Effect of Locomotion on Body Temperature Control Mechanism

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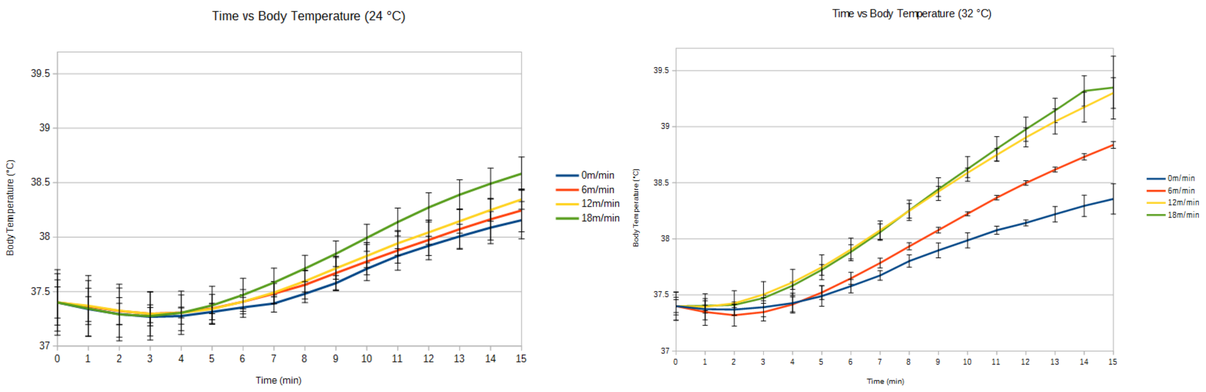
Motivation

Although humans' and other mammals' body temperature may fluctuate due to daily variation, their body temperature remain relatively constant. However, in some cases, they experience hyperthermia despite this thermoregulatory mechanism. For instance, a stimulant such as Methamphetamine (Meth) is known to cause life-threatening hyperthermia. The injection of Meth not only causes hyperthermia but also enhances locomotion, a movement of a body, which may complicate the temperature response. The objective of this research is to observe how various intensity level of physical activities taken in different ambient temperatures affect temperature dynamics. This will allow us to analyze thermoregulatory mechanism.

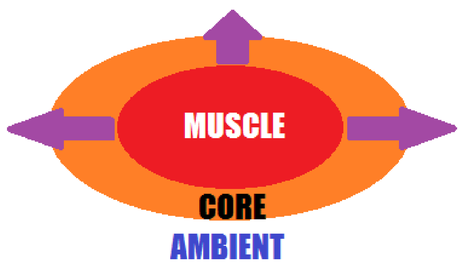
Constructing the Experiment

A total of 32 rats were seperated into two groups of 16 rats each; one group was tested in the cool enviornment (24°C) while the other group was tested in the hot environment (32°C). Each group was divided into 4 subgroups depending on their exercise intensity (i.e. 4 rats in each subgroup). Over 15 mins, rats were placed in a treadmill with a speed of 0m/min, 6m/min, 12m/min, and 18m/min around either the cool or the hot enviornment.



- We noticed the drop in temperature for 24 °C and the delay in temperature rise for 32 °C.
- In 32 °C, the slope of the temperature curve is more dramatic in increase of the treadmill speed than that of 24 °C.

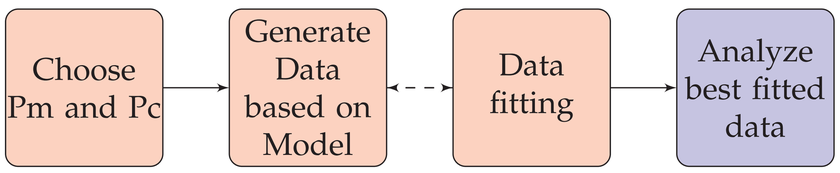
Method



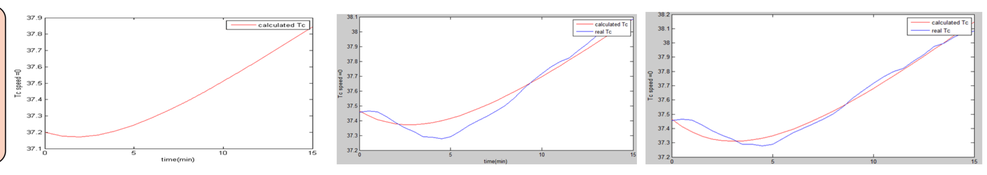
- Heat Dissipation from muscle to core (body) to ambient environment
- Muscle temperature increases as body movement increases
- Assume $\eta_{mc} = \eta_{cm}$ (i.e. the volume of muscle and the volumn of the core is the same)

$$\frac{dT_c}{dt} = P_c - \eta_{cm}(T_c - T_m) - \eta_{ca}(T_c - T_a)$$
$$\frac{dT_m}{dt} = P_m - \eta_{mc}(T_m - T_c)$$

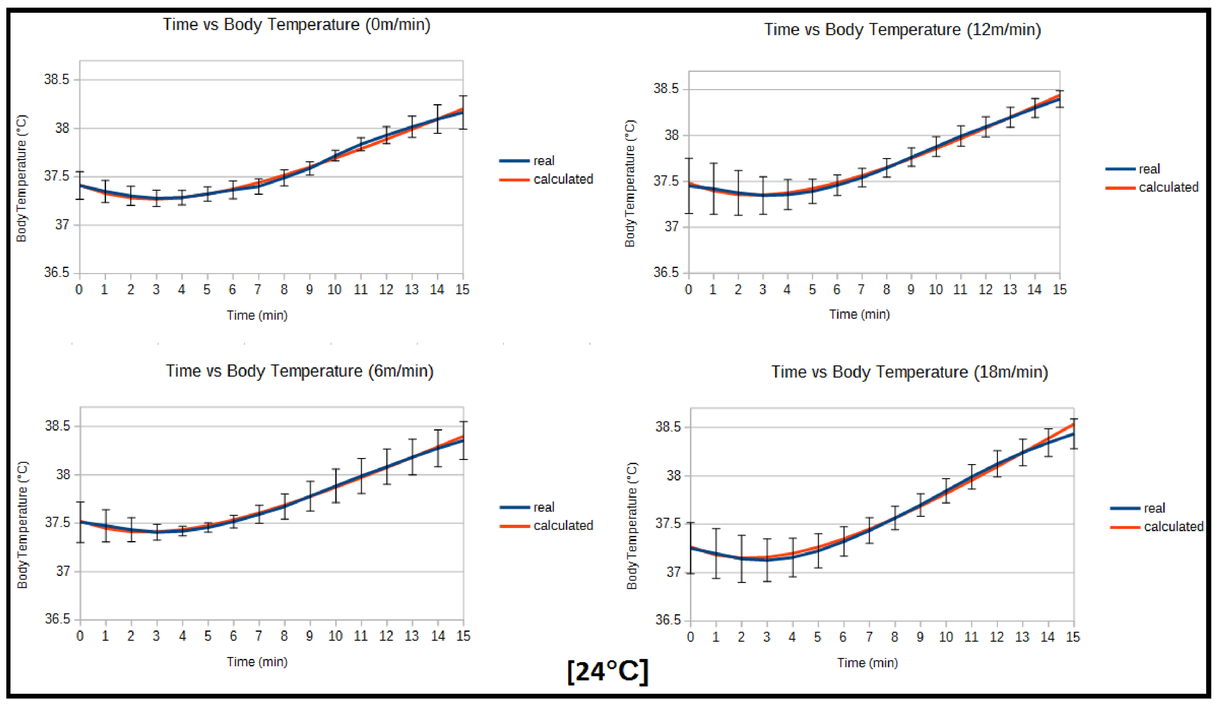
- P_c, P_m : heat production of the core (body) and heat production of the muscle
- T_c, T_m, T_a : core temperature (37.4 37.5°C), muscle temperature and ambient temperature (32°C or 24°C)
- η_{ca}, $\eta_{mc} = \eta_{cm}$: heat dissipation constant between core and the ambient enviornment ($\frac{1}{50}$ in our experiment) and heat dissipation constant between core and muscle ($\frac{1}{10}$ in our experiment)

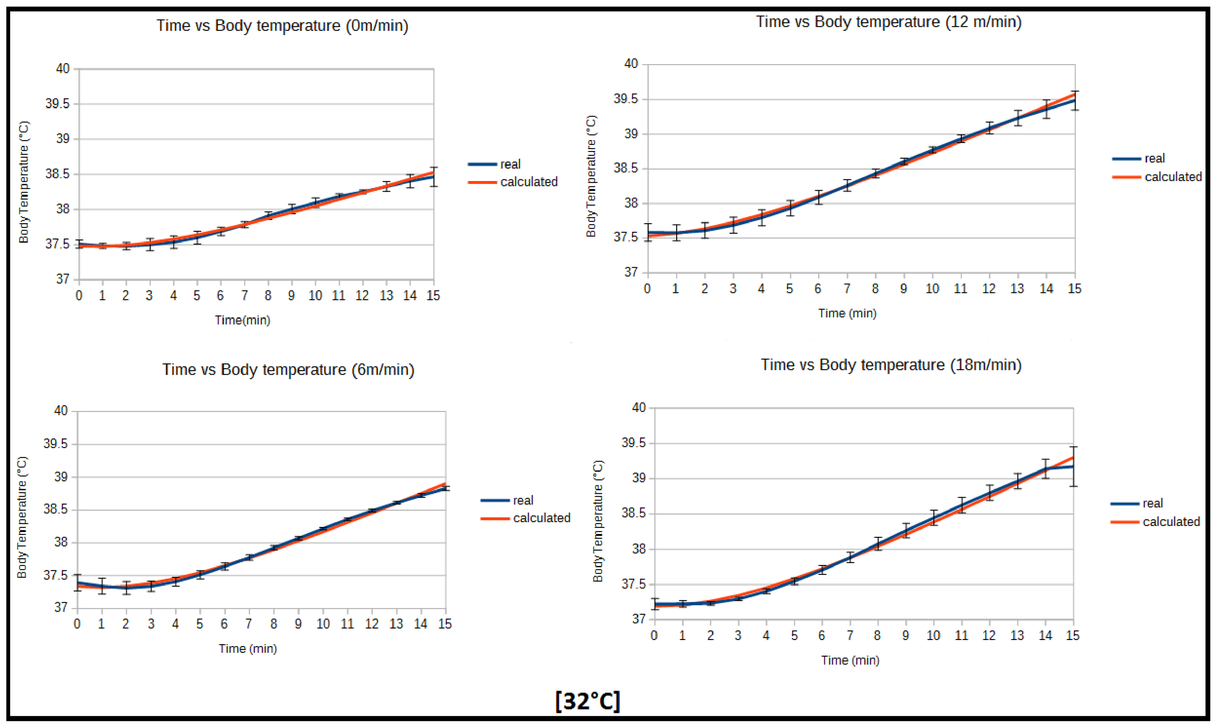


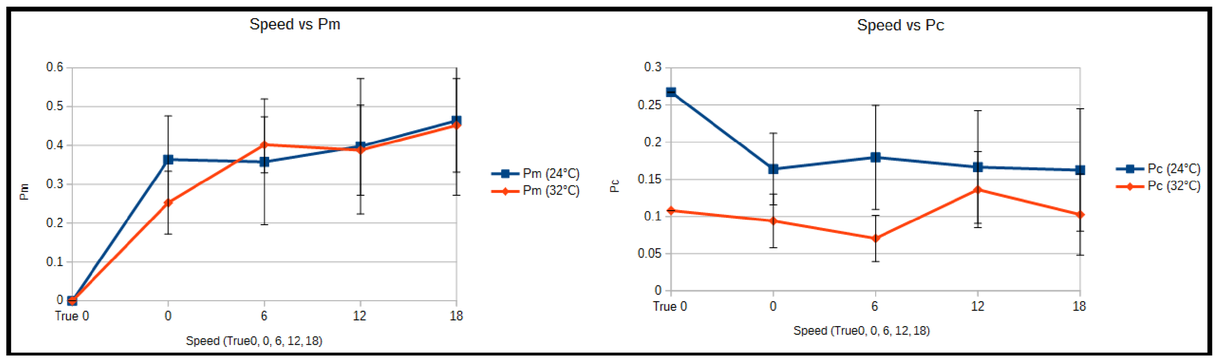
Pm = 0.3, Pc = 0.08?



Results and Discussion







- "True 0" is when $P_m = 0$. The respecting Pc value can be calculated by setting $P_m = \eta_{ca}(T_c - T_a)$.
- We notice that P_m dramatically increases as speed becomes True 0 to 0 m/min. This is an indication of rats body's engagement.
- We notice that there is a significant drop in P_c in 24 °C while there is no significant drop in 32 °C, P_c when the speed varies from True 0 to 0m/min

Conclusion

- We successfully showed how rats compensate their body temperature in varying ambient temperature and varying intensity of exercise.
- In high temperature, heat production from core is maintained low attempting to maintain rats' body temperature low
- In a room temperature, heat production from the core is maintained low as soon as rats expect locomotion.

References

[1] Yaroslav, M., Maria V. Zaretskaia, and Dmitry V. Zaretsky. Meth math: modeling temperature responses to methamphetamine, *Am J Physiol Regul Integ Comp Physiol.* Feb. 5, 2014. (doi:10.1152/ajpregu.00365.2013).