

The human thermoneutral and thermal comfort zones: Thermal comfort in your own skin blood flow

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Human thermoregulation is achieved via autonomic and behavioral responses. Autonomic responses involve 2 synchronous ‘components’. One counteracts large thermal perturbations, eliciting robust heat loss or gain (i.e., sweating or shivering). The other fends off smaller insults, relying solely on changes in sensible heat exchange (i.e., skin blood flow). This sensible component occurs within the thermoneutral zone [i.e., the ambient temperature range in which temperature regulation is achieved only by sensible heat transfer, without regulatory increases in metabolic heat production (e.g., shivering) or evaporative heat loss (e.g., sweating)].¹ The combination of behavior and sensible heat exchange permits a range of conditions that are deemed thermally comfortable, which is defined as the thermal comfort zone.¹ Notably, we spend the majority of our lives within the thermoneutral and thermal comfort zones. It is only when we

are unable to stay within these zones that deleterious health and safety outcomes can occur (i.e., hypo- or hyperthermia). Oddly, although the thermoneutral zone and thermal preference (a concept similar to the thermal comfort zone) has been extensively studied in non-human animals, our understanding of human thermoregulation within the thermoneutral and thermal comfort zones remains rather crude.

Kingma et al.² have begun to decipher the biophysical criteria dictating the human thermoneutral and thermal comfort zones. Their analyses produced 3 primary findings. First, the thermoneutral zone is not constrained to an ambient temperature range, alone. Rather, it also depends on skin and internal temperatures. Second, the thermal comfort zone is smaller than the thermoneutral zone. And third, in a more applied (i.e., real world) state the thermoneutral and thermal comfort zones are shifted and widened. These findings have implications regarding the design of metabolic studies and the built environment. However, the true utility of these data may be that they provide a framework from which hypotheses can be developed regarding the mechanisms and modulators of thermoregulation within, and dictating the boundaries of, the human thermoneutral and thermal comfort zones.

The analyses of Kingma et al.² indicate that a given ambient temperature within the human thermoneutral zone does not always ensure that sweating or shivering will be prevented. Instead, the thermoneutral zone is also dependent on skin and internal temperatures. Skin blood flow is dictated by skin and internal temperatures,³ and skin blood flow modifies insulation and therefore, sensible heat exchange. Hence, such findings highlight the importance of understanding the

control of skin blood flow within, and how skin blood flow dictates, the thermoneutral zone. Unfortunately however, such knowledge is limited, and is based largely on data derived from young, healthy people.⁴ This is not ideal, as there are likely instances in which the control of skin blood flow within thermoneutral conditions is altered. For example, a case study of one 73 year old male found that, compared to younger individuals, the skin blood flow responses during moderate changes in skin temperature, which fall within the thermoneutral zone, were relatively sluggish.⁴ This suggests the thermoneutral zone is altered with age, but experimental evidence is required. Thus, the data from Kingma et al.² highlight the importance of understanding how alterations in the control of skin blood flow impacts the human thermoneutral zone.

By constraining their model to skin temperatures classically described as being thermally comfortable, Kingma et al.² have uniquely demonstrated that the human thermal comfort zone comprises a smaller span of ambient temperatures than the human thermoneutral zone. Interestingly, this is in contrast to the prevailing wisdom that the thermoneutral and thermal comfort zones are virtually indistinguishable.⁵ Thermal comfort dictates the initiation of thermoregulatory behavior.⁶ Therefore, these analyses suggest that behavior is initiated prior to the boundaries of the thermoneutral zone being reached. Notably, this is in contrast to findings indicating that slight increases in shivering or sweating are evident upon the decision to behaviorally thermoregulate.⁷ This discrepancy is likely the result of the imposed, thermally comfortable, skin temperatures. Nevertheless, the utility of these analyses, at least partially, lies in their quantitative nature, providing a basis from which further hypotheses can be tested. Thus, experimental research is

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required in order to understand the relationship between the human thermal comfort and thermoneutral zones, as well as circumstances in which any apparent relationships are altered.

Another novel aspect of the analyses by Kingma et al.² was the addition of a functional circumstance. Through modifying insulation and metabolic rate this analysis simulated a person wearing a business suit and conducting light office work. Their data revealed that the human thermoneutral and thermal comfort zones are shifted to lower ambient temperatures and a wider range of ambient and skin temperatures, when compared to the nude, supine condition. This was an important inclusion seeing as though we spend most of our time clothed and in conditions above basal metabolic rate. Thus, there is real world applicability of these analyses. Again however, the value of these data may be that they provide information from which hypotheses can be developed. For instance, the impact of clothing and slight changes in metabolic rate on mechanisms and modulators of skin blood flow

and body temperatures within the thermoneutral and thermal comfort zones remain virtually unknown. Such a real world understanding is important, as it would help identify those populations with altered thermoneutral and/or thermal comfort zones, which would place them at an increased risk of deleterious health and safety outcomes during thermal insults.

The elegant analyses by Kingma et al.² provide novel insights into the determinants of the thermoneutral and thermal comfort zones in humans. Their data provide the groundwork from which further hypotheses can be developed and tested regarding understanding the mechanisms and modulators of temperature regulation within, and dictating the boundaries of, the human thermoneutral and thermal comfort zones. As highlighted, a particular emphasis should be placed on the control of skin blood flow. The importance of such research should not be downplayed. We spend the majority of our lives within the thermoneutral and thermal comfort zones. It is only when we are unable to stay within these zones that the risk of

deleterious health and safety outcomes increases. Thus, understanding the determinants of the human thermoneutral and thermal comfort zones in both function and dysfunction, will unlock important insights regarding this often overlooked, but most sensitive of thermoregulatory responses.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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