

Body Composition Laboratory

Body composition refers to the relative percentage of body tissue-bone, fat, muscle and others. These tissues are distinguished into fat-free mass and fat mass. Fat-free mass includes the skeleton, body water, muscle, connective tissue and teeth, while the fat mass includes essential fats (that which is required for normal physiological functioning) and non-essential fats (adipose/fat stores). The ratio of these two divisions can provide an indication of the percent body fat (%BF). This ratio can help determine if an individual is overweight or overfat.

An overweight individual is in excess of his or her 'normal' weight. This is not a harmful condition, unless it is accompanied by overfatness. Overfatness is a greater percent of the body's weight being composed of excess fat. This condition is harmful and has been related to several health problems and diseases, such as heart disease and stroke. Many factors have a role in a person's body composition. Heredity may possibly predetermine the level of fatness of an individual. Endocrine disorders of the thyroid and predisposition to fatness ('baby fat') may also contribute to an individual's fat ratio. However, the primary factor for being overfat is a higher caloric intake than caloric utilization.

Measuring body composition and %BF is not an absolute measurement. Body composition measurement techniques are indirect estimates and provide only an assumed %BF. There are a number of ways to assess body composition. These procedures differ in the time, expense, and expertise required and in accuracy of the results they provide. All of these procedures are subject to some error and can only provide an estimate of the actual percent body fat. Errors in body composition estimates can result from either the actual measurement procedures, from the equations selected to calculate %BF, or from both. Moreover, because most methods are based on the average population, they are less accurate with very lean or obese individuals. Because of individual deviations from the norms, accuracy of %fat values also varies from person to person. For these reasons, most procedures currently used for body composition assessment have a standard error of 3 to 4% at best. This means that only approximately two-thirds of all measurements are within three percentage points of the actual %fat. Thus, for someone who was measured at 18% BF, the true %fat probably ranges between 15% to 21%. Consequently, one should not look at a body composition as a precise measurement, but as an estimate within a close range. Standards for fatness have been established to provide desirable ranges of %BF for men and women, and even for various ranges.

Anthropometric procedures consist of body mass index, waist to hip ratio and skinfolds. Body mass index (BMI) is commonly used in epidemiological studies to determine the fatness of populations. It is a good measurement to classify an individual into a group based on fatness. However, it is not a good measurement to show changes within an individual.

There has been considerable scientific evidence that the amount of fat accumulation around the waist and hips is more dangerous (metabolic disease-wise) than fat elsewhere in the body. Waist to Hip ratio evaluates this fat accumulation. It is an easy-to-take measurement and is used extensively in epidemiological studies to describe the risk of metabolic disease in large populations. Example: if the waist girth were the same as the hip girth the ratio would be 1.0.

Since the waist girth should be smaller than the hips, the ratio should always be less than 1.0. This is not a good measurement to monitor changes within an individual, but is good to classify an individual for health risk.

The development of skinfold (anthropometric) measurements came as the result of investigations for simpler and less expensive method for determining body composition. Body circumferences and/or skinfold (SKF) thickness are used in a regression equation, of which there are many available, for prediction of body composition. Among the most commonly employed are the generalized equations for use with SKF measurements developed for adult males and females by Jackson and Pollock (1978) and Jackson, Pollock, and Ward (1980), respectively. They are termed generalized because they are most accurate in predicting body composition of people with relatively average amounts of BF. Generalized equations tend to be less accurate with the very lean (e.g. athletes), obese, or other special populations. Other, more appropriate, equations have been developed for such populations which increase their accuracy for prediction of body composition.

The major source of error in anthropometry lies in the actual SKF measurement. Making accurate SKF measurements is more than simply pinching the skin somewhere around a particular area and measuring the thickness. There are precise sites on which the measurements are to be taken. A well-trained technician can obtain results that approach the precision of underwater weighing. Unfortunately, most people who take SKF measurements are not well trained. Obtaining consistently accurate SKF measurements requires training and experience.

Anthropometric Assessment:

Body Mass Index (BMI):

1. Obtain the weight in pounds of the individual and divide this value by 2.2 to determine their weight in kilograms. Record in your *Data Sheet*.
2. Obtain the height in inches of the subject and multiply this value by 0.0254 to determine height in meters. Record in your *Data Sheet*.
3. Square height (meters)
4. Place all appropriate values into the following equation:

$$BMI = \frac{\text{weight (kg)}}{\text{height (m)}^2}$$

5. Record this value in your *Data Sheet*.
6. Refer to page 8 for reference standards.

Girth measurements

1-site Girth measurement:

1. Please refer to Figure 1 for the appropriate girth sites for males or females (pg 9).

2. With a non-elastic measuring tape, obtain the subjects girth measurement (round to the nearest cm or in).
3. Using the subjects' weight, place the 2 respective measures into the appropriate nomogram (males or females) and draw a respective line to connect the 2 measurements (Figure 2-3, Page 9).
4. The intersecting measurement from the nomogram is the predicted value of %BF, record this value on your *Data Sheet*.

Tanita Body Composition Analyzer – Bioelectrical Impedance

Arrows on the Tanita display will prompt you in order

1. Turn on the Tanita Body Composition Analyzer
2. Enter the approximate weight of the subject's clothes (~0.6 Lbs.)
3. Select gender/body type: male/female athletic/standard
4. Enter age
5. Enter Height (feet' inches'')
6. Wait for prompt to step on
7. Instruct subject to step on scale and place balls of feet on the circular indents
 - a. Make sure subject is not in contact with any surroundings
8. Stand still on the scale until you hear a beep
 - a. Tanita will produce a paper printout with all information
9. Record these numbers on your *Data Sheet*

Skinfolds: Jackson/Pollock (J-P) Method (See Figure 4, pg 10)

1. Take all SKF measurements on the right side of the body.
2. We will be using the 3 site SKF measurement for both males and females.
3. See Figure 4 for the correct SKF for the appropriate sex.
4. Take the SKF measurements when the client's skin is dry and lotion- free.
5. Grasp the SKF firmly between the thumb and index finger of your hand. The fold is lifted 1 cm above the site to be measured.
6. Lift the fold by placing the thumb and index finger 8 cm (~3 inches) apart on a line that is perpendicular to the long axis of the skinfold. The long axis is parallel to the natural cleavage lines of the skin. For individuals with extremely large skinfolds, the thumb and finger will need to be separated more than 8 cm in order to lift the fold.
7. Keep the fold elevated while the measurement is taken.
8. Place the jaws of the caliper perpendicular to the fold, approximately 1 cm below the thumb and index finger, and release the jaw pressure slowly.
9. Take the SKF measurement 4 seconds after the pressure is released.
10. Open the jaws of the caliper to remove it from the site. Close the jaws slowly to prevent damage or loss of calibration.
11. Take 1 measurement at each site (rotational order) and repeat 3 times. Record all data into your *Data Sheet*.
12. Calculate the mean for each respective site and then sum up the 3 means and record into your *Data Sheet*.
13. Find the %BF using the appropriate table for either males or females (Table 6-16, 6-17, pgs 11-12). Record in your *Data Sheet*.

Underwater weighing:

Underwater (hydrostatic) weighing is a method to determine the density of the body (D_b). This method, which is based on Archimedes' Principle, is generally regarded as the "gold standard" for body composition assessment, although this claim is being made less of late because of newer and more sophisticated procedures. Because BF is less dense than water, it increases one's buoyancy while the fat-free mass (FFM), which has a density greater than water, makes one sink. Once the density of the body is known, special equations can be used to convert it to %BF. D_b can be calculated as body weight divided by body volume. The mass of the body is referred to as body mass-in-air (BM_a), whereas body volume (based on Archimede's principle) is the loss of mass ($BM_a - BM_w$) of an immersed body (BM_w) to the volume of that body.

$$D_b = \frac{BM_a}{BM_a - BM_w}$$

Procedure:

1. The subject should abstain from eating for at least 2 -3 hours prior to test.
2. The tank should be clean and filled with fresh, warm (32-36° C) water.
3. Determine residual volume (RV) through the appropriate gender specific prediction equation:

Men:

$$RV = (0.06858 * \text{Height} \text{ ______ in}) + (0.017 * \text{Age} \text{ ______ yrs}) - 3.477 = \text{ ______ L}$$

Women:

$$RV = (0.08128 * \text{Height} \text{ ______ in}) + (0.009 * \text{Age} \text{ ______ yrs}) - 3.9 = \text{ ______ L}$$

4. Obtain the subjects weight and height while wearing their bathing suit. Record to nearest 0.5 kg.
5. Ask subject to void bladder and rinse their body off in the shower, this will eliminate dead skin cells.
6. Have subject enter the tank and sit comfortably in the chair. The water level should be about shoulder depth when the subject is seated.
7. Measure and record the water temperature just prior to each test, even if several are done in sequence. For subject comfort, the water temperature should be between 32-36° C. Note and record the water density at the measured temperature (see chart below) on your *Data Sheet*.

Water Temp (° C)	Water Density (D_w)
30	0.995678
31	0.995372
32	0.995057
33	0.994734
34	0.994403
35	0.994063
36	0.993716
37	0.993360

8. Instruct the subject carefully in all procedures before beginning the actual measurement.
9. Give the following instructions to the subject:
 - a. Submerge and shake your hair free of all bubbles. Press all of the air bubbles out of your bathing suit as well.
 - b. Attach the nose clip if desired and hyperventilate for 4-5 breaths, then exhale most of the air with your head still out of the water.
 - c. Submerge *slowly* and completely while exhaling the remaining air you're your lungs. While totally submerged, completely force *all* the air out of your lungs. The technician will record your underwater weight when he/she is satisfied that you have exhaled as much air as possible (no more air bubbles appear around your mouth). You will repeat this procedure a total of 7 to 10 times.
10. Instruction to technician:
 - a. Instruct the subject to submerge and surface slowly so as to minimize wave formation and expedite the procedure.
 - b. Be sure the subject is totally submerged, exhales all air completely, and is not touching the sides or bottom of the tank. Encourage the subject to exhale all air out of their lungs.
 - c. Quickly and carefully record the underwater weight of the subject from the scale. When done, tap on the tank to notify the subject to come out of the water.
 - d. Take a minimum of seven weights and record the mean of the highest 3 weights that are within $\pm 1\%$ of each other as the actual underwater weight. When successive weights plateau, the test can be terminated.
 - e. Remember: Record the tare weight (weight of chair) after the test.
 - f. Calculate D_b using the following equation:

$$D_b = \frac{W_{t_{air}}}{\left[\frac{W_{t_{air}} - W_{t_w}}{D_w} \right] - (RV + 0.1L)}$$

Where: $W_{t_{air}}$ = body weight in air (kg)
 W_{t_w} = body weight in water (kg)
 D_w = water density ($\text{kg} \cdot \text{L}^{-1}$)
 RV = residual volume (L)
 0.1L is the assumed volume of gas in the GI tract

- g. Record the data on your *Data Sheet*.

11. **Calculation of %BF** – Now that you have estimated total D_b , the relative amount of body fat can be estimated from D_b using the principle that fat is less dense than lean tissue. One of the following equations can be used to convert D_b to %BF. Note that each equation will give slightly different estimates of BF.

12. Used both of the following equations to estimate the %BF. Record these values in your *Data Sheet*.

$$\%BF \text{ (Siri, 1961)} = \left[\left(\frac{4.950}{D_b} \right) - 4.500 \right] * 100$$

$$\%BF \text{ (Brozek et al., 1963)} = \left[\left(\frac{4.570}{D_b} \right) - 4.142 \right] * 100$$

11. Record these values in your *Data Sheet*.

Create a Data Sheet before you enter the lab!!!!

Note: you will turn this in with your laboratory report.

Be sure to show all work on calculations.

Create a bar graph of the various methods of estimating %BF, clearly label your different assessment methods.

Questions:

1. What is your subjects' BMI %tile ranking? What does this mean? What is their classification?
2. According to %BF how does your subject rank? NOTE: See page 13. Was this %BF within the recommended range for their age?
3. Were the %BF estimations the same for the various methods? If not, explain possible reasons why.
4. List and discuss reasons for errors that could be made in each method?
5. Are the SKF estimated higher or lower than those obtained from underwater weighing? Would you expect this finding to hold true in other subjects? Why or why not?
6. Discuss the multiple methods of assessing body composition. Which of these methods are the most accurate? Least accurate? Which ones are the most cost effective?
7. How could exercise impact the estimation of body composition?
8. Why are there differences in %BF between males and females? See Page 13, Tables 4-3, 4-4.

REFERENCES:

Brozek, J., Grande, F., Anderson, J. T., & Keys, A. (1963). Densitometric analysis of body composition: Revision of some quantitative assumptions. *Annals of the New York Academy of Sciences*, 110, 113-140.

Harrison, G. G., Buskirk, E. R., Lindsay Carter, J. E., Johnston, F. E., Lohman, T. G., Pollock, M. L., Roche, A. F., & Wilmore, J. H. (1988). Skinfold thickness and measurement technique. In T. G. Lohman, A. F. Roche, & R. Martorell (Eds.), *Anthropometric standardization reference manual* (pp. 55-70). Champaign: Human Kinetics.

Heyward, V. H., & Stolarczyk, L. M. (1996). *Applied body composition assessment*. Champaign: Human Kinetics.

Jackson, A. S., & Pollock, M. L. (1978). Generalized equations for predicting body density of men. *British Journal of Nutrition*, 40, 497-504.

Jackson, A. S., & Pollock, M. L. (1985). Practical assessment of body composition. *The Physician and Sportsmedicine*, 13, 76-90.

Jackson, A. S., Pollock, M. L., & Ward, A. (1980). Generalized equations for predicting body density of women. *Medicine and Science in Sports and Exercise*, 12, 175-182.

Lohman, T. G., Pollock, M. L., Slaughter, M. H., Brandon, L. J., & Boileau, R. A. (1984). Methodological factors and the prediction of body fat in female athletes. *Medicine and Science in Sports and Exercise*, 16, 92-96.

Siri, W. E. (1961). Body composition from fluid space and density. In J. Brozek & A. Hanschel (Eds.), *Techniques for measuring body composition* (pp. 223-244). Washington, DC: National Academy of Science.