



# A Wearable Calorie Expenditure Monitoring Device Based on Predicted Heat Strain Model

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## Abstract

Existing wearable fitness trackers use algorithms to estimate metabolic rate from pedometers and heart rate monitors. These systems have two known sources of inaccuracy: first, the relationship between heart rate and oxygen uptake varies between individuals; second, a variety of conditions, such as stress, illness, dehydration, high temperatures, and environmental humidity can contribute to a heart rate increase, even when the subject is not experiencing metabolic rate changes and the oxygen uptake stays the same. To avoid these sources of inaccuracy, we propose a new wearable calorie expenditure monitoring device based on a predicted heat strain model (PHSM). PHSM has been used to evaluate the thermal stress experienced by a human subject during exercise in a hot environment. Using the heat balance equations of the PHSM in reverse, we can calculate the metabolic rate from physiological and environmental sensor readings. We propose a wearable system that uses PHSM to calculate the metabolic rate with several temperature sensors, a humidity sensor, a sweat rate sensor, and an accelerometer. The collected data will be sent to a smart phone with Bluetooth. A machine-learning algorithm will use the accelerometer data to determine walking speed and posture. Other information (age, environmental conditions) will be obtained from the user and the Internet.

## PHSM

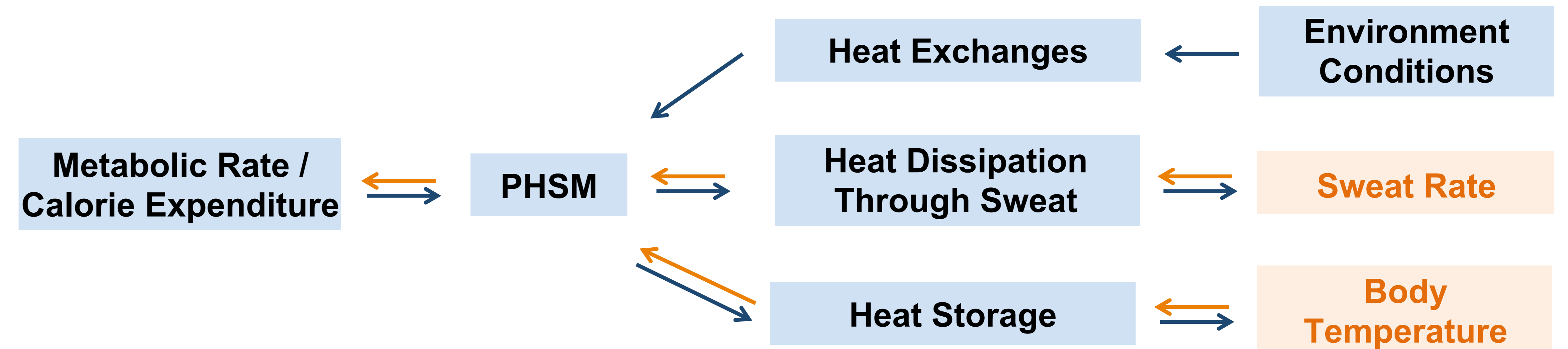
An equation that describes a predictive heat strain model (PHSM) from the ISO 7933 standard ) is summarized as:

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

- M : Metabolic rate (calorie expenditure)
- $C_{res}$  : 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

PHSM predicts sweat rate and body temperature from environmental conditions, and an assumed metabolic rate (blue arrows). Our proposed *inverse PHSM* would predict metabolic rate from environmental conditions, and measurements of sweat rate and body temperature (red arrows).



## Wearable System and Experimental Design

A smart-phone application is being developed to collect data from a wearable platform, and to use PHSM to estimate calorie expenditure. Reference calorie consumption data will be obtained by indirect calorimetry, which is the accepted clinical standard.

