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Response to Simpson (2024): Standard heat stress indices may not be appropriate for assessing marathons

Significance:

We value comments on our research paper in a Commentary in this issue (Simpson, S Afr J Sci. 2024;120(1/2), Art. #16445). Acknowledging the Universal Thermal Comfort Index (UTCI)'s limitations in capturing individual physiological responses remains important; however, we argue for its appropriateness based on recent thermophysiology and heat exchange advancements during its development and broader alignment with standardised indexing efforts. Our original research paper set out with these considerations in mind, and our conclusions remain valid. We further argue for refinement of the UTCI for specific activities instead of using the PET. Finally, future efforts should focus on monitoring data in real-world scenarios to validate and improve thermal indices.

We thank Simpson[1] for his insightful commentary on our research paper[2], which critically examines the appropriateness of a *standard* heat stress index for a specific event. In our research, we chose the Universal Thermal Comfort Index (UTCI) to evaluate heat stress during a major ultra-marathon event. We acknowledge that while UTCI provides a broad overview of heat responses in the average person, and may not capture the specific physiological reactions and microclimatic conditions experienced by each athlete, this limitation is inherent to all heat-related stress indices.[3] We argue that the UTCI is the appropriate index to use, as it is based *on the most recent scientific progress in both thermophysiology and heat exchange theory.*[4,5] The validation of the physiological equivalent temperature (PET) vs UTCI (or other indices) was beyond the scope of our paper, because it has been done numerous times.[6,7] Our conclusions, as we set out in our objectives and data analysis, remain valid and are supported by Simpson's own calculation of the UTCI, despite his criticism of the index – which will hold true in many other comparisons as well.[3,8]

However, to verify our decision to use the UTCI, we will briefly examine the history of this index within the greater bioclimatic community. The UTCI was developed to consolidate the wide range of thermal comfort indices – by 2015, more than 162 indices were documented in the scientific literature.[9] Subsequently, our selection aligns with the mission of the International Society of Biometeorology Commission 6 and the European COST Action 730, which aimed to standardise such indices.[3,10,11] Our decision to use the UTCI for assessing marathon running was also informed by other peer-reviewed studies.[12-14] The choice of an indicator that has been used in previous peer-reviewed studies also allows for comparisons between studies. The UTCI has also been applied to a range of sporting events[15], and physical activities[16]. Despite the limitations of the UTCI, the vision of the larger research community and published peer-reviewed articles directed our use of the index. According to us, there is no other peer-reviewed index that was specifically developed for a ultra-marathon (during which runners cover 89 km, over complex topography, with water points every 3 km, over various landscapes) which accounts for individual heat adaptations, training history, injury history, sweat rate, evaporative cooling, and race day hydration strategies.

Simpson rightly points out that the fixed metabolic rate (MET) that is prescribed by the UTCI might have underestimated the METs of the runners. However, the metabolic rate parameters are derived from Fiala's multi-node human physiology and thermal comfort model, which is widely accepted as the most advanced thermophysiological model to date.[17-19] The UTCI-Fiala contains substantially more physiological parameters than the simple PET-Munich Energy-balance Model for Individuals (MEMI). A comparison between the MEMI model (and other basic metabolism models) and the UTCI-Fiala model[5] indicated that the UTCI-Fiala model was more accurate in representing the physiological responses in a variety of environmental conditions. A possible reason for this finding is the fact that the UTCI-Fiala model was built on studies which included athletes.[5,19] Just because the PET allows the user to change the MET, does not mean that the underlying model is fundamentally correct.

A similar argument can be used for the clothing model query. The UTCI clothing model dynamically[20] adjusts for increases and decreases in temperature, whereas the simple PET model assumes uniform clothing[21]. Due to the Comrades Marathon's early morning start, and especially when the event starts in Pietermaritzburg, runners typically dress in warm attire and remove clothing as the event continues throughout the day. However, we agree that the clothing can be tailored for specific activities, which could in some cases alter the conclusions drawn. Nevertheless, the PET will lead to less accurate findings than a model in which the UTCI is modified. Therefore, we suggest that future research must rather focus on refining the UTCI to also consider individual changes in MET and clothing.

Despite the above arguments, we reiterate that the goal of our original research paper was not to evaluate all 162 indices, but to specifically apply the UTCI (as used in other peer-reviewed studies) to examine the possible prevalence of heat stress among runners and predict the possible influence of a change in climatological conditions on the incidence of exertional heat illness among athletes due to a change in the event date.

According to Grundstein and Vanos[22], who were referenced in our paper, researchers who investigate thermal indices can be classified into two primary groups: the bioclimate and the physiology communities. Our approach aligns with the bioclimate perspective, focusing on mostly generalised and predicted physiological variables combined with advanced meteorological data. The comments of Simpson[1] suggest a more balanced perspective by contending for a more tailored approach. However, we suggest that this modification should be based on the UTCI.

Alternatively, and drawing from the climate modelling community, we recommend the ensemble approach for future research. This would require that future efforts are based on a variety of heat stress indices that are tailored for specific scenarios. Such an approach can assist researchers to find possible variations in outcomes and indices. Similar to the Coupled Model Intercomparison Project Phase 6 (CMIP6) and Coordinated Regional Climate Downscaling Experiment (CORDEX) initiatives[23,24], the ensemble approach can help future researchers to strengthen the accuracy of conclusions when using heat stress indices.

We value Simpson's Commentary as it compels researchers to expand on existing research approaches, pointing towards more nuanced and detailed investigations into heat stress during physical activities. We also recognise that the choice of the applied heat stress index can significantly impact study outcomes, as was also the case with our study. Therefore, despite the value of the UTCI in providing researchers with a broader understanding of the thermal environment, the ideal would be to supplement the UTCI with local, micro-meteorological, and physiological data that are specific to the conditions and participants involved in a specific event. However, since the publication of the paper, we have engaged in more than six thermic-related investigations in collaboration with medical and sports scientists, especially focusing on high-level track and field, and road running events. These efforts aim to enhance our understanding of the correlation between environmental conditions and athletes' physiological responses to these conditions. We hope that these investigations will further contribute to the refinement of heat stress indices for use in real-life scenarios. Ultimately, the aim is to improve our understanding of the role that environmental factors play in sports performance and injury risk.

Competing interests

We have no competing interests to declare.

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