Name _____ Section _____ Date _____

Lab A6-2 *Bioelectrical Impedance Analysis (BIA)*

Bioelectrical impedance analysis involves passing a small electrical current through the body and measuring the resistance encountered. Fat-free tissues are good conductors of electrical current, while fat is not. Therefore, the amount of resistance to electrical current is related to the amount of fat-free tissue in the body and can be used to estimate percent body fat.

Equipment

1. BIA analyzer
2. Partner/technician (results will be more accurate if the test is administered by an experienced technician)
3. Room with a normal ambient temperature (about 72°F or 22°C)
4. Table or mat with a nonconductive surface
5. Alcohol pads
6. Weight scale
7. Tape measure or other means of measuring height
8. Marking pen (optional)

Preparation

The person being tested should follow these preparation guidelines:

- Do not drink alcohol within 48 hours of the test.
- Do not engage in moderate or vigorous physical activity within 12 hours of the test.
- Do not eat or drink anything within 4 hours of the test.
- Urinate within 30 minutes of the test.
- Do not use any diuretic medications within 7 days of the test unless prescribed by a physician.

Female subjects should avoid being tested during a stage of their menstrual cycle in which they perceive they are retaining water.

Instructions

Note: Instructions may vary with the type and brand of BIA analyzer; refer to the manufacturer's instructions for the particular analyzer in use. The instructions given here are for tetrapolar analyzers that use four electrodes applied to the wrist, hand, ankle, and foot.

Person Being Tested

1. Measure your height and weight, and record the results and the unit of measurement.
   Height: _____ Weight: _____
2. If necessary, convert your height measurement to centimeters and your body weight to kilograms.
   Height: _____ in. × 2.54 cm/in. = _____ cm
   Weight: _____ lb ÷ 2.2 lb/kg = _____ kg
3. Electrodes will be attached on your right hand and foot. Remove your right shoe and sock, and lie on the nonreactive surface. Move your arms away from your body so that there is no contact between your arms and your torso. Spread your legs about 45° apart so that your thighs do not touch.

Person Administering Test

1. Locate the correct site for placement of the electrodes; place them on the right side of the body.
   Sensor/proximate electrodes
   - Dorsal (back) surface of the wrist: The upper border of the electrode should bisect the head of the ulna (the bone that protrudes from the wrist). You may find it helpful to draw a horizontal line across the wrist at the level of the head of the ulna.
   - Ventral (front) surface of the ankle: The upper border of the electrode should bisect the lateral and medial malleoli (the two bones that protrude from either side of the ankle). You may find it helpful to draw a horizontal line across the ankle at the level of the malleoli.

(over)

Source/distal electrodes

- Back of the hand: The electrode should be placed at the base of the second or third metacarpophalangeal joint—the point where the bone of the hand (metacarpal) meets the bone of the finger (phalanx) for the index or middle finger.
- Top of the foot: The electrode should be placed at the base of the second or third metatarsophalangeal joint—the point where the bone of the foot (metatarsal) meets the bone of the second or third toe (phalanx).

There should be at least 5 centimeters (2 inches) between the electrodes.

2. Clean the skin at the site of the electrode placement with an alcohol pad. Attach the electrodes and then connect the lead wires to the appropriate electrodes.
3. Follow the manufacturer's instructions for obtaining a reading for resistance.
   Resistance: _____ ohms

Calculating Fat-Free Mass

BIA analyzers typically calculate percent body fat automatically. However, many experts recommend that these values *not* be used unless you know which equations are programmed into the analyzer and whether the equations are valid and appropriate for you. Instead, they suggest plugging the value the analyzer records for resistance into a known formula for calculating fat-free mass (FFM), from which percent body fat can be derived.

The formulas presented here are appropriate for adults age 17 to 62. People who are obviously lean should use the formula labeled <20% body fat (men) or <30% body fat (women). People who are obviously obese should use the formula labeled ≥20% body fat (men) or ≥30% body fat (women). If you are not obviously lean or obese, plug values into both the formulas for your gender and average the two results.

To complete the calculations, you'll need to enter the following:

H = Height in centimeters: _____ cm (height will be squared in the calculations)
R = Resistance in ohms: _____ ohms
BW = Body weight in kilograms: _____ kg
A = Age in years: _____ years

Women

Lean (<30% body fat)

$FFM = (0.000646 \times H^2) - (0.014 \times R) + (0.421 \times BW) + 10.4$

$FFM = (0.000646 \times [\underset{\text{[height (cm)]}}{\_\_\_\_\_}]^2) - (0.014 \times \underset{\text{[resistance (ohms)]}}{\_\_\_\_\_}) + (0.421 \times \underset{\text{[body weight (kg)]}}{\_\_\_\_\_}) + 10.4$

$= \_\_\_\_\_$ kg

Obese (≥30% body fat)

$FFM = (0.00091186 \times H^2) - (0.01466 \times R) + (0.29990 \times BW) - (0.07012 \times A) + 9.37938$

$FFM = (0.00091186 \times [\underset{\text{[height (cm)]}}{\_\_\_\_\_}]^2) - (0.01466 \times \underset{\text{[resistance (ohms)]}}{\_\_\_\_\_}) + (0.29990 \times \underset{\text{[body weight (kg)]}}{\_\_\_\_\_})$

$- (0.07012 \times \underset{\text{[age (years)]}}{\_\_\_\_\_}) + 9.37938 = \_\_\_\_\_$ kg

Not obviously lean or obese

FFM = (FFM from lean formula + FFM from obese formula) ÷ 2

$FFM = (\underset{\text{[FFM (lean)]}}{\_\_\_\_\_} + \underset{\text{[FFM (obese)]}}{\_\_\_\_\_}) \div 2 = \_\_\_\_\_$ kg

Men

Lean (<20% body fat)

$FFM = (0.00066360 \times H^2) - (0.02117 \times R) + (0.62854 \times BW) - (0.12380 \times A) + 9.33285$

$FFM = (0.00066360 \times [\underset{\text{[height (cm)]}}{\_\_\_\_\_}]^2) - (0.02117 \times \underset{\text{[resistance (ohms)]}}{\_\_\_\_\_}) + (0.62854 \times \underset{\text{[body weight (kg)]}}{\_\_\_\_\_})$

$- (0.12380 \times \underset{\text{[age (years)]}}{\_\_\_\_\_}) + 9.33285 = \_\_\_\_\_$ kg

(over)

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Obese (≥20% body fat)

FFM = $(0.00088580 \times H^2) - (0.02999 \times R) + (0.42688 \times BW) - (0.07002 \times A) + 14.52435$

FFM = $(0.00088580 \times [\underset{\text{[height (cm)]}}{\_\_\_\_\_}]^2) - (0.02999 \times \underset{\text{[resistance (ohms)]}}{\_\_\_\_\_}) + (0.42688 \times \underset{\text{[body weight (kg)]}}{\_\_\_\_\_})$

$- (0.07002 \times \underset{\text{[age (years)]}}{\_\_\_\_\_}) + 14.52435 = \_\_\_\_\_$ kg

Not obviously lean or obese

FFM = (FFM from lean formula + FFM from obese formula) ÷ 2

FFM = $(\underset{\text{[FFM (lean)}}{\_\_\_\_\_} + \underset{\text{FFM (obese)]}}{\_\_\_\_\_}) \div 2 = \_\_\_\_\_$ kg

Example:

A 21-year-old male who is 5′7″ tall, weighs 154 lb, had a resistance of 475 ohms, and is not obviously lean or obese.

Height: 5′7″ = 67 in. × 2.54 cm/in. = 170 cm

Weight: 154 lb ÷ 2.2 kg/lb = 70 kg

FFM (lean formula) = $(0.00066360 \times 170^2) - (0.02117 \times 475) + (0.62854 \times 70) - (0.12380 \times 21)$
$+ 9.33285 = 19.17804 - 10.05575 + 43.9978 - 2.5998 + 9.33285 = 59.85$ kg

FFM (obese formula) = $(0.00088580 \times 170^2) - (0.02999 \times 475) + (0.42688 \times 70) - (0.07002 \times 21)$
$+ 14.52435 = 25.59962 - 14.24525 + 29.8816 - 1.47042 + 14.52435 = 54.29$ kg

FFM (average) = (59.85 + 54.29) ÷ 2 = 57.07 kg

Calculating Percent Body Fat

Percent body fat can be calculated from fat-free mass and total weight.

Fat mass: $\underset{\text{(total body weight)}}{\_\_\_\_\_}$ kg – $\underset{\text{[fat-free mass (FFM)]}}{\_\_\_\_\_}$ kg = _____

Percent body fat: $\underset{\text{(fat mass)}}{\_\_\_\_\_}$ kg ÷ $\underset{\text{(total body weight)}}{\_\_\_\_\_}$ kg = $\boxed{\_\_\_\_\_}$ %

The young man in our example would calculate his percent body fat as follows:

Fat mass: 70 kg – 57.07 kg = 12.93 kg

Percent body fat: 12.93 kg ÷ 70 kg = 0.185, or 18.5%

Sources: Heyward, V. H. 2002. *Advanced Fitness Assessment and Exercise Prescription,* 4th ed. Champaign, Ill.: Human Kinetics. Segal, K. R., et al. 1988. Lean body mass estimation by bioelectrical impedance analysis: A four-site crossvalidation study. *American Journal of Clinical Nutrition* 47(1): 7–14. Stolarczyk, L. M., et al. 1997. The fatness-specific bioelectrical impedance analysis equations of Segal et al. Are they generalizable and practical? *American Journal of Clinical Nutrition* 66(1): 8–17.