Impact of human body shape on convective heat transfer coefficient

Health Theme

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MOTIVATION

Warming climate is regularly exposing more humans to **extreme heat**. Strategies for individuals to cope with the heat could be optimized using quantitative models of thermal exchange between humans and their surroundings. However, relevant studies focused only on **average young Caucasian adults[1]**, consequently there exists a **limited understanding of the effect of different body shapes on heat transfer with the surrounding. This knowledge is particularly important because** heat disproportionally impacts the elderly, children, and individuals with high body mass index (BMI).

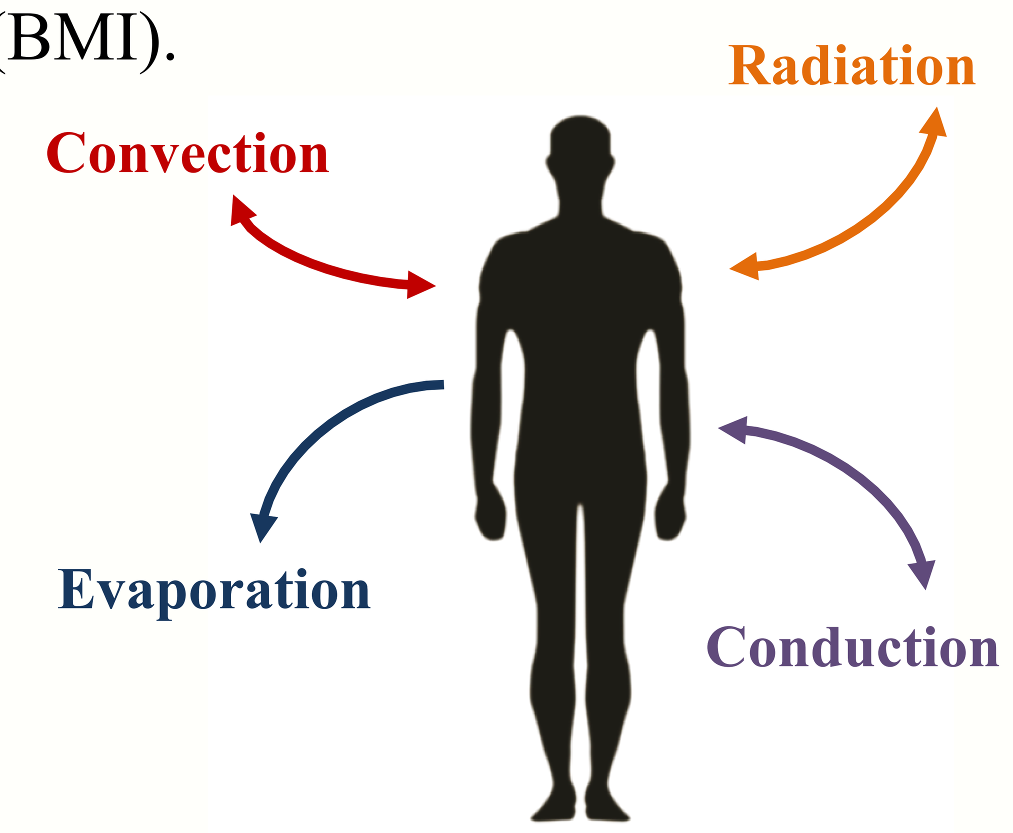

Fig.1 Modes of heat exchange between humans and environment

OBJECTIVE

To begin to address this knowledge gap, we **numerically compute the convective heat transfer coefficient (CHTC) for body shapes** representing the diverse population of United States.

METHODOLOGY

- Preparing 3D human models representing **1-99 percentile[2]** variation in height and BMI of adults in the USA using **Meshmixer** software.
- Conducting **Non-Isothermal flow** simulation on the manikins using **COMSOL Multiphysics** software.
- Computing the **average whole-body convective heat transfer coefficient**.

MODEL PARAMETERS

Parameter	Value
Turbulence Model	Low Reynolds number k-ε
Air Speed	2 m/s
Turbulence Intensity	5%
Turbulent Length Scale	0.05 m
Air Temperature	25°C
Human Body Temperature	35°C

KEY FINDINGS

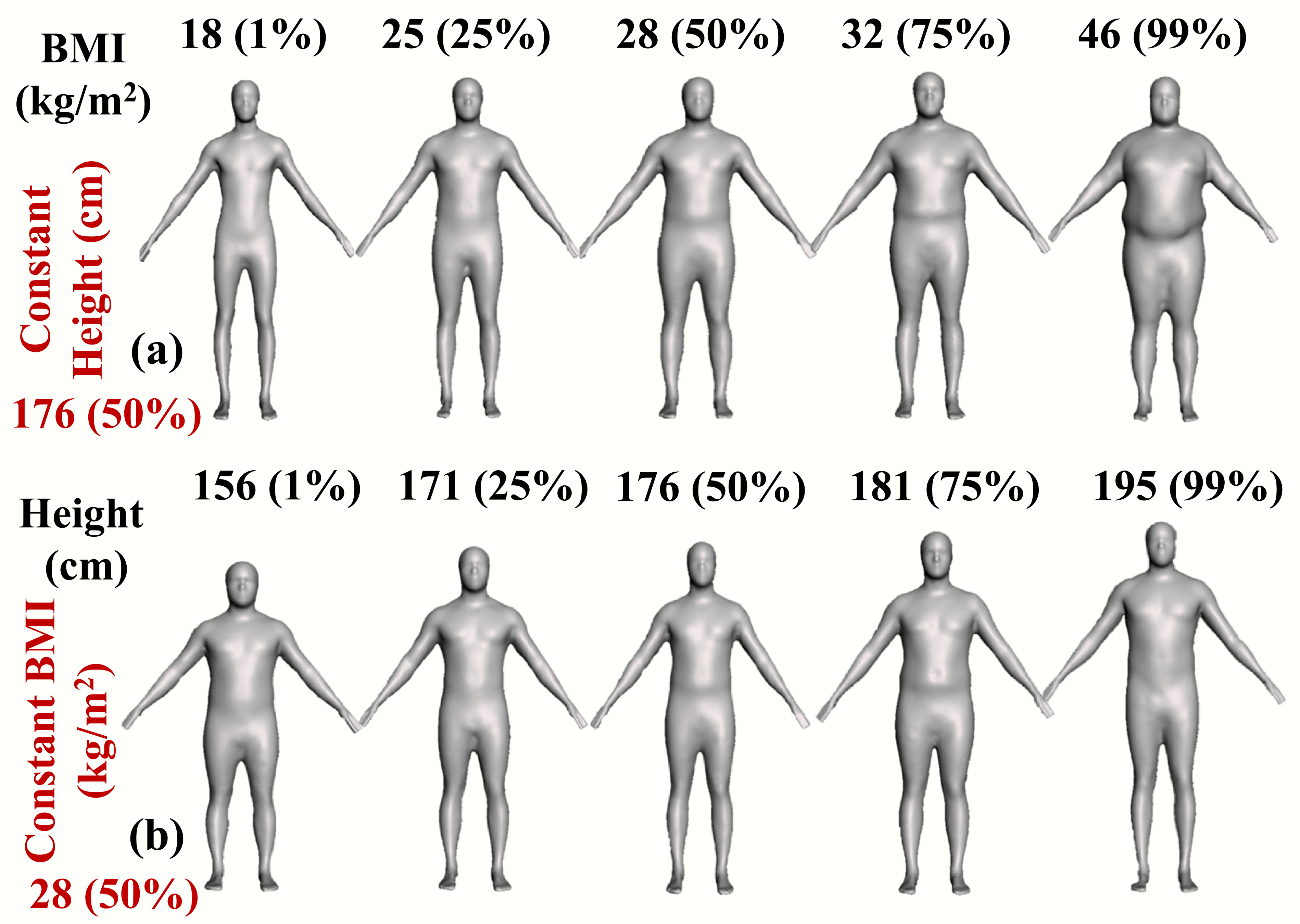

Fig.2 **[a]** Manikins with constant 50th percentile height but varying BMI
[b] Manikins with constant 50th percentile BMI but varying height

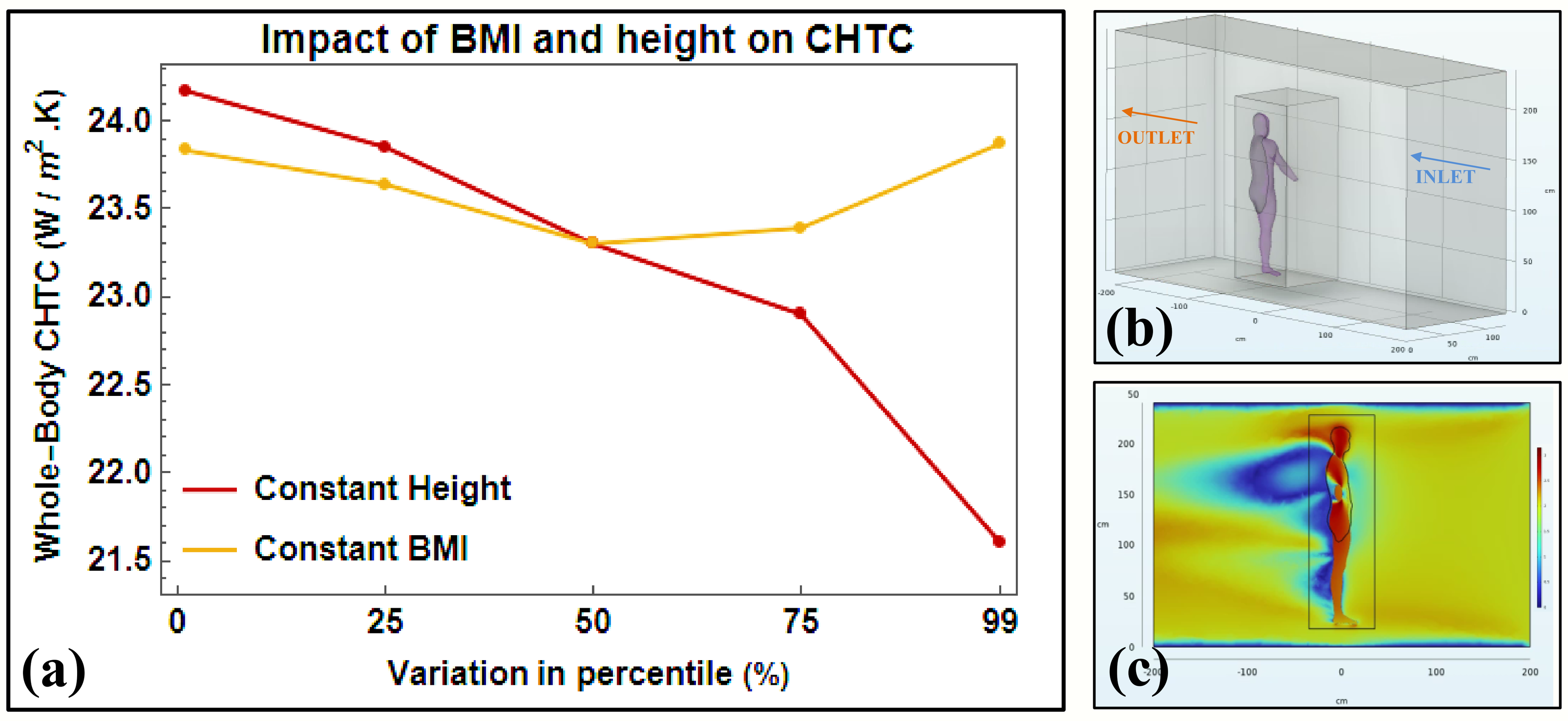

Fig.3 **[a]** Impact of BMI and height on CHTC, **[b]** Design of the virtual wind tunnel in COMSOL, **[c]** Example airflow distribution around the manikin

FUTURE WORK

- To extend the research to study the female body shapes
- To numerically analyze the impact of air speed and turbulence on CHTC and experimentally validate it using the state-of-the-art Thermal Manikin ANDI in a walk-in wind tunnel.

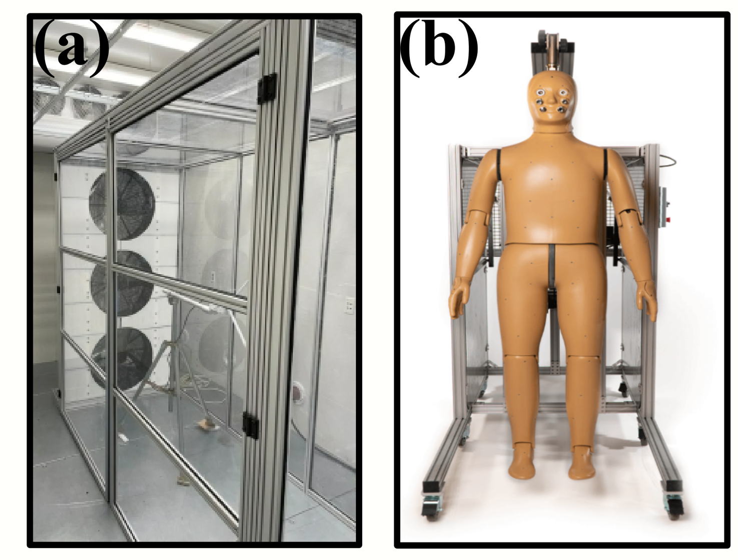

Fig.4 **[a]** Walk-in wind tunnel at WCPH, **[b]** Thermal Manikin ANDI[3]

ACKNOWLEDGMENT & REFERENCES

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[1] Jingxian Xu , Agnes Psikuta , Jun Lia, Simon Annaheim , René M. Rossi, Influence of human body geometry, posture and the surrounding environment on body heat loss based on a validated numerical model, Building and Environment 166 (2019) 106340
[2] Konrad Rykaczewski, Lyle Bartels, Daniel M. Martinez, Shri H. Viswanathan, Human body radiation area factors for diverse adult population, International Journal of Biometeorology (2022)
[3] Thermal Manikin ANDI - Thermetrics

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