We can use these solutions and tailor them for different population groups.

It is important for us to understand the physiological mechanisms of how heat affects health or performance outcomes to ensure these solutions are more targeted. This will not only optimise the limited resources we have at hand, but also ensure that more people are positively impacted by these strategies. We cannot simply expect broad policies or solutions to safeguard humans amidst the rise in extreme temperatures. We need these solutions to be more specific and that's where the role of physiology becomes vital.

Associate Professor Jason Lee, Director, Heat Resilience and Performance Centre, Yong Loo Lin School of Medicine, National University of Singapore (Singapore)

6. https://medicine.nus.edu.sg/hrpc/

Using Yoga and Breathing Techniques to Combat Heat Stress

Exposure to heat beyond our thermoneutral zone disrupts homeostasis in the body which triggers thermoregulatory mechanisms such as sweating, respiratory convection, dissipation. This ultimately causes fluid loss and dehydration, leading to a change in blood pressure, central venous pressure, blood volume, plasma similarity, and body temperature.

For the body to function normally, these parameters must be kept in a narrow range, however, exposure to heat can disrupt the whole functioning of the body thereby affecting health, both physical and mental. At the All India Institute of Medical Sciences Jodhpur, we research autonomic responses to wellness practises. Yoga is a structured part of the Indian lifestyle and a specific form of yoga known as *'pranayama'* involves respiratory modulation. Since breathing is the first thing that is affected by stress, including heat stress, our research attempts to delineate the effect of respiratory modulation on cardiovascular and autonomic oscillations and understand the underpinning physiological mechanisms and pathways of stress.

Our research has revealed that slow and deep breathing has the capacity to shift autonomic balance towards parasympathetic dominance which therefore helps a person deal with stress better. The literature has also shown that *pranayamas* can be effective in cooling the body during periods of extreme heat. If we can combine this ancient practise of yoga with scientific research, we can develop a toolkit for people to use during heatwaves. Thus, people can use their own breathing to deal with acute heat exposure and we can train people to make them more resilient and better adapt to the environment.

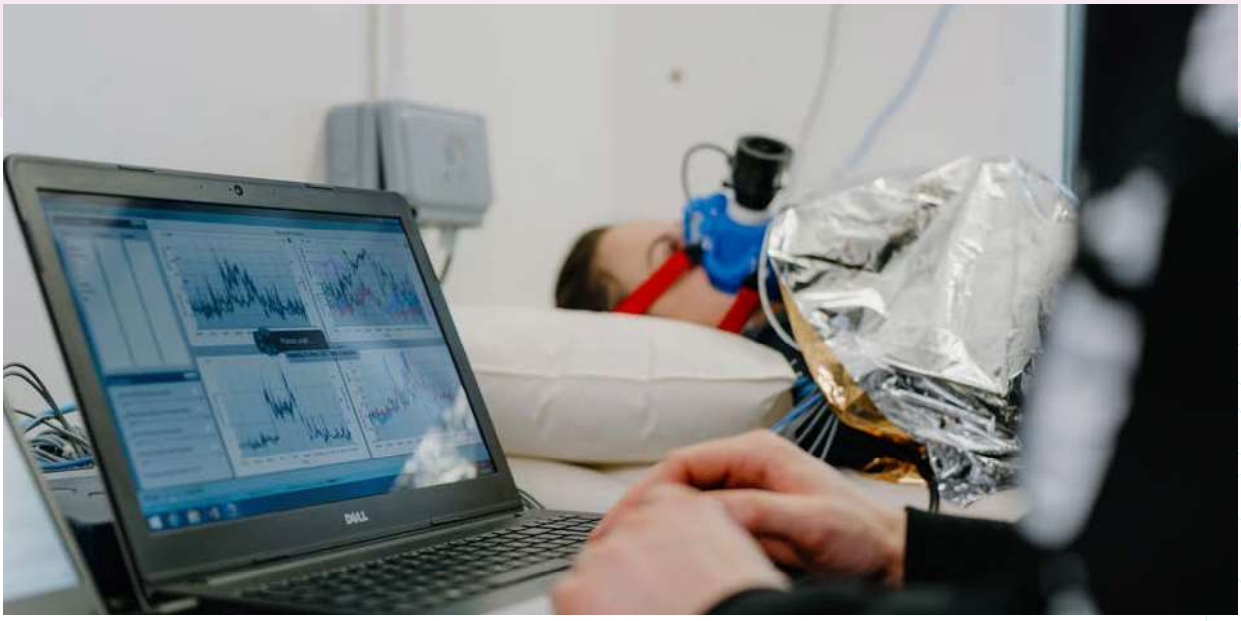
Dr Om Lata Bhagat, All India Institute of Medical Sciences Jodhpur (India)

Improvised Prehospital Methods to Reduce Cold Stress in Humans

Cold exposure-related morbidity and mortality are a significant burden during and after natural disasters and extreme weather events such as earthquakes and flooding. This burden is amplified in pre-hospital environments where more sophisticated cold protection methods and medical facilities are unavailable. To address this problem researchers at Bangor University recently tested the effectiveness of wrapping people in a building membrane, with and without hot water bottles, to reduce physiological and perceived cold stress in humans. These methods were chosen because they can be improvised in low-resource environments by those at risk and first responders, for example, salvaged from destroyed buildings.

Bangor's research found that wrapping people in building membrane reduced physiological (higher mean skin temperature and lower metabolic heat production) and perceived cold stress (felt warmer and more comfortable) compared with no protection, and that the building membrane wraps were as effective as foil blankets, a commonly used hypothermia prevention strategy. The addition of hot water bottles to the building membrane or foil blanket barrier wraps further improved perceived cold stress, but not physiological cold stress. The lessons learnt from these laboratory studies will inform pre-hospital and prolonged field care medical training delivered by knowledge exchange partner Remote Area Risk International.

Sam Oliver PhD FHEA, Professor of Applied Human Physiology, School of Psychology and Sport Science, Bangor University (UK). The work was a knowledge exchange collaboration between Sam Oliver and Sam Leaney from the Institute for Applied Human Physiology (https://www.bangor.ac.uk/iahp), Bangor University and Matthew Davies from the Institute for Remote Area Risk And Medicine (https://www.r2rinternational.com/iraram), *supported by a Bangor University Innovation and Impact Award, and funded by Research Wales Innovation Fund.*



Researcher Sam Leaney testing the effectiveness of common and improvised prehospital methods to reduce cold stress in the environmental chambers of the Institute for Applied Human Physiology, School of Psychology and Sport Science, Bangor University.

How Heat Impacts Pregnant Women and their Unborn Children in The Gambia

Our research at the MRC Unit The Gambia at the London School of Hygiene and Tropical Medicine (LSHTM), focuses on maternal health and the risks of heat to pregnant mothers and their unborn children in the Gambia.[7,8] We previously worked primarily with people living in rural areas who relied on subsistence farming for income.

Our research showed that pregnant women exposed to very high levels of heat stress in their normal everyday working lives have an acute change in both maternal and foetal physiology. The mother's core temperature went up and the foetal heart rate was observed to be very high or very low and there was also a reduction in blood flow to the foetus. This could potentially be one of the pathways to explain the association between maternal heat exposure and poor birth outcomes such as still birth, preterm birth, and low birth weight.

When looking for solutions to protect mothers from this, we explored the option of whether they can change their working schedule i.e. if they could start to work later in the evening. However, after speaking with the women, we found that this was often not an option for them. Thus, it is important to note that some of these simple behavioural changes might be difficult to achieve because of social and community factors that prevent women from having the ability to change their working lives.

We have also received funding from the Wellcome Trust to look at the biological vulnerabilities of pregnancy in terms of exposure to heat and birth outcomes. For this project, we will follow a much larger group of women throughout the course of their pregnancy and post-delivery to better understand the pathways linking heat and poor birth outcomes. We will recruit women from the interior of The Gambia where the temperatures can reach almost 50°C and compare them to a group recruited from a cooler area in The Gambia, nearer to the coast, where the average temperature is around 30°C.

These two groups of women will be followed up throughout their pregnancy. We will scan them regularly and evaluate how heat impacts their well-being, sleep, food security, and physiology. We will also collect biological samples at delivery; for example, we will collect samples from the placenta and the cord to understand if there are changes that occur in the placenta that mediate the risks we see with heat exposure and birth outcomes.

Dr Ana Bonell, Medical Research Council Unit The Gambia at the London School of Hygiene and Tropical Medicine (UK)

7. https://www.lshtm.ac.uk/research/units/mrc-gambia
8. https://www.lshtm.ac.uk/research/centres-projects-groups/gambia-heat-in-pregnancy-study

Protein Nutrition, Healthy Ageing and Climate Change: How Do We Combine the Three?

Food production accounts for 20–30% of the UK's greenhouse gas emissions (GHG) and therefore plays an important role in climate change.[9] Greenhouse gases are emitted at every stage of the food chain, from agricultural production (farming methods and land use) through to processing and manufacturing (packaging and transportation), consumer activities (storage and cooking), and food waste disposal. Meat and, to a lesser extent, milk and dairy are the largest contributors to diet-related GHG emissions.

Plant-based protein-rich foods may be considered more sustainable for the environment than animal based protein-rich foods. Based on estimates of GHG emissions associated with the UK's supply and production of different food groups, plant-based food sources fall into low and moderate carbon footprint categories, whereas as mentioned above animal proteins fall into the high category. Combinations of potato and rice protein, corn and pea protein, and soy and hemp protein appear to be complementary in providing a complete essential amino acids (EAA) profile for supporting muscle protein synthesis (MPS) as the primary regulator of muscle mass. A bean and quinoa bowl provides an example meal to "cover" amino acid requirements from a single vegetarian dish.

Diet clearly makes significant contributions to global warming and climate change. On the basis of current scientific knowledge, animal-based protein sources are more readily-available than plant-based protein sources, at least on a like-for-like basis.

Future protein recommendations should take a holistic approach by considering muscle health, appetite and other nutrients of concern. But climate change threatens our very survival and that of our ecosystems and consideration of this fact must drive food policy above all else. These recommendations will likely include a marked increase in plant-based foods, but without elimination of meat or dairy.

Dr Oliver Witard, Faculty of Life Sciences and Medicine, Kings College London, UK

9. https://www.gov.uk/government/statistics/final-uk-greenhouse-gasemissions-national-statistics-1990-to-2018

Applied Physiology: A Critical Discipline in Times of Climate Change

Worldwide, climate change is also driving more frequent and severe flooding events.[10] These changes have placed an increased demand on those required to perform search and rescue in flooded areas. With research in this area, we are now beginning to understand the physiological demands placed on rescuers, the need for customised personal protective equipment (PPE) and other kit, and the required standard operating procedures (SOPs) and policies for those conducting rescue operations.

Our research in this area was the first to focus on the physical and thermal demands placed on flood rescuers. Ten experienced flood rescuers undertook a 60-minute simulated flood rescue task in representative cold and warm flood rescue conditions from recent flooding events.

The results were informative. In the cold, foot temperatures cooled to the region where non-freezing cold injury becomes a risk, and neuromuscular cooling reached a level where strength and agility were impaired. The first result in the "warm" condition indicated that existing SOPs were not tenable. Even modified less stressful "warm" conditions resulted in the deep body temperature increasing uncontrollably in half of the participants.

These findings have changed the SOPs of flood rescue organisations, and the PPE offered to them. As a result, flood rescuers should be safer and perform more effectively in flood rescue situations, to the benefit of all. This is yet another example of the importance of physiology research and its application for the health and safety of rescuers and the communities they serve. As always, however, prevention is better than cure. We must do all we can to mitigate future climate change, rather than just responding to the problems it causes, especially if that approach puts rescuers at risk.

Professor Mike Tipton and Dr Gemma Milligan, Extreme Environments Laboratory, University of Portsmouth, UK; and Adrian Mayhew National Operations & Safety Manager, Surf Lifesaving GB

10. https://www.worldweatherattribution.org/heavy-rainfall-which-led-to-severe-flooding-in-western-europe-made-more-likely-by-climate-change/

Using Thermal Physiology to Optimise Indoor Fan Usage to Reduce Greenhouse Gas Emissions from Air Conditioner Use

When looking at the impact of extreme heat on humans it is useful to take a lifespan approach. We know that extreme heat can be detrimental to the health of pregnant women and their babies. Children are at a greater risk of exertional heat illness when they are playing sport or if they are in an educational setting. When we get to adulthood, people working in environments exposed to extreme heat are at a greater risk. Further, as we age, our ability to thermoregulate through sweating reduce and that also coincides with a reduced behavioural adaptive capacity to heat.

At the Heat and Health Research Centre, we aim to better understand the underlying mechanisms associated with heat-related impacts on human health and well-being.[11] It is important to understand these mechanisms to develop more targeted and effective solutions that are fit for purpose in the settings which they will be implemented.

Another key aspect of our work is understanding ways in which we can reduce the impacts of extreme heat through different interventions. We research sustainable, low resource strategies that can help vulnerable populations without exacerbating climate change.

We have found ways to reduce greenhouse gas emissions (GHG) from air conditioner use during hot summer days without compromising thermal comfort. GHG emissions from air conditioning use are quite substantial in places such as Australia, North America, China, and Southeast Asia.

Our study looked at historical changes in temperature to understand when the threshold for warm thermal discomfort is exceeded – this is when people are likely to switch on an air conditioning unit.[12] We found that if we increase air velocity across the skin, this thermal comfort threshold temperature is increased by 3-4°C. This means that, if the air conditioner thermostat is adjusted accordingly, throughout a given hot day an air conditioning unit will be switched on later and for a shorter duration, while the person will remain just as thermally comfortable.

This information was used to estimate how much GHG emissions would be reduced if everyone in Australia who has an AC unit adopted this strategy. We found that over a typical year a potential reduction in GHG from air conditioner use of 70-75% could be achieved.

Professor Ollie Jay, Director, Heat and Health Research Centre, University of Sydney (Australia)

11. https://www.sydney.edu.au/medicine-health/our-research/research-centres/heat-and-health-research-centre.html
12. Malik A, et al. The potential for indoor fans to change air conditioning use while maintaining human thermal comfort during hot weather: an analysis of energy demand and associated greenhouse gas emissions. Lancet Planetary Health. 2022; 6(4): E301-309 Available from: https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(22)00042-0/fulltext

The Physiological Society

As the largest network of physiologists in Europe, with academic journals of global reach, The Physiological Society continues a 145 year tradition of being at the forefront of the life sciences. We support the advancement of physiology by promoting collaboration between physiologists around the world, organising world-class conferences and publishing the latest developments in our scientific journals. Research in physiology helps us to understand how the body works in health, what goes wrong in disease, and how the body responds to the challenges of everyday life.

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