



Algorithm to Calculate Human Calorie Expenditure Based on a Predicted Heat Strain Model

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Abstract

A predicted heat strain model (PHSM) has been used to evaluate the thermal stress experienced by a human subject during exercise in a hot environment. In the PHSM, equations describing the thermal balance of a human body predict the physiological response, including sweat rate and internal temperature, for a given metabolic rate. In this paper, we propose that the heat balance equations of the PHSM may be used in reverse, to calculate the metabolic rate from physiological and environmental sensor readings. We develop distinct algorithms for ordinary situations, as well as a common, extreme case, in which the heat strain exceeds the body's ability to dissipate heat through evaporation of sweat. Compared with the algorithm currently used in commercial calorie expenditure monitors, the new algorithm we propose may provide a more reliable and precise calculation.

PHSM

$$M = C_{res} + E_{res} + C + R + E + S$$

M: Metabolic rate

C_{res} : Heat flow by respiratory convection

E_{res} : Heat flow by respiratory evaporation

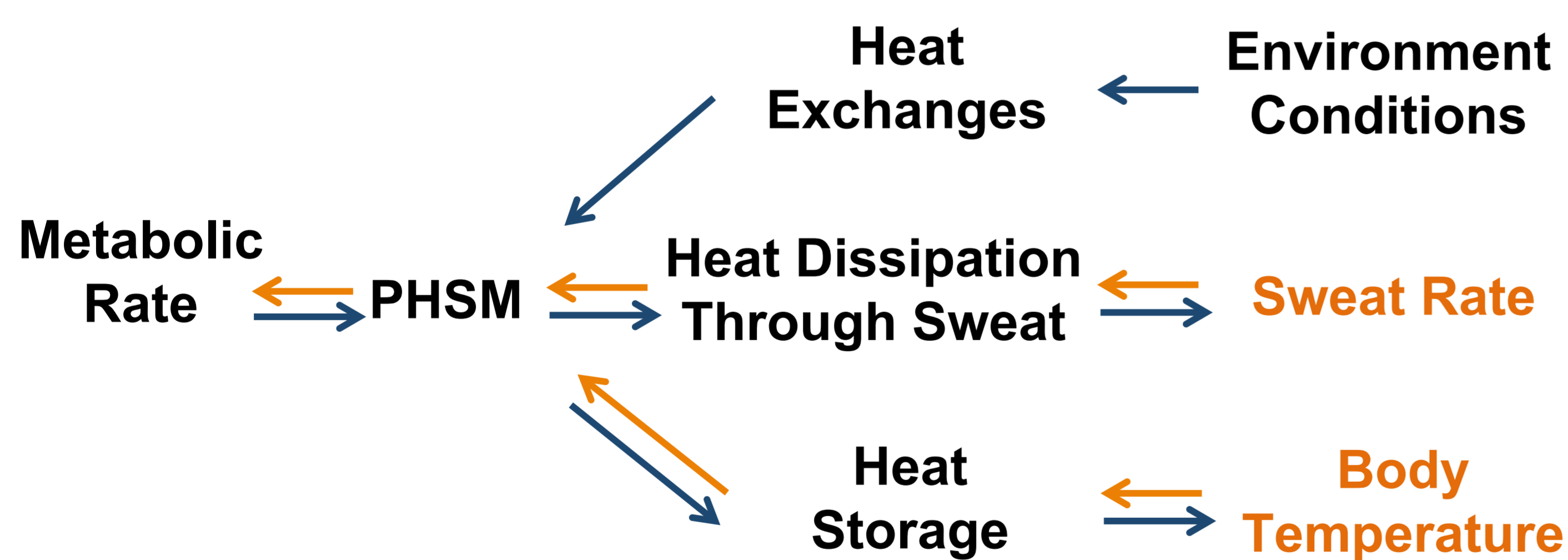
C: Heat exchange on the skin through convection

R: Heat exchange on the skin through radiation

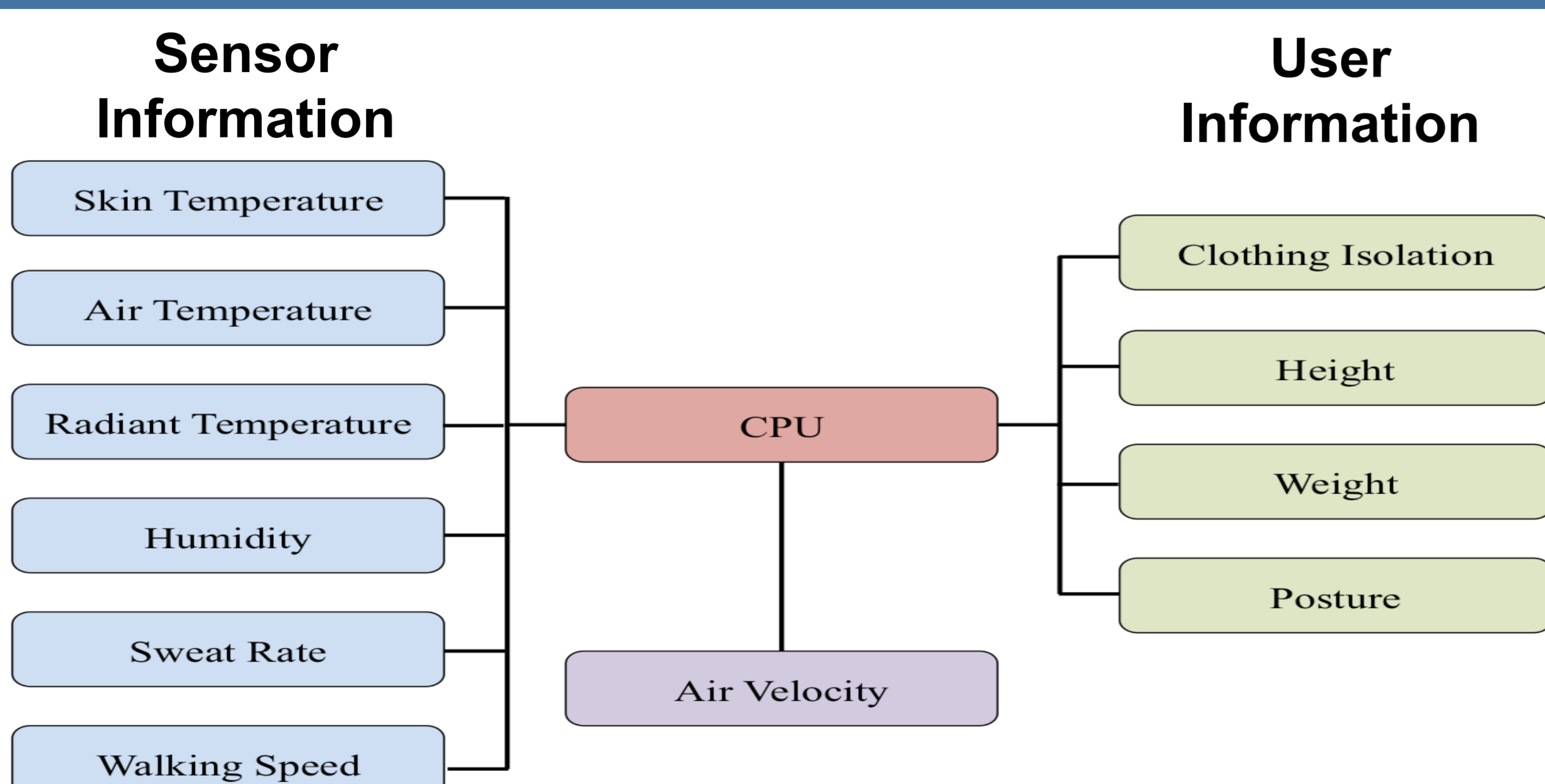
E: Heat exchange on the skin through evaporation

S: Heat storage

Model Theory

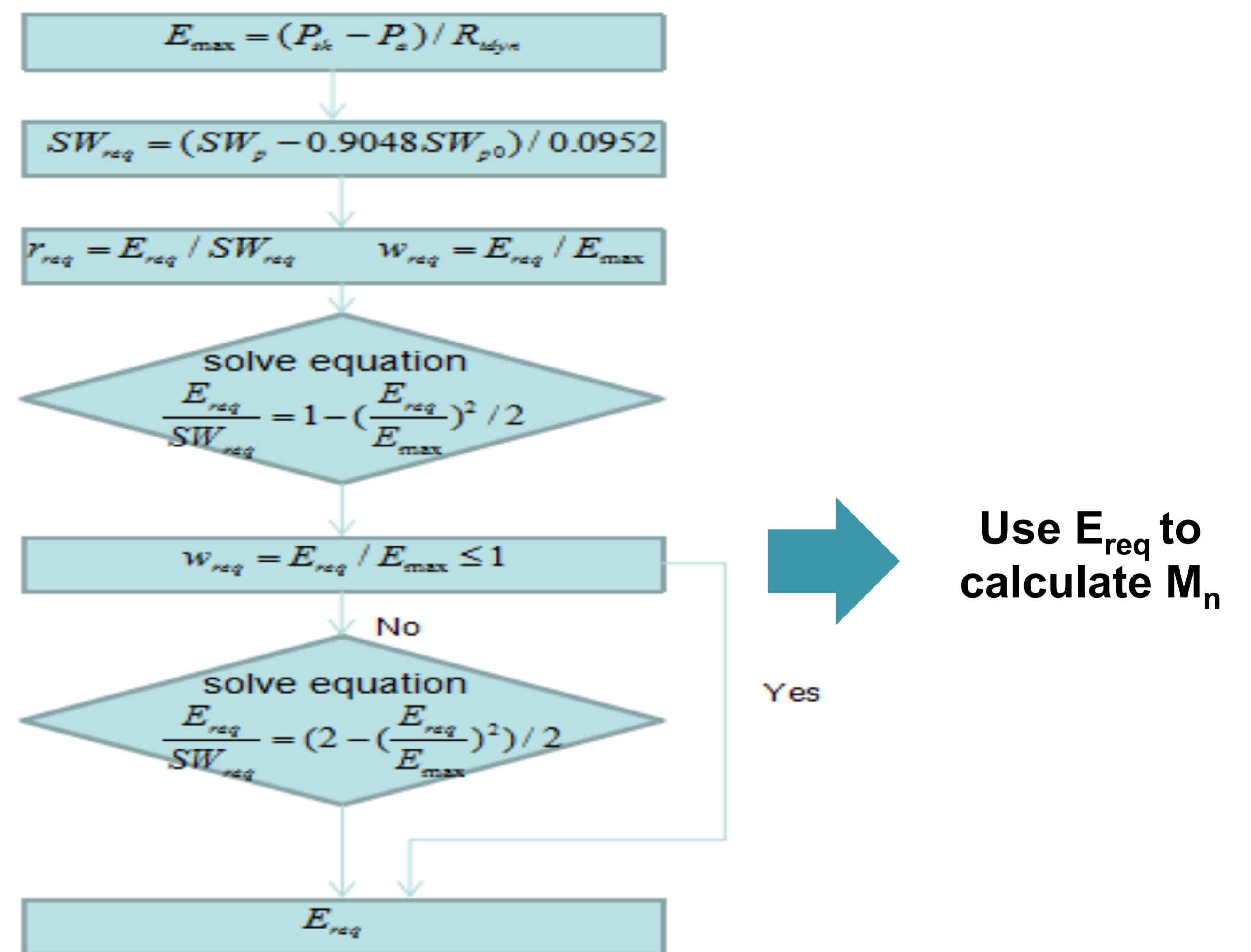


Proposal for Wearable System



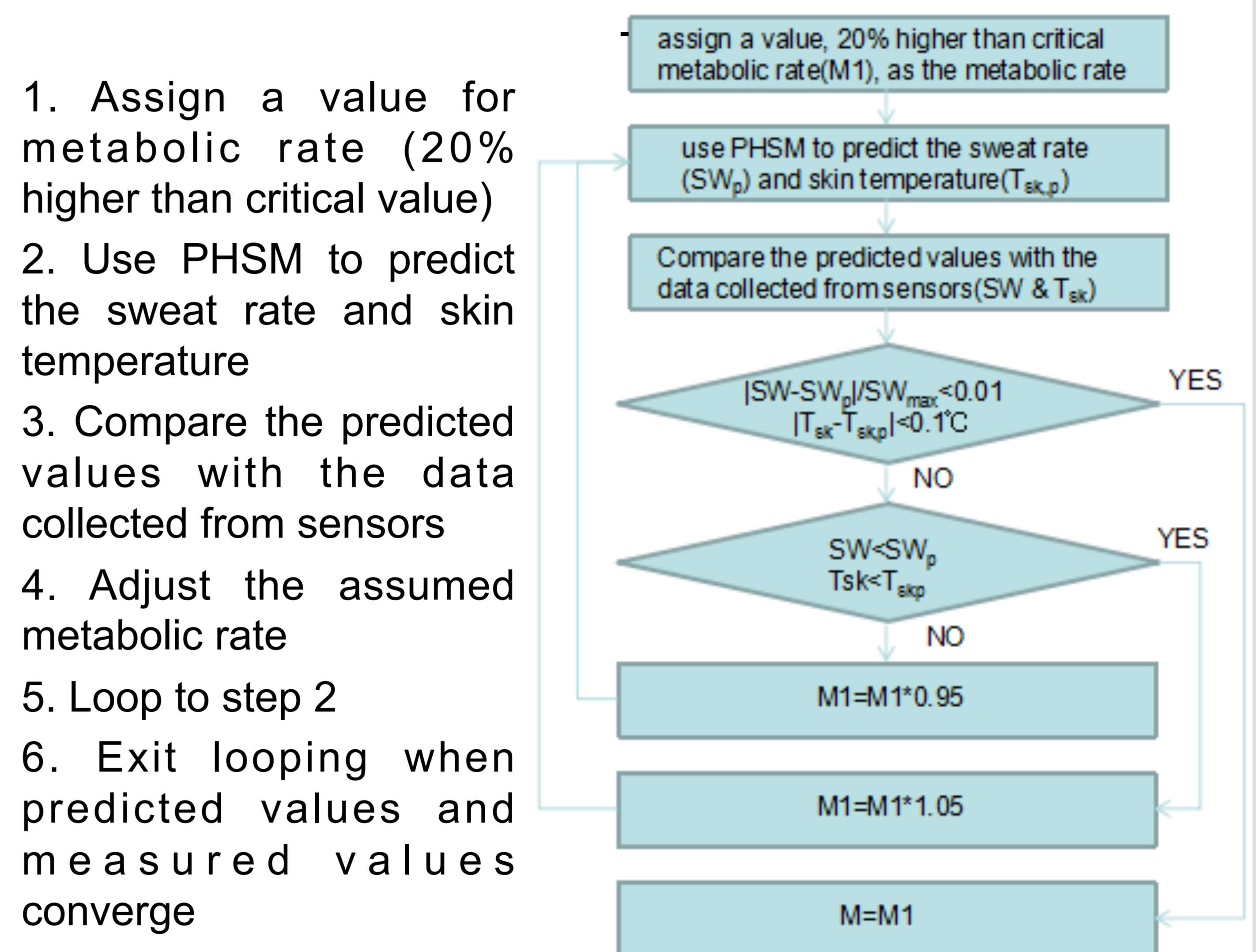
Algorithm Flow

Required Evaporative Heat Flow Calculation for M_n - Metabolic Rate in Normal Conditions



M_n : Metabolic rate in normal condition

Iterative Algorithm for Metabolic Rate Determination, M_1 - Metabolic Rate in Extreme Conditions



Metabolic Rate Determination

If $M_n \leq$ Threshold Metabolic Rate, $M = M_n$

If $M_n \geq$ Threshold Metabolic Rate, $M = M_1$

Conclusion

- We review and analyze the PHSM, its procedure, and algorithms, with the objective of applying it to calorie expenditure monitoring.
- Based on whether heat can be dissipated through sweating efficiently, we define two categories, normal cases and extreme cases.
- We then propose a dual method to calculate metabolic rate based on these conditions. A sensor system which has the potential to precisely monitor calorie expenditure is also proposed.