Name _____ Section _____ Date _____

Lab A6-1 *Hydrostatic (Underwater) Weighing*

Equipment

1. Calibrated scale for measuring underwater body weight to the nearest 0.01 kilogram (10 grams); a 10–15 kg autopsy scale or load cell is typically used.
2. Tank of sufficient size and shape for total body submersion (at least 4–5 feet in each dimension). A swimming pool can be used if there is little turbulence; the scale can be suspended from a diving board. The water should be comfortable, between about 85° and 92° F (29° and 33° C).
3. Weighted, submersible chair apparatus or canvas swing
4. Temperature gauge for measuring water temperature
5. Weight scale
6. Yardstick or other means of measuring height
7. Partner to read measurements
8. Scuba weight belt (optional)

Preparation

The scale should be suspended over the tank, and the chair should be hung securely from the scale. The scale and chair should be positioned so that when a person sits in the chair, the water in the tank comes up to the top of his or her shoulders.

Wear a lightweight bathing suit, and take care to expel any air trapped between your body and the bathing suit. Don't eat or smoke for at least 2–3 hours before the test, and avoid foods that can cause excessive amounts of intestinal gas. Empty your bladder just before taking the test. Weigh yourself (dry and on land), and have a partner measure your height. Weigh the chair apparatus (in water), and record the temperature of the water. In each case, note the unit of measurement.

Body weight (on land): _____ Height: _____

Weight of chair apparatus (underwater): _____ Water temperature: _____

Instructions

1. Sit securely in the chair. If you have trouble staying underwater, a weighted scuba belt may be used. However, if you use a belt, weigh it and add its weight to the weight of the chair apparatus when you record it.
2. Exhale as fully as possible and then hold your breath. It is very important to push as much air as possible out of your lungs.
3. Slowly lean forward until your head and shoulders are underwater. (At this point, your entire body should be submerged.) To help your partner read the scale accurately, keep the water as calm as possible and stay underwater for about 5–10 seconds.
4. Your partner should record your underwater weight to the nearest 10 grams (0.01 kilogram). He or she may find it helpful to steady the scale with one hand.
5. Repeat the test 4–10 times until a consistent reading is obtained. For your underwater weight, use the average of the three heaviest measurements.

   1. _____ 2. _____ 3. _____ 4. _____ 5. _____

   6. _____ 7. _____ 8. _____ 9. _____ 10. _____

   Average of three heaviest measurements: _____ kg

(over)

Calculating Percent Body Fat

1. Determine net underwater weight (NUW) by subtracting the weight of the chair apparatus from your total underwater weight. If necessary, convert pounds to kilograms by multiplying your weight in pounds by 0.4545 kg/lb.

   Total weight of chair and weight belt: _____ kg

   Average of three heaviest total underwater weight measurements: _____ kg

   NUW = _____ kg − _____ kg = _____ kg
   (underwater weight) (chair weight)

2. Determine water density (WD) by using the list below. If necessary, convert the temperature measurement of the water in the tank from degrees Fahrenheit to degrees Celsius using the following formula:

   (_____ °F − 32) × 0.5556 = _____ °C

°C	Water density (g/ml)	°C	Water density (g/ml)
24	0.997299	33	0.994707
25	0.997048	34	0.994375
26	0.996786	35	0.994036
27	0.996516	36	0.993688
28	0.996236	37	0.993333
29	0.995948	38	0.992969
30	0.995650	39	0.992598
31	0.995344	40	0.992220
32	0.995030		

   Source: Diem, K., and C. Lentner. 1974. *Documenta Geigy Scientific Tables.* Ardsley, N.Y.: Geigy Pharmaceuticals.

   WD = _____

3. Determine residual volume (RV)—the amount of air left in your lungs after maximum exhalation—by measuring it directly using specialized equipment or estimating it using the following formulas. (If you need to convert your height measurement from centimeters to inches, divide it by 2.54.)

   Men

   RV = (0.017 × _____) + (0.06858 × _____) − 3.447 = _____ liters
   [age (years)] [height (in.)]

   Women

   RV = (0.009 × _____) + (0.08128 × _____) − 3.9 = _____ liters
   [age (years)] [height (in.)]

4. Calculate body density using the following formulas. If you need to convert pounds to kilograms, multiply your weight in pounds by 0.4545 kg/lb.

   BW = body weight (in kilograms)

   NUW = net underwater weight from step 1 (in kilograms)

   WD = water density from step 2

   RV = residual volume from step 3

   Body volume (BV) = [(BW − NUW) ÷ WD] − (RV + 0.1)

   BV = [(_____ − _____) ÷ _____] − (_____ + 0.1) = _____
   [weight (kg)] [underwater weight (kg)] (water density) (residual volume)

   Body density (BD) = BW ÷ BV

   BD = _____ ÷ _____ = _____
   [weight (kg)] [body volume (BV)]

(over)

5. Determine percent body fat by plugging the value for body density into the appropriate formula from the table below. (*Note:* Population-specific formulas do not exist for all ethnic or age groups; use the formula for whites of the appropriate age and gender if there is no specific formula appropriate for you.)

Population-Specific Formulas for Conversion of Body Density to Percent Body Fat

Population	Age	Gender	Percent Body Fat
Ethnicity			
White	8–12	Male	(5.27 ÷ BD) – 4.85
		Female	(5.27 ÷ BD) – 4.85
	13–17	Male	(5.12 ÷ BD) – 4.69
		Female	(5.19 ÷ BD) – 4.76
	18–59	Male	(4.95 ÷ BD) – 4.50
		Female	(4.96 ÷ BD) – 4.51
	60–90	Male	(4.97 ÷ BD) – 4.52
		Female	(5.02 ÷ BD) – 4.57
Black	19–45	Male	(4.86 ÷ BD) – 4.39
	24–79	Female	(4.86 ÷ BD) – 4.39
Hispanic	20–40	Female	(4.87 ÷ BD) – 4.41
American Indian	18–62	Male	(4.97 ÷ BD) – 4.52
	18–60	Female	(4.81 ÷ BD) – 4.34
Japanese Native	18–48	Male	(4.97 ÷ BD) – 4.52
		Female	(4.76 ÷ BD) – 4.28
	61–78	Male	(4.87 ÷ BD) – 4.41
		Female	(4.95 ÷ BD) – 4.50
Levels of body fatness			
Anorexic	15–44	Female	(4.96 ÷ BD) – 4.51
Obese	17–62	Female	(4.95 ÷ BD) – 4.50

Source: Adapted by permission from V. Heyward, and D. Wagner. 2004. *Applied Body Composition Assessment,* 2nd ed. Champaign, IL.: Human Kinetics. Used with permission from the publisher.

Percent body fat = (_____ ÷ _____) – _____ = _____%
(factor from table) (body density) (factor from table)

Example: An 18-year-old white male
Body weight = 180 lb
Height = 70 in.
Weight of chair apparatus = 3.15 kg
Water temperature = 87° F
Average of three largest underwater weights = 6.77 kg

1. Determine net underwater weight (NUW):
   NUW = 6.77 kg – 3.15 kg = 3.62 kg
2. Determine water density (WD):
   (87° F – 32) × 0.5556 = 31° C
   WD (from table) = 0.995344
3. Determine residual volume (RV):
   RV = (0.017 × 18) + (0.06858 × 70) – 3.447 = 1.6596 liters
4. Determine body volume and body density:
   Body weight = 180 lb × 0.4545 kg/lb = 81.81 kg
   BV = [(81.81 – 3.62) ÷ 0.995344] – (1.6596 + 0.1) = 76.796
   BD = 81.81 ÷ 76.794 = 1.065
5. Determine percent body fat:
   Percent body fat = (4.95 ÷ 1.065) – 4.50 = 0.148, or 14.8%