A HUMAN-CENTRED APPROACH TO CLIMATE CHANGE: FROM PHYSIOLOGY TO POLICY TO ACTION

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Do you remember the time when an article on climate change had to start with a wealth of statistics on the climate? Those days are gone, such an opening salvo is no longer required. As we sit in the UK and write in the world's warmest February on record, with Spring a month early, it must be obvious to all that across the globe we are witnessing changes in our climate. These changes are resulting in diverse risks and challenges, ranging from the direct threats of extreme weather, to challenges to food and water supplies, mental and physical health. There are knock-on consequences for health care systems, social unrest, migration, mortality and the existence of humanity, and these issues are set to get worse.

Physiology is the science of life. It describes the mechanisms of living things, from cell function to the integrated behaviour of the whole body. It includes examination of the influence of the external environment on human physiology and pathophysiology. As such, it should be a central weapon in the response to climate change. For example, those designing green indoor and outdoor living spaces must know what constitutes thermal comfort for a human. Therefore, an understanding of thermal physiology should contribute to the design specification.

What do we know about this? Humans evolved via intellectual and technological advancement, rather than alterations in body composition (more blubber or fur). The oldest building made by hominids (in Tanzania) was a windbreak constructed by *Australopithecus* ~3.25. million years ago. More than 1 million years ago, *Homo erectus* was building huts from stones, branches and furs. Clothing might have been used by humans 120,000 years ago. Throughout history, humans have used these behavioural adaptations to create a microclimate next to the skin, and consequent body temperatures, that matched the same, comfortable, thermal state seen when naked and at rest in their East African origin (skin temperature 33°C, deep body temperature 37°C). Thus, anyone who reports feeling thermally comfortable is likely to have body temperatures that are very close to these (Tipton et al, 2007).

While an intellect-driven, technological form of evolution has its advantages and has been "successful", underpinning an explosion in the numbers of humans on the planet, it has two major drawbacks. Firstly, we become very dependent on technology for comfort, function and survival. This is particularly evident when it fails or is overwhelmed and we see tens of thousands of excess deaths

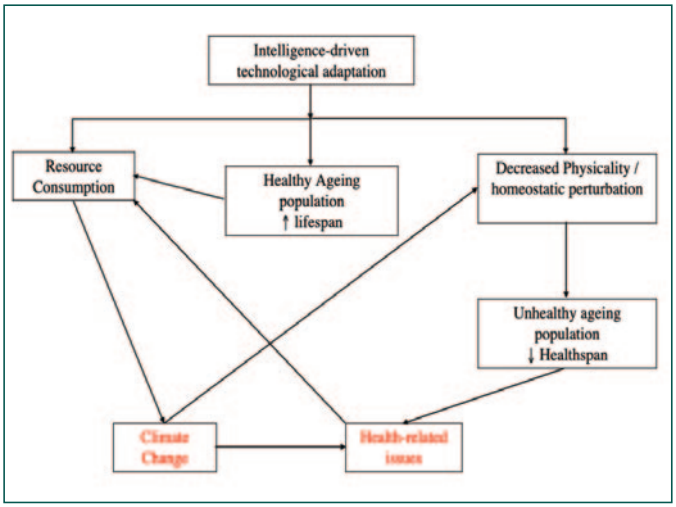

Figure 1. The link between intelligence-driven technological adaptation, climate change and health-related issues (from Tipton & Montgomery, 2022)

occurring during cold snaps and summer heat waves. Secondly, a technological approach can consume finite resources and, when the energy required comes from fossil fuels, the problem of climate change is compounded as we use more energy to cool, heat, pump and blow, and thereby enter a vicious and descending spiral.

Other reasons for understanding human physiology to help adapt to, and mitigate, climate change include the insight it gives into critical areas such as: vulnerable populations; nutrition; adaptation to heat; and cooling strategies to avoid heat illness.

Vulnerable populations

The populations vulnerable to climate change in the form of warming include:

- The very young
- Older people (>75 years)
- The pregnant
- The homeless
- Those living in poverty
- Those with comorbidities
- Those on some prescription drugs
- Those working in hot environments
- Those working in Personal Protective Equipment
- Those new to an environment

The reasons for the vulnerability of these groups differ. They range from the simple overwhelming of a compromised thermoregulatory system, to changes in the cardiovascular, biochemical and neurophysiological state of the body with warming and an individual's inability to respond to these changes. In all cases, understanding the physiological mechanisms underpinning these vulnerabilities enables targeted and optimised interventions to improve outcomes.

Nutrition

Physiologists are researching how dietary protein choices can help mitigate climate change. Plant-based protein rich foods are considered more sustainable for the environment than animal-based protein, but the ability of these different sources must also be considered in terms of the maintenance of muscle structure and function.

Heat adaptation

Humans can acclimatise to heat in as few as 5-10 days, this results in a range of physiological adjustments including lower body temperatures, improved cardiovascular function and improved functionality and thermal comfort in the heat. Thermophysiologists know a lot about this process and the associated improvements in resilience and functionality. We know less about the value of acclimatisation for different populations, including vulnerable populations. Heat acclimatisation alone would not have enabled humans to move too far away for their equatorial origins; wider migration required technology-based behavioural adaptation. It is critical that these technologies are effective but sustainable (e.g. natural cooling rather than air-conditioning); this is an area that requires more consideration (Figure 2).

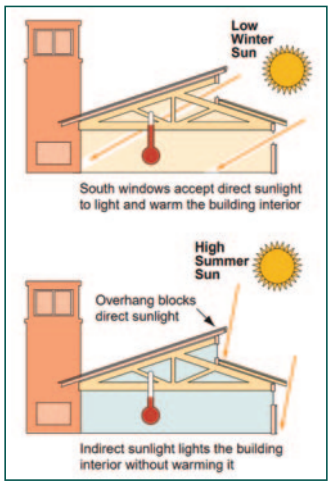

Figure 2. Zion Canyon visitor centre – built in 1960 with consideration of the thermal environment. A chimney to create airflow (can be closed) and strategically placed windows to use/avoid radiant heat.

Effective and sustainable cooling strategies

By far the best way to cool a hot human is to understand how the body attempts to lose heat naturally, and then augment these processes. So it is, that hand immersion in cold water or fanning, that allow the body to deliver heat to the skin and then help remove it, are more effective than ice vests, air and liquid conditioned garments that try and overwhelm the thermophysiological responses of the body.

Gaps in our current understanding

Despite the above, there remain important gaps in our understanding around topics like: the response of different populations to chronic heat exposure; how different co-morbidities and prescription medicines interact in the presence of heat; the relationship between increased heat stress and mental health and neurological conditions; the relationship between heat and immune function; the response of cells to heat at the molecular and biochemical level; individual variation in the responses to heat and differing susceptibility to heat illness; the best cooling strategies for those with differing disabilities. We need to know more in these areas.

Coordinated rapid action across research and policy

We have provided just a few examples of how an understanding of physiology can optimise the response to the causes and consequences of climate change. Understanding the physiological basis of differing vulnerability across the population can guide the design of built environments and the effectiveness of public health interventions, as well as prioritise research and preventative interventions. But, whilst physiology is a critical component of the responses to climate change, it is not enough. The path to comprehensive solutions also requires collaborative, integrated action by politicians, policy makers, civil servants, epidemiologists, engineers, architects, climate change scientists, behavioural psychologists, healthcare professionals, botanists and others - to provide fundamental, comprehensive understanding of what humans can tolerate, what needs to be achieved and how it might be achieved. The silos in which expertise mostly exist, as a result of the way we learn more and more about less and less, must be deconstructed, and the response to this existential challenge must be collaborative and prioritised.

A Heat Resilience Strategy for the UK

There is an urgent need for a heat resilience strategy, founded on an understanding of how the human body works and fails, that coordinates expertise, governments, businesses and communities across the UK to improve resilience to climatic extremes. This needs to be facilitated and enabled by informed policy; too often the translation of scientific findings into policy is interrupted or overlooked; this could be a firm requirement of funding bodies. In calling for a human-centred multi-stakeholder heat resilience strategy, The Physiological Society has recommended:

i. The establishment of a Heat Adaptation Research Exchange Taskforce, chaired by the Cabinet Office working closely with other government departments and devolved administrations. This Taskforce should tackle

research gaps and increase the speed of research translation into policy and action.

ii. The formation of a Human-Centred Climate Adaptation Design and Planning Institute to accelerate the adaptation of the built environment to higher temperatures, with governments across the UK mandating thermally efficient design principles and promoting the use of green infrastructure.

iii. A requirement that all employers develop a physiologically informed and sustainable plan for workers during extreme heat events to protect health, safety, wellbeing and productivity, including introducing statutory guidance on maximum temperatures for different levels of activity and types of Personal Protective Equipment worn.

iv. Bringing together public health professionals from across the UK and devolved governments, local authorities, and charities to deliver a public health campaign and expanded early warning systems focused on supporting vulnerable groups to improve their long-term resilience to heat and preparedness for heatwaves.

It is only through the seamless integration and collaboration between disparate groups that we can optimise our response to a climate threat that is not waiting for us.

References

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