BIOL 207 Human Anatomy & Physiology II • Lab 10 **Metabolic Rate, Caloric Intake and Expenditure**

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In this lab, you will investigate metabolic rate and you will estimate the number of Calories you take in and burn in a typical day.

Metabolism refers to the sum total of the chemical changes which occur in the body. Energy can be measured in many ways. The usual physiological unit of energy metabolism is the calorie. A **calorie** is the amount of energy required to heat 1 mL of water by one degree Celsius. This is a very small amount of energy, so physiologists measure energy in Calories ("big-C" calories). A Calorie is one kilocalorie (1,000 "little-c" calories). All caloric measurements in this class will be measured in Calories, and you'll find that this is true of all reports on the energy content of food or energy burning of exercise. The more energy your body can get from a food, the more Calories that food has. The more exhausting some exercise is, the more Calories have been used.

1. ESTIMATING BASAL METABOLIC RATE

Basal metabolic rate (BMR) is the minimum expenditure of energy necessary to live. It is expressed in terms of Calories burned per hour per body surface area (Cal / hr·m^2).

Calories per hour ***is*** metabolic rate. However, depending on the shape and composition of your body, you may lose heat quickly or slowly. Since humans maintain a stable internal body temperature, if you lose heat quickly you must generate more heat to stay alive, and this must be factored into any measurement of BMR.

For example: a tall, skinny person will lose heat much faster than a short, round person who weighs the same. The tall, skinny person must burn more Calories per hour just to survive. The amount of heat a person must generate in order to live – and therefore the amount of energy they must create – will not be the same from person to person.

For this reason, BMR is measured as the Calories per hour you must generate per square meter of body surface (Cal / hr·m^2). By standardizing metabolic rate to a given surface area (one m^2), we can compare the metabolic rates of people of different body shapes, sizes, and compositions.

The criteria for measuring BMR include 12 hours of fasting, 8 hours of sleep, minimal activity, and complete rest in the supine position. Clearly, measuring BMR is very involved. Because of this, physiologists often approximate BMR by measuring a person's rate of Oxygen absorption. This is known as **indirect calorimetry**. Oxygen consumption can be used to approximate BMR because it is known that the body uses one liter of Oxygen to generate about 4.825 Calories.

In the following exercise, you'll use measurements of Oxygen absorption to estimate BMR.

Estimating the basal metabolic rate (BMR) based on Oxygen absorption

A subject breathes normally into a O_2 spirometer for 3 minutes with their nose closed off. Under "Measurements" you will find spirometer traces showing this breathing. You will see the trace move up and down, representing tidal volume (TV). The trace drifts upwards as the subject's body absorbs oxygen. I found this confusing at first, too. These curves, however, are different from the once we measured in the respiration lab in that they **do not show air, but oxygen**. Curves like these can be obtained by a spirometer that includes a sensor to measure the O_2 concentration in the in- and exhaled air.

1. Determine the amount of O_2 absorbed by the subject by reading low points of TV at the beginning and the end of the timed test. Subtract the beginning O_2 volume from the end volume and record the difference below. ending volume O_2 – initial volume O_2 = ____.52_____ liters O_2 absorbed during trial

2. Divide the volume of O_2 absorbed by the number of minutes of the trial to get the volume of O_2 absorbed per minute.

   _____.1733____ liters O_2 absorbed per minute

3. Multiply by 60 minutes per hour to get the amount of O_2 absorbed per hour.

   ___10.4______ liters O_2 absorbed per hour

4. Because the amount of O_2 in the air varies depending on temperature and pressure, correct the volume of O_2 absorbed per hour to standard temperature and pressure (STP) by multiplying by a correction factor. Given room temperature and our altitude, use a correction factor of 0.9.

   ____9.36_____ liters O_2 absorbed per hour at STP

5. Multiply this number by 4.825 to convert liters of absorbed O_2 per hour to Calories burned per hour.

   _____45.162____ Calories burned per hour

6. Using the subject's height and weight, determine the subject's body surface area using the attached nomogram (*Figure 1*). To use the nomogram, find the height on the left scale and the weight on the right scale. Draw a line between those two points and read of the surface area on the middle scale. body surface area = ____1.53_____ m^2

7. Determine BMR by dividing Calories burned per hour by body surface area.

   BMR = ____29.5176_____ Calories / $hr \cdot m^2$

8. Compare the subject's BMR with a normal value for their age and sex by determining the percent deviation from their BMR from their age and sex's normal BMR value, found in *Table 1*. Take the

difference between the calculated BMR and normal BMR, then divide by the normal BMR. Express this as a percent and include + or – to denote above or below normal, respectively.

percent deviation from normal = (subject's BMR – normal BMR) / (normal BMR) x 100 = _-24.022_%

Here is an example of this calculation using the curve labels "example"

1. 1 L O_2 – 0 L O_2 = 1 L O_2 absorbed during the trial
2. 1 L O_2 / 3 min = 0.333 L O_2 absorbed per minute
3. 0.333 L O_2/min x 60 min/hr = 20 L O_2 absorbed per hour
4. 20 L O_2/hr x 0.9 = 18 L O_2 absorbed per hour at STP
5. 18 L O_2/hr x 4.825 Cal/L O_2 = 86.85 Cal burned per hr
6. from the nomogram: a 5'10", 180 lb male has a body surface area = 2 m^2
7. 86.85 Cal/hr / 2 m^2 = 43.425 Cal/hr•m^2 = BMR
8. percent deviation from normal = (43.425 – 41.43) / 41.43 = 0.048 = +4.8%

★ This man's BMR is 4.8% above the normal value for an 18 year old male (Table 1). He would be said to have a "fast metabolism". In order to maintain his weight, he would have to eat more Calories than a normal male his age. Or, you could say that he would probably lose weight more easily than a normal male his age.

Assignment part 1/3: Do these calculations for either Subject 1 or Subject 2 (your pick) and fill in the blanks above.

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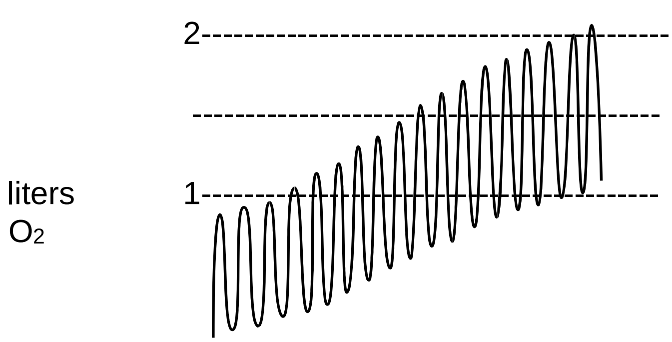
<u>Measurements</u>

EXAMPLE – 5'10", 180 lb, male, 20 years old



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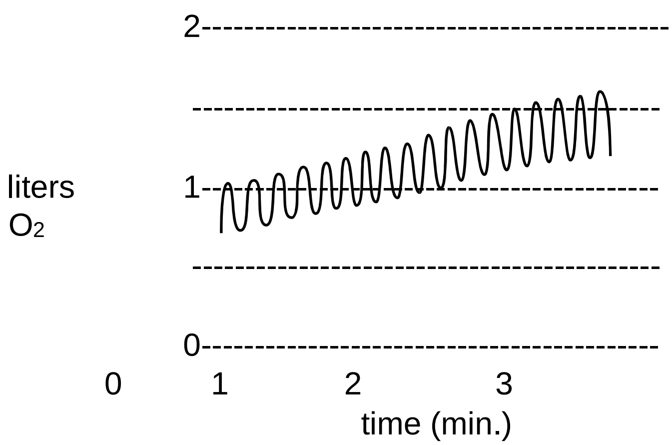
0 1 2 3

time (min.)

Subject 1 – 5'2", 120 lb, female, 18 years old



Subject 2 – 5'6", 220 lb, male, 26 years old

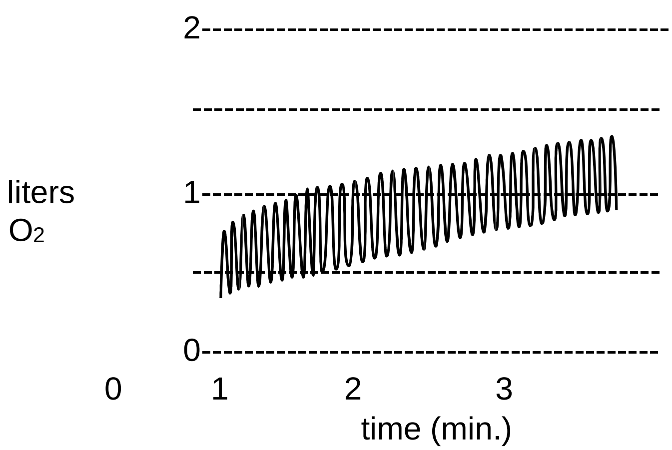
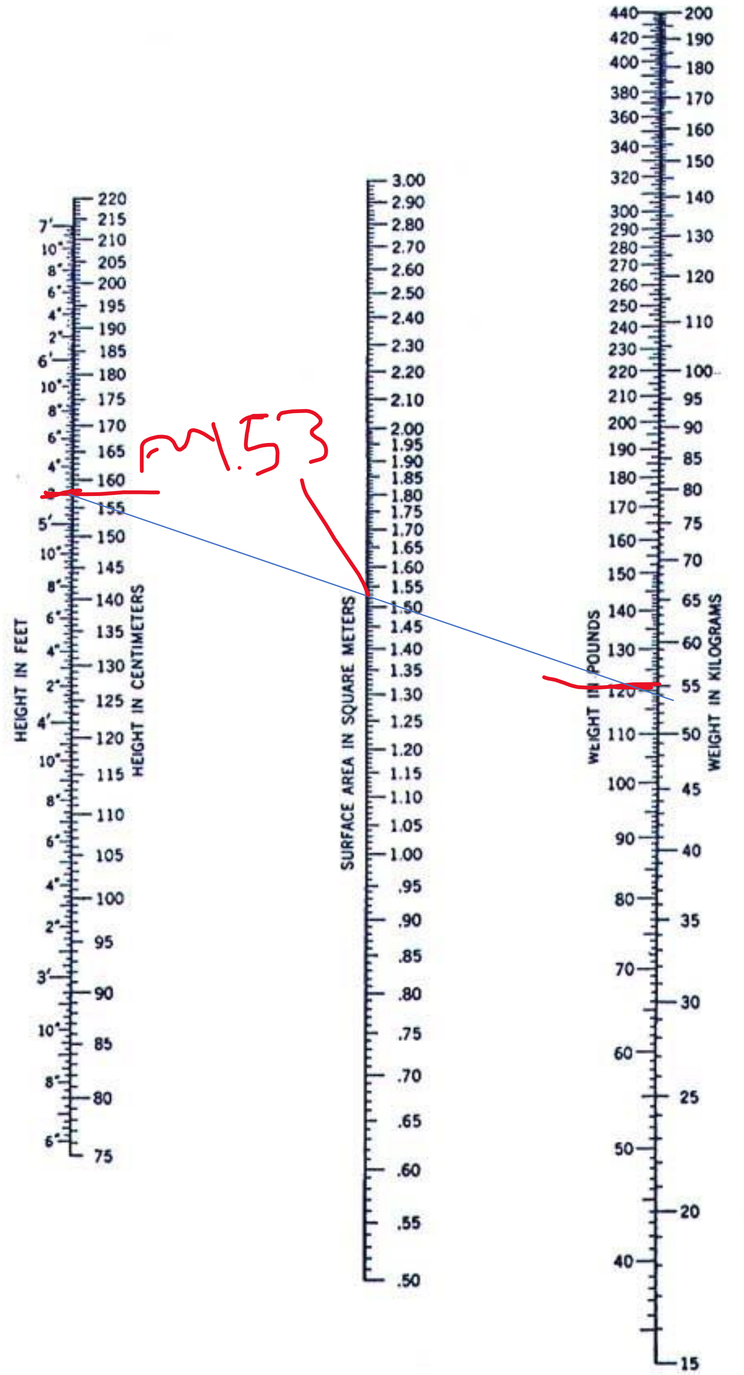


Table 1: Normal BMR Values (Cal / hr·m²)

Age Range	Female	Male
18-19	38.85	43.32
20-21	38.30	41.43
22-23	37.60	40.82

24-27 36.74 40.24

2. ***Figure 1: Determining Based on Height*** ***Nomogram for Body Surface Area and Weight***



Assignment part 2/3:

CALORIC INTAKE AND EXPENDITURE

Over the course of 24 hours, record every food you eat (Caloric intake) and every activity you do (Caloric expenditure). A sheet to record the data is attached.

The energy needed to perform a physical activity is often expressed in metabolic equivalents (METs). METs correlate your rate of energy expenditure to your resting metabolic rate. By definition, 1 MET is the energy expended per kilogram of body weight per hour when sitting quietly. Sleep has a MET value of 0.9 Calories per kilogram per hour. Heavy exercise may have a MET value in the teens.

On the sheet entitled *Calories Expended Per Day*, record the physical activity you perform during each 15 minute interval of a typical 24 hour day. After you record your daily activities, assign a correct MET value to each activity. To do this, find your activity in the **Compendium of Physical Activities**. (Use the most recent MET value listed for the activity.) Use the descriptions of the activities to gauge which activity in the Compendium is closest to the activity you performed.

I have posted a copy of the *Compendium of Physical Activities* to Canvas. You can also download it here: **http://prevention.sph.sc.edu/tools/docs/documents_compendium.pdf**

To convert METs to Calories burned, use the posted *Calories Expended Per Day Summary* sheet. Add up the total time you spent performing each activity (in hours). Multiply this time by the MET value of the activity. This gives you the number of Calories you expended per kilogram of body weight. Multiply this value by your body weight (in kilograms) to find how many Calories you burned doing that activity.

Over the same 24 hour period, record the foods you eat and the amount you eat. To determine the number of Calories you took in, use the Nutrition Facts labels on the foods' packages. If you go to a restaurant, ask for a list of the Nutrition Facts for the food they serve or go to their website; chain restaurants all have this information.

Assignment part 3/3:

APPLYING YOUR KNOWLEDGE

Now that you know how many Calories you took in and how many Calories you burned over the course of one day, answer the following questions. For each question, assume that **one pound of body fat equals 3500 Calories**. Show your work.

1. Based on your Caloric intake and expenditure, were you losing weight or gaining weight over the 24 hour period? If every day were the same as this one, how many days would it take for you to gain 5 pounds?

Gaining Weight (81.1325 < 1520). It would take about 12 days to gain 5 pounds (17500/[1520-81.1325]=12.1623).

2. Assume your Caloric intake and expenditure are perfectly equal, meaning your weight is stable. You decide to make a change: you begin waking up 30 minutes early and going on a jog, running for 30 minutes at 7 mph (8.5 minute mile). How many days would it take to lose 5 pounds?

.5 x 11.5= 5.75 x 11.5= 66.125. 1520+66.125=1586.125.
17500/1586.125= 11.03317834. It would take about 11.03319 day
to gain 5 pounds.

3. Assume your Caloric intake and expenditure are perfectly equal. You decide to make a change: you begin going to Starbucks every day and buying a grande-peppermint-whitechocolate-mocha-no foam-with sprinkles-at 260 dC and drinking the whole thing. To cut back on Calories, you have it made with nonfat milk and without whipped cream. According to Starbucks' website, this drink contains 430 Calories. How many days will it take to gain 5 pounds?

1520+430= 1750. 17500/1750=10. It would take about 10 days to
gain 5 pounds.