HUMAN BODY

Bicycling and Calories

Take-Home Experiment

Purpose:

To investigate the methods a human body uses to keep constant temperature and to compare the cooling of a human body by convection, radiation and evaporation of sweat.

Introduction:

When the body uses energy to produce movement, heat is produced. Sweating, the body's way of keeping our body temperature at 37^{o}C, has a cooling effect as it evaporates off of our skin, due to the latent heat of evaporation of water. In order to keep our internal temperature at 37^{o}C, the skin must be cooler than this so that the heat is conducted to the skin. A skin temperature of 32-33^{o}C is comfortable, 35^{o}C is uncomfortable, and it is intolerable if it reaches 37^{o}C.

When your skin temperature is higher than the temperature of the environment, you radiate heat into the environment, but when it is lower, you absorb heat radiated from the environment. Power also comes from the sun at a rate of 1366 W/m^{2}. When your skin temperature is higher than the temperature of the environment, you will not absorb any of this since heat always flows from hot to cold, but when your skin temperature is lower that the environment you will absorb this. You body has to sweat to balance out the heat flowing into and out of your body so that your skin temperature remains at ~33^{o}C. The amount of sweat produced depends on the vigorousness of the exercise and the ambient temperature.

In the problem set we calculated the amount of sweat the body has to generate in order to get rid of excess heat when a person bikes for an hour on a hot summer day. We know that a typical 70 kg person's body produces energy at a rate of ~500 W while biking, 80% of which is converted into heat (100 W of basic metabolism and 75% of the remaining 400W). We also know that the energy absorbed or released during vaporization (Q) is defined to be Q=Lm, where L is the latent heat of the substance and m is the mass of the substance. From this, it is easy to calculate the mass of water (sweat) needed to cool the body by the when it is producing energy at a given rate. Now, we want to do the opposite. If we measure how much sweat a person produces, can we measure the energy their body is producing?

Challenge:

Estimate the power used during biking by measuring the amount of fluid lost to get rid of excess heat and describe how this changes based on the ambient temperature.

Equipment:

- A reliable scale
- A bike

Key Concepts:

Convection, radiation, evaporation.

Method:

We want to compare the fluid lost on a hot day and on a cool day when biking the same route at the same speed. To do this, weight yourself (without clothes on), bike for a set amount of time, and weigh yourself again (without clothes on, as wet clothes will weigh more). Take note of how fast you are going so that you can duplicate the ride again on another day. If you are going to drink water during your bike ride, you must weigh the full water bottle before your ride and weigh it again when you return, making sure not to pour any of the water out or spit it out. The idea is that the different of your weight (taking into account the water consumed) before and after the ride is due to the sweat loss.

Questions to Think About:

Does someone sweat more or less on a hot day? Why?

How much heat is produced or lost by the body while a person is biking? Do they balance?

Variations:

1. Try different activities and see how they compare.

2. Try this experiment at various temperatures. From this, you should be able to produce a curve of how much you sweat you will produce in terms of the temperature. This will allow you to be able to predict how much you will sweat on a day with a given temperature, and consequentially how much water you should bring with you.

Suggested assigned time:

1 week. You will need to go for two separate bike rides on days with similar weather but a substantial temperature difference. For the 2nd variation, allow many weeks.

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