HUMAN BODY

Bicycling and Calories

Problem Set Solutions

Problem 1: Sweating

If you go bicycling on a hot summer day, the surrounding air cannot cool you efficiently so you need to sweat to maintain your body temperature. A typical 70 kg person's body produces energy at a rate of approximately 500 W during bicycling, 80% of which is converted into heat (100 W basic metabolism + 75% of remaining 400W = 400W). What is the volume of water (sweat) the body has to generate to get rid of the excess heat during one hour of bicycling?

Problem 1: Sweating

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.

In one hour, the energy produced by the biker is

$$Q = (400\ \text{W})\,(60\ \text{min})(\frac{60\ \text{s}}{1\ \text{min}}) = 1.4\text{x}10^{6}\ \text{J}$$

The latent heat of water (sweat) is 2.3×10^6 J/kg.

Rearranging the equation we know that

$$m = \frac{Q}{L}$$

So,

$$m = \frac{1.4\ \text{x}\ 10^{6}\ \text{J}}{2.3\ \text{x}\ 10^{6}\ \text{J/kg}} = 0.6\ \text{kg}$$

And since we know the density of water is ~ 1 kg/L, the biker's body has to generate 600 ml of water (sweat) to cool the biker down. This is almost 2½ cups! This is also the amount that the biker needs to drink to replace the lost fluid.

Problem 2: Running Speeds

After spending the holiday with your family, you have put on a bit of weight. You decide to go running and do a 6.0 km long run on flat terrain. You are wondering whether you should run the distance at a fast or a moderate pace to burn more calories. You go online and read that a 59 kg person burns 590 kcal running at 9.7 km/h for an hour and 797 kcal running at 12.9 km/h for an hour. Should you run the 6.0 km at a fast (12.9 km/h) or a moderate (9.7 km/h) pace to burn more calories? Explain your reasoning and show all your work.

Problem 2 Solution: Running Speeds

What we know:

d = 6000 m
m = 59 kg
t = 3600 s
v_m = 9.7 km/h = 2.69 m/s
$kcal_m$ = 590 kcal
v_m = 12.9 km/h = 3.58 m/s
$kcal_m$ = 797 kcal

At a moderate pace:

$$t = \frac{d}{v} = \frac{6000\,\text{m}}{2.69\,\text{m/s}} = 2230\,\text{s}$$

$$\text{calories}: (\frac{590\,\text{kcal}}{1\,\text{h}})(\frac{1\,\text{h}}{3600\,\text{s}})2230\,\text{s} = 365\,\text{kcal}$$

At a fast pace:

$$t = \frac{d}{v} = \frac{6000\,\text{m}}{3.58\,\text{m/s}} = 1676\,\text{s}$$

$$\text{calories}: (\frac{797\,\text{kcal}}{1\,\text{h}})(\frac{1\,\text{h}}{3600\,\text{s}})1676\,\text{s} = 371\,\text{kcal}$$

At either pace you burn practically the same number of calories so you can run at a slower pace, it will just take a bit longer.

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