PhD proposal:

Consideration of inter and intra-individual variability related to heat vulnerability factors in thermo-physiological model

Supervision team:
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Context:
Because of climate change, inducing increasingly long, frequent and intense heatwaves, and urbanization changing urban micro-climatic conditions (e.g. urban heat island effect), both outdoor and indoor overheating become a major issue for coties and public health. In this context, the PEPR VDBI project VF++ ("Cool Cities by and for Users: Integrating Soft, Green, and Grey Solutions to Promote the Health of Inhabitants in a Sustainable Environment") aims to study the links between urban planning/building, heat and health, as defined by the WHO, at the individual scale in order to contribute to creating sustainable cities and innovative buildings. The research goals of this project are mainly to develop methods to:

- Understand the interactions between physical environments and individuals' psychological and physiological reactions as well as their experiences of ambience and practices, depending on socio-spatial specificities,
- Analyze the effects of these interactions on health, in a context of overheating
- Assess the relevance and robustness of integrative heat-adaptation strategies with regards to health

The present work is a part of the VF++ project. More specifically, it focuses on individual vulnerability factors affecting physiological responses induced by thermal stress, and their numerical modeling for applications to thermal comfort and health.

Research question and objectives
Thermophysiological models simulate heat transfer between human body and environment, within the human body and thermoregulatory responses. They allow calculating thermal comfort, heat stress or heat strain indices. These models supported the development of exposure limits for industrial, military and sports applications. However, they generally simulate a specific population: young healthy "standard" men while many inter-individual variability factors (age, sex, height, weight, physical capacity, etc.) change the body thermal properties, the thermoregulation capacity and the individual heat vulnerability.

Moreover, physiological vulnerability evolves over time. At short-term, repeated exposure can deteriorate the recovery capacity because of thermophysiological fatigue or heat-related illness. Over several days, a prolonged exposure leads to physiological adaptions called acclimatization. These adaptations decrease the physiological strain, the risk of heat-related illness and improve the physical performance in hot environments. These effects disappear in the absence of regular exposure. The acclimatization ability varies according to some individual vulnerability factors such as age. However, the effects of history exposure, notably acclimatization, are not taken into account in current thermo-physiological models.

Thus, the aim of this thesis is to better understand the effects of inter and intra-individual vulnerability factors and exposure history, and to integrate them in thermo-physiological models. Eventually, the models will have to be adapted to different types of vulnerable populations.

Methods

The physiological variability and vulnerability factors will first be studied based on a in depth literature review, interviews with physicians and researchers, and data produced by VF++ partners or by other projects (H3Sensing, MuSIC). The work will then focus on modeling the physiological factors identified as the most impactfull in thermophysiological models. For that purpose, the relevance of different models (e.g. Gagge's, JOS-3 and NHTM) will be discussed through model analysis and inter-comparisons. The models will be adapted and tested against physiological data collected in the project and in partner projects.

In relation with other VF++ tasks, this PhD student will participate in the definition of output indicators from thermo-physiological models and their thresholds to study health risk. According to the outputs selected, a meta-model of health risk distribution according to individual parameters distribution in a population and simplified thermal exposure data could be developed.

Expected Skills

- Education: Master's degree in thermal or thermo-physiology sciences
- Knowledge: heat transfer
- Programming (python), Data processing, literature review
- A strong interest in collaborative and interdisciplinary work and in the VF++ project

Contacts and Application Submission

Send CV, cover letter and Master's grade by email before April 30th to: lucie.merlier@insa-lyon.fr, marika.vellei@u-bordeaux.fr, Adrien.TOESCA@cstb.fr and celia.sondaz@insa-lyon.fr

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