The self regulation of exercise performance in the heat

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INTRODUCTION:
Self-paced exercise intensity is thought to be regulated in anticipation of homeostatic catastrophe through the feedforward calculation of heat storage rate (HSR). However, estimations of mean body temperature ($T_{body}$) using a weighted average of rectal ($T_{re}$) and mean skin ($T_{sk}$) produces erroneous HSR. Since esophageal temperature ($T_{es}$) is a more sensitive index of core temperature, its inclusion in an estimate $T_{body}$ may better reflect changes in HSR.

Purpose: To compare estimates of HSR using a two-compartment thermometry model (CTM) with two different core temperatures and weighting coefficients in thermoneutral (TN) and hot (HOT) conditions.

METHODS:
Participants: five males (23.4±3.82 y, 73.68±7.27 kg, BSA 1.9 ±0.1 m$^2$) cycled at a fixed RPE on cycle ergometer until power output declined to 70% of the initial 3-min average.

Conditions: The ambient conditions were TN (25.2±0.7°C; RH 31.0±4.0%) and HOT (35.1±0.8°C; RH 23.7±4.7%).

Instrumentation: Esophageal, rectal and skin (7 sites) temperatures were measured continuously. Indirect calorimetry was measured continuously to determine metabolic heat production.

Rate of Heat Storage: calculated using partitional calorimetry (HSR$_c$) and from four CTM equations with typical weighted coefficients using thermometry (HSR$_t$).

CONCLUSIONS:
1) CTM are poor indicators of HSR with significant underestimation of HSR during TN which has been shown in previous studies
2) Theses results question the validity of a feedforward mechanism of exercise intensity regulation to prevent homeostatic catastrophe

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RESULTS:
Despite no difference in HSR$_c$ between HOT and TN in the first 5 min of exercise (Figure 2), power output was significantly lower in HOT vs TN by 15 min (p<0.01). In TN, estimates of HSR, using core/shell weighting, but not $T_{es}$ alone, showed negative HSR values between 0-3 min (Figure 3A,B, C). In contrast, HSR using $T_{es}$ for CTM (Figure 3B,D) show higher HSR from 3-6 min of exercise. A significant difference was observed in HSR for $T_{body}$ calculations with core defined by $T_{re}$ (Figure 3A,C) compared to core defined by $T_{es}$ (Figure 3B,D) during 3-4 min of exercise in HOT (p<0.05) and 3-6 min for TN (p<0.05).

Figure 1. The Borg RPE scale

Figure 2. Average rate of heat storage (kJ/min) during initial 5 minutes of exercise for TN and HOT

Figure 3. Estimates of heat storage rate using $T_{body}$ calculations with weighted coefficients of A) 0.79*T$_{re}$+ 0.21*T$_{sk}$ B) 0.9*T$_{es}$+ 0.1*T$_{sk}$ C) 0.9*T$_{es}$+ 0.1*T$_{sk}$ D) T$_{es}$ x = p < 0.05 for HOT; ǂ = p < 0.05 for TN.