LUND UNIVERSITY

Human responses in heat – comparison of the Predicted Heat Strain and the Fiala multi-node model for a case of intermittent work

Lundgren Kownacki, Karin; Martinez, Natividad; Johansson, Bo; Psikuta, Agnes; Annaheim, Simon; Kuklane, Kalev

2016

Document Version:

Publisher's PDF, also known as Version of record

[Link to publication](#)

Citation for published version (APA):

Lundgren Kownacki, K., Martinez, N., Johansson, B., Psikuta, A., Annaheim, S., & Kuklane, K. (2016). *Human responses in heat – comparison of the Predicted Heat Strain and the Fiala multi-node model for a case of intermittent work*. 50-51. Abstract from 11th International Meeting on Thermal Manikin and Modeling, Suzhou, China.

Total number of authors:

6

General rights

Unless other specific re-use rights are stated the following general rights apply:

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: <https://creativecommons.org/licenses/>

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

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

Karin Lundgren-Kownacki^{1,*}, Natividad Martínez², Bo Johansson¹, Agnes Psikuta², Simon Annaheim², Kaleb Kuklane¹

¹ Department of Design Sciences, Lund University, Sweden.

² Laboratory for Protection and Physiology, Empa, Switzerland.

*Corresponding author: Karin Lundgren-Kownacki, E-mail: karin.lundgren_kownacki@design.lth.se

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.

References:

- [1] Malchaire JBM (2006) Occupational heat stress assessment by the Predicted Heat Strain model. *Ind. Health* **44**: 380-387.
- [2] Fiala D, Lomas KJ, Stohrer M (2001) Computer prediction of human thermoregulatory and temperature responses to a wide range of environmental conditions. *Int J Biometeorol.* **45**: 143–159.
- [3] Lundgren-Kownacki K, Dahl M, Gao C, Jakobsson J, Linninge C, Song D, Kuklane K (2016) Exploring how a traditional diluted yoghurt drink can prevent heat strain during medium-intensity intermittent work. To be published.
- [4] Ramanathan NL (1964) A new weighting system for mean surface temperature of the human body. *J. Appl. Physiol.* **19**: 531–533.