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Human Responses in Heat – Comparison of the Predicted Heat Strain and the Fiala Multi-node Model for a Case of Intermittent Work

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Abstract

The two most widely used mathematical models of human thermal regulation include the rational Predicted Heat Strain (PHS) (ISO7933:2004) [1] and the thermophysiological model by Fiala (version FPCm5.3, *ErgonSim*, Germany) [2]. The approaches of the models are different, however, they both aim at providing accurate predictions of the thermophysiological responses to thermal environments of an average person. The aim of this study was to compare and analyse predictions of the two models against experimental data. The analysis also includes a gender comparison. The experimental data comprised of ten participants (5 males, 5 females, average values were used as input) conducting an intermittent protocol of rotating tasks (cycling, hand rotation, stepping and arm crank) with breaks ranging between 134-291 W/m² in a climatic chamber (34°C, 60% RH) [3]. The validation consisted of the graphical comparison against experimental data from 2.5 hours of data of rectal temperature (Fig. 1a) and mean skin temperature based on contact thermometry from four body locations (Ramanathan [1964] equation [4]) (see Figure 1b).

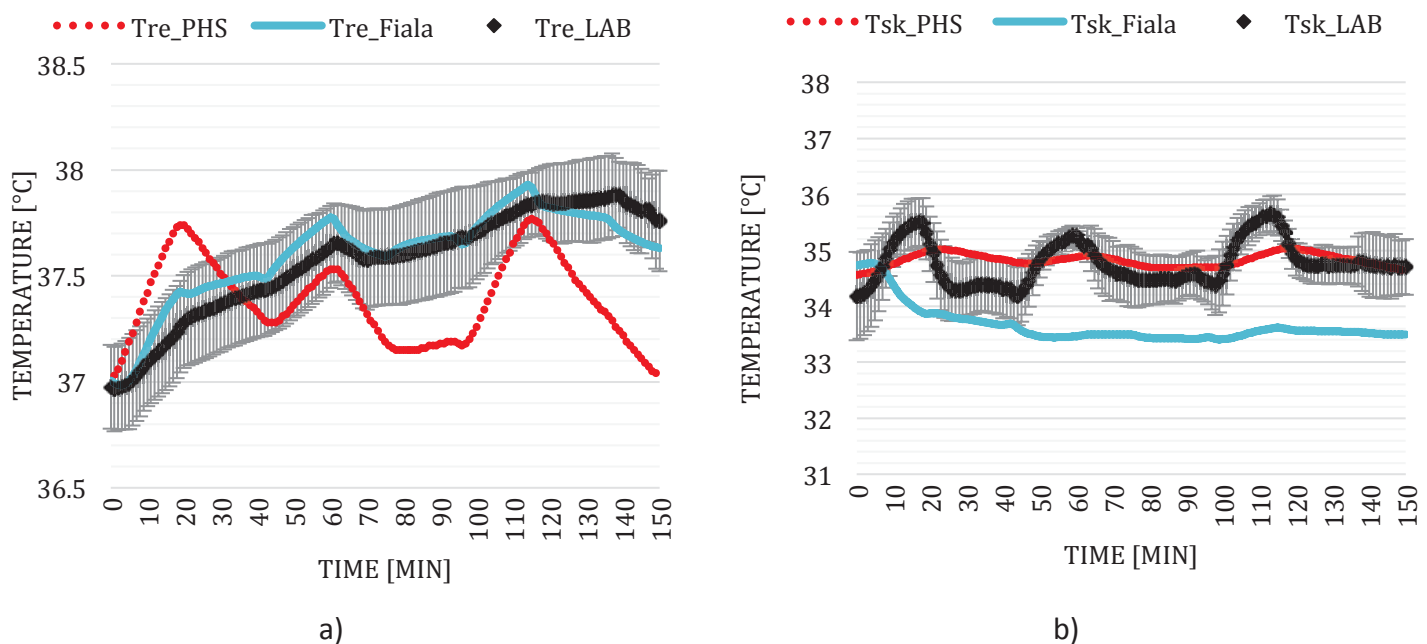


Figure 1. Comparison of experimental data (mean and SD) and predicted values by PHS and Fiala models for the average male: a) Rectal temperature (T_{re}) and b) Mean skin temperature (T_{sk}).

The PHS model over-predicted rectal temperatures in the first phase for males and the cooling effectiveness of the recovery periods, for both males and females. As a result, the PHS simulation underestimated the thermal strain in this context. The Fiala model accurately predicted the rectal temperature throughout the exposure. The experimental mean skin temperature fluctuated due to changes in the activity phases. This was not reflected in any of the models however, it was more so in the PHS simulation model and not at all in Fiala. As both models predicted responses more accurately for males than females we suggest that in future development of the models it is important to take this result

into account. The paper further discusses possible sources of the observed discrepancies and concludes with some suggestions for modifications.

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