

Prediction of Core Body Temperature, Sweat Rate, Cardiac Output and Stroke Volume for Firefighters using a 3D Whole Body Model

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Purpose: The proposed project will determine the core body temperature (T_c), sweat rate, cardiac output and stroke volume for individual firefighters using a whole body computational model. The hypothesis of this research is that the harmful effects of heat-induced stress in firefighters can be negated by responding to the predicted values of T_c , sweat rate, cardiac output and stroke volume.

Design: The objectives for the project are defined by the following four aims: 1) Revise the existing human body model to incorporate the firefighting suit. 2) Adapt the existing model to recreate the results of the collected data during live burn studies. 3) Determine the variations in core body temperature (T_c), sweating rate, cardiac output, stroke volume and heart rate during live burn activities in real time. 4) Inform fire departments of the warning signs that may lead to adverse events when exposed to working in hot environment.

Methods: The firefighting data, comprising of the heart rate time series and variation of T_c with time for individual firefighters is initially analyzed. The project is then implemented using the whole body model, which comprises of two components: the Pennes bioheat equation to simulate the temperature distribution in the body, and an energy balance equation to determine the change in blood temperature during a process. There are two major inputs to the computational whole body model. One is the heart rate time series and the other is the geometry and physiological details of the individual firefighters. The model is updated with the firefighter's geometry, which includes the firefighting suit. The heart rate time series is used as an input to obtain the result parameters. T_c obtained from the model is verified with the actual variation of T_c over time.

Results: The results obtained from this research are T_c , sweat rate, cardiac output and stroke volume for individual firefighters. The baseline case for the computational whole body model, without the firefighting suit, has been completed and verified. The baseline model is now updated with new geometry, which includes the firefighting suit. The model has been further adapted to incorporate the initial and boundary conditions for the available live-burn data.

Conclusion: The results obtained from this project would enable us to quantify the heat stress and physical exertion levels. With the aid of the predictive model, an accurate assessment of the physiological effects of heat strain on firefighters can be estimated, while also accounting for the age, sex and differences in physical parameters. It can also be used to notify management officials of the hazards of exposure to heat strain on

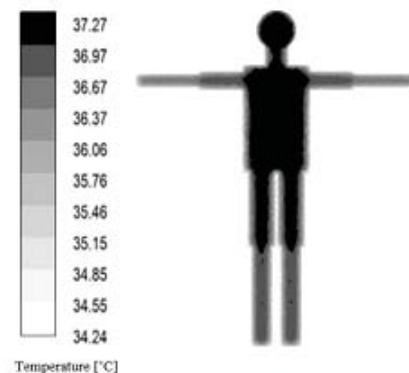


Figure 1: Steady state solution of human body model without firefighting suit at 25 °C

firefighters identifying potential adverse events before they occur. Using these results, use of existing physiological monitoring devices can be limited or be modified to analyze health hazards and safety risks.

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