Chapter 8

Blood Pressure, Heart Rate, Ankle-Arm Index, Standing Height, Body Weight and Abdominal Circumference

BACKGROUND

This chapter addresses blood pressure and heart rate, which are cardiovascular measures and height, weight and waist circumference which are used to assess body size and fatness.

Blood pressure is a key indicator of healthy aging. Systolic blood pressure is the maximal blood pressure with each heartbeat and is recorded as the first or upper number in a blood pressure recording. With aging, the vessels stiffen and the maximal pressure is augmented. This stiffening of the vessels also results in a greater drop in blood pressure with each heartbeat, thus the diastolic blood pressure (the second number), goes down. In combination, the difference between the systolic and diastolic blood pressure, called the pulse pressure, increases with age. Even if blood pressure does not rise to a level requiring treatment with antihypertensives, an increase in systolic blood pressure alone or pulse pressure is a useful measure of the degree of vascular aging.

- Key change variables for blood pressure will include:
    - the difference between the average of the baseline systolic blood pressure and the average of the follow-up systolic blood pressure.
    - the difference between the average of the baseline diastolic blood pressure and the average of the follow-up diastolic blood pressure
    - the difference between the baseline pulse pressure and the follow-up pulse pressure

Change in blood pressure can be examined in those on and those not on blood pressure treatment separately or combined with adjustment for use of blood pressure medication.

Heart rate is a measure of cardiovascular fitness or can reflect abnormal heart rhythm. Heart rate goes up with exercise and illness, including cardiac arrhythmias. A low resting heart rate of about 60 beats per minutes is found in fit individuals but lower than 60 can reflect a block in the heart rhythm.

- Change in heart rate will be defined as the simple difference. Adjustment for heart slowing medications may be required for some analyses.

The ankle-arm index (AAI) is a non-invasive measure of atherosclerotic obstruction in the legs and is a general marker of atherosclerotic burden. This measure was assessed in Year 1, Year 2 (only for newly enrolled participants) and in Year 3 for all enrollees (returning and new).

Height, weight and waist circumference are basic measures of anthropometry or body size and can reflect the body composition as well. The metric of weight adjusted for height squared is well correlated with percent body fat and is called body mass index or BMI. Waist circumference is used to assess central fat deposition.
Standing height also reflects bone mineral density and osteoporotic fracture of the spine. Height loss occurs with aging and is accelerated in osteoporosis.

- Change in height, weight, waist circumference and BMI will be taken as the simple difference between the baseline and the follow-up values.
- For maximal height or for measurements that need to be adjusted for maximal

adult height, the baseline leg length should be used.
- If a participant cannot stand to measure standing height at Visit 3, height will be set to missing.

Definitions:
Blood Pressure**:** Level of blood pressure is subject to biologic and observer variations, the latter being due to errors in measurement. The purpose of a specific protocol for the measurement of BP, a stringent certification procedure for technicians who measure BP, and a standard automated blood pressure measurement device in LLFS is to minimize error in measurement.

The seated BP reading for LLFS is an average of three systolic and diastolic BP's calculated by computer. When any of the blood pressure readings are out of range, it will trigger an "alert" and subsequent participant/ physician notification. Please see Chapter 6- – Alerts for out of range values, specific instructions and template notification letters.

In November, 2017, the American College of Cardiology/American Heart Association recommended new blood pressure guidelines according to the following criteria:

Table 8.1: 2017 Classification of BP in Adults Aged 18 Years or Older[1]:

		Systolic	Blood	Pressure	(mm Hg)
		<120	120-129	130-139	≥140
Diastolic	<80	Normal	Elevated	Stage 1	Stage 2
Blood	80-89	Stage 1	Stage 1	Stage 1	Stage 2
Pressure (mm Hg)	≥90	Stage 2	Stage 2	Stage 2	Stage 2

[1] Classification based on the average of two or more readings on two or more occasions. BP indicates blood pressure; DBP diastolic blood pressure; and SBP, systolic blood pressure.

Table 8.2: Follow-up Criteria for Initial BP Measurement for Adults Aged 18 Years or Older[3]:

BP Range, mm Hg	Recommended Follow-up
Diastolic BP:	
< 80	Have your blood pressure rechecked within 2 years
80-89	Have your blood pressure rechecked within 1 year
90-99	See your doctor about your blood pressure within 2 months
100-109	See your doctor about your blood pressure within 1 month
110- 119	See your doctor about your blood pressure within 2 weeks
≥120	See your doctor about your blood pressure immediately
Systolic BP, when DBP < 90 mm Hg:	
< 120	Have your blood pressure rechecked within 2 years
120-139	Have your blood pressure rechecked within 1 year
140-159	See your doctor about your blood pressure within 2 months
160-179	See your doctor about your blood pressure within 1 month
180-209	See your doctor about your blood pressure within 2 weeks
≥210	See your doctor about your blood pressure immediately

[3] When recommendations for follow-up of DBP and SBP are different, the shorter recommended time for recheck and referral should take precedence.

Standing Height: Height with no shoes on a flat, uncarpeted floor.

Body Weight: Weight with no shoes.

Waist circumference: Circumference at the level of the umbilicus with the participant standing erect.

EQUIPMENT

- Omron HBP-1300 Professional Blood Pressure Monitor or equivalent model)
- Handi-stat stature measuring tool, painter's tape, pencil and measuring tape.
- SECA Integra 840 or 841 or 803 digital scale
- Steel/fiberglass tape calibrated in centimeters
- BP cuffs in five sizes:
  - 1 large adult cuff
  - 2 regular adult cuff
  - 1 extra-large (thigh) cuff
  - 1 small cuff
  - 1 extra-small cuff
- Ankle-arm index supplies
  - Handheld 8 megahertz Doppler Probe with Built-in Speaker
  - Supply of replacement batteries specific to Doppler model
  - Doppler Conducting Gel
  - Omron 1300 digital blood pressure machine
  - Blood Pressure Cuffs (1 large, 1 thigh, 3 adult small, 3 adult regular)
  - Black Eyeliner Pencil
  - Tissues to Remove Conducting Gel

**Do not use the measurements provided on the cuffs. Refer to the chart in Table 8.3and/or Panel 9 for appropriate cuff sizes.

MEASURE: BLOOD PRESSURE MEASUREMENTS

1. If possible, make sure that the device is plugged in. The device can operate on battery power for up to two hours. Insure that the device readouts are pointing away from the participant so that the participant cannot see the results.
2. Record the last four digits of the serial number, located on the back side of the Omron HBP-1300 machine, on the form in Question 1a.
3. Measure right arm circumference and record it to the nearest cm in Q1b. (See instructions below for measuring left arm if there is a medical reason to avoid using the left arm.)

Arm circumference is measured by having the participant stand facing away from the observer with the right arm bent 90 degrees at the elbow, with the hand on the mid-section. The tip of the acromion process (shoulder bone) is located and the length of the upper arm from the acromion process to the olecranon process (tip of the elbow) is measured with a tape. The midpoint is marked and the participant is asked to relax the arm at the side. The tape measure is then wrapped around the arm over the midpoint mark, making sure that the tape is level.

Mark cuff size used for the blood pressure measurement with the Omron HBP-1300device in Question 1c. Cuff size is determined by the arm circumference measured in Question 1b. The appropriate size cuff for a given arm circumference appears below and on the form. Proper size of the cuff is essential for accurate blood pressure measurement.

Medical Reason to Measure Left Arm - If there is a medical reason (e.g., chronic pain, paralysis, amputation, fistula) to avoid using the right arm, measure left arm. Document which arm was measured in Q2a, select the appropriate response for cuff placement in Q2b and, if right arm was not used, document reason right arm was not used in Question 2c.

Table 8.3: Arm Circumference Chart for Determining Correct Cuff Size

Arm Circumference	Cuff Size
12-17.9 cm	Extra-Small/Child
18-21.9 cm	Small
22-31.9 cm	Regular
32-41.9 cm	Large
42-50 cm	Extra-Large

4. Place both cuffs on the participant, and record in Question 2b whether the cuffs wereplaced on the forearm or the upper arm. When possible, the cuff should be placed on the upper arm. However, in obese individuals, the cuff may be placed on the forearm to allow for measurement of blood pressure with the Omron HBP-1300 device. Forearm placement: lower edge of the cuff (where the tube is connected) should be located approximately 6 cm proximal to the styloid process of the ulna, palpable at the wrist. The hoses should exit over the radial artery.
5. Palpate and mark the brachial artery with an X. Connect the cuff tubing to the Omron HBP-1300 by twisting the female adaptor into the male connection on the machine.
6. During the five minute waiting period, the participant should remain sitting in a chair and not read, with feet flat on the floor. Conversation should be kept to a minimum during the subsequent blood pressure measurements.

7. The Omron HBP-1300 inflates the cuff automatically once the machine is turned on by pressing the blue "START/STOP" button on the lower, right-hand side of the screen. Turn on the machine AFTER the five minute waiting period and when the first measurement is ready to be taken. Record the systolic, diastolic, and pulse values at the first set of blood pressure measurements onto the form in Questions 3a and 3b. If the participant wants to know what the measurement is, do not tell him or her. Instead, give them all 3 readings after the final reading. Also, please record this first BP reading in Q6a for the ankle-arm index measure.
8. Wait one minute after the first measurement has concluded before obtaining the next set of measurements. Record the systolic, diastolic, and heart rate values onto the form in Questions 4a and 4b after the second set of blood pressure measurements. If the participant wants to know what the measurement is, do not tell him or her. Instead, give them all 3 readings after the final reading.
9. Wait one minute after the first measurement has concluded before obtaining the next set of measurements. Record the systolic, diastolic, and heart rate on the form after the third set of blood pressure measurements in Questions 5a and 5b. If participant would like to know their blood pressure, give them all 3 recordings.
10. Wait one minute and take one blood pressure reading for the left arm (for the ankle-arm index) and record in Q6a.
11. Turn off the Omron HBP-1300 by holding the blue "START/STOP" button for approximately 3 seconds and the screen powers off.

MEASURE: ANKLE-ARM BLOOD PRESSURE

Background and Rationale

The ankle-arm index (AAI) is the ratio of the ankle to arm systolic blood pressure. It is reduced to less than 1.0 when there is obstruction to blood flow in legs. The AAI is a non-invasive measure of atherosclerotic obstruction in the legs and is a general marker of atherosclerotic burden. The degree of sub-clinical and clinical atherosclerosis is hypothesized to be related to the decline in lean mass and increase in abdominal adiposity with age. AAI is associated with atherosclerotic disease in other vascular beds and predicts subsequent mortality and cardiovascular mortality. The impact of sub-clinical cardiovascular disease on loss of bone and muscle mass and subsequent disability is not clear.

Equipment and Supplies

- Handheld 8 megahertz Doppler Probe with Built-in Speaker
- Supply of Alkaline Batteries specific to your Doppler
- Doppler Conducting Jelly
- Omron 1300 digital blood pressure machine
- Blood Pressure Cuffs (1 large, 1 thigh, 3 adult small, 3 adult regular)
- Black Eyeliner Pencil
- Tissues to Remove Conducting Jelly

Equipment Use

Using the Doppler.

- Push button in to turn on and gradually turn the volume up. Apply AQUASONIC or any gel made for ultrasonic physical therapy equipment to the tip of the Doppler probe. Next, place the probe over the artery (brachial or posterior tibial).
- The frequency used is 8 Megahertz (vibrations of 8 million times per second). In order to hear the signal above background noise, the instrument must be pushed in toward the artery. Angling the beam upstream improves the signal. For deeper vessels, the unit will have to be tilted back toward perpendicular, but NOTE: the instrument works poorly or not at all if held fully perpendicular to the flow. It must always be angled into and IN LINE with the flow. Please refer to **Figure 1**.

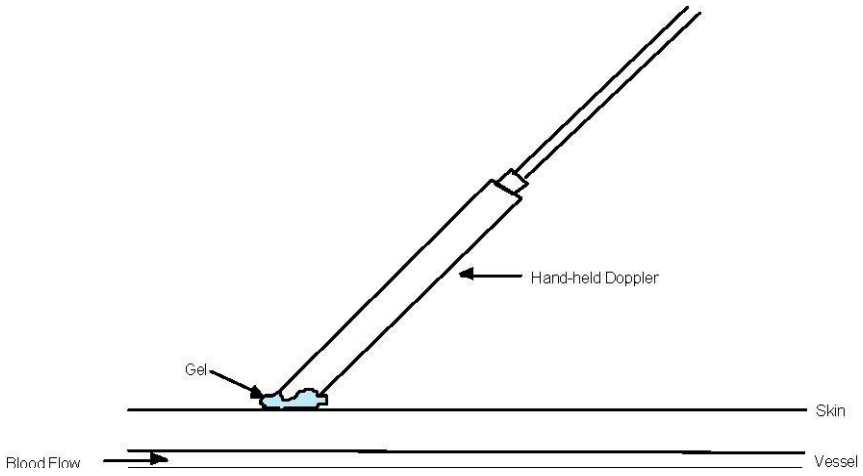

Figure 1

- In some places along the posterior tibial artery, there is anatomical hiding of the vessel by muscle or tendons. Move up or down the vessel a little to find the best signal above background noise.
- The purpose of the Doppler is to determine if blood is or is not flowing under the cuff. For correct interpretation, the probe MUST be centered directly over the artery and must not be moved while inflating the cuff.
- Please note that the Doppler unit turns itself off after 5 minutes automatically. This may occur in the middle of a measurement. This is may vary by Doppler model.

Equipment Maintenance

KEY POINT: Use only ultrasound gel.

The Probe. The probe consists of two crystals; one for transmitting the ultrasound waves and the other for receiving the reflected waves. If either crystal is damaged, the probe will not work properly or will not work at all. The crystals are covered by epoxy resin. This resin is attacked by any gel or liquid containing the chloride ion. Therefore, NEVER use ECG paste or cream as the contact medium between the skin and the crystals. Use AQUASONIC or any gel made for ultrasonic physical therapy equipment. In an emergency use any surgical jelly or lubricant, even Vaseline or mineral oil. Remove the gel after use with a soft tissue. If the probe has dried gel on it, wash it off under running water and dry with a soft tissue. Do NOT scrape off the gel because this may damage the epoxy coating. Do NOT autoclave the probe. Gas sterilization is OK.

KEY POINT: To preserve battery life or power, turn off unit immediately after using. As the battery drain, the signal will get weaker to the point where the instrument just doesn't work. Most batteries drain because the instrument has been left on. It takes less than a minute to make a blood pressure measurement. Turn the unit off immediately after removing it from the skin. Have appropriate replacement batteries for the specific Doppler model. Three screws hold the battery in the case. After loosening or removing the screws, gently lift up the back to replace the battery (this may vary by model).

Strange Noises from the Doppler. On occasion, there are unusual noises from the Doppler that do not indicate a problem with the Doppler. The normal sound will become obvious with experience in performing this test. Following are some common complaints and their causes.

1. Popping noises when the probe is first placed on the skin. Scratchy sound at first.

   Cause: Bubbles in the gel that are moving and/or popping. Also hair movement can cause noise. Remedy: Use a new glob of gel that looks clear, push down enough so hair is immobilized, and just wait a few seconds for things to settle down. If the noise isn't there when the probe is clean (no gel) and suspended in the air, the Doppler and/or probe are probably not at fault.

2. Bad static when the dry probe is moved in the air.

   Cause: a loose connector where the probe connects to the instrument, a broken shield wire in the cable either at the connector or as it comes out of the probe. This can be diagnosed by wiggling the wire or connectors gently. There is NORMALLY some static generated when the cable is flexed, but it isn't severe. Remedy: QC Officer will arrange to replace probe or get connectors fixed.

3. High-pitched tone.

   Cause: radio interference from a mobile service, police station nearby, even another Doppler working nearby. Usually occurs near large open windows, rarely in the center of the building. Remedy: Move to another room.

4. Howling noise when the probe with gel on it is held or laid on a table.

   Cause: acoustic feedback through the probe acting as a microphone. If it doesn't occur without gel on the probe, everything is OK.

Safety Issues and Exclusions

All participants enrolled in LLFS (except for the Denmark field center) are eligible for ankle-arm index measurement with the following exceptions:

- Persons with a fistula (where the cuff would be placed), open wounds including venous stasis ulcers, rashes, or any open wound
- Persons with bilateral amputations
- Persons unable to lie down at a 45° angle or less.

These are recorded as "missing data." See data entry form.

Additionally, some participants will have rigid arteries in the legs and the arteries cannot be occluded before the dial reads 300 mmHg. It is possible to find this in only one leg. This should be recorded as "unable toocclude" in Q10g.

Protocol

Clinic Protocol. The participants are being asked to lie flat or semi-recumbent. Flat or semi-recumbent is defined as the trunk being raised no more than 45 degrees from the surface of the examining table. If the participant is unable to lie at 45 degrees or less, they are excluded. Please record this on the form. To facilitate examiner ease in measuring the ankle arm blood pressures, a three wheeled stool is recommended to move from the arm position to the foot position.

Home Visit Protocol. The measurement can be performed in both the home and the clinic using the same protocol. In the home environment the measurement can be performed with the participant lying in a recliner, on their bed, or on the couch. The head can be supported by a pillow in a semi-recumbent position as described above. Two kitchen chairs can be used for examiner ease in moving from the arm position to the foot position. If you are unable to complete the procedure, document this by checking the appropriate reason in Q10g. Note on 3/26/07 a new option "Unable to follow instructions due to CI (cognitive impairment) was added".

Participant Preparation

- Record the first seated systolic blood pressure measurement from the right arm on the data collection form in Q6a.
- Measure the systolic blood pressure in the left arm using the same protocol as the measurement for the right arm and record in Q6a.
- If the measurements differ by more than 10 mm Hg, use the arm with the highest pressure as the reference arm. Mark the arm used in Q6b.
- Ask the participant to remove their shoes, socks and stockings so that the ankles are bare to mid-calf, if this has not been done already.
- Remove the sleeve of reference arm.

Lay the participant on the examining table with the reference side toward the observer and the feet at the free end of the table. Keep the participant recumbent or semi-recumbent for at least five minutes before measuring blood pressure.

Application of Cuffs:

1. Place three blood pressure cuffs on the participant:

   (a) Place one cuff on the reference arm. Note: Use the same cuff size that was used for the blood pressure measurement, if the blood pressure has already been taken. If the blood pressure has not yet been taken, please refer back to the blood pressure measurement chapter for directions on how to determine which cuff size to use.

   (b) Place one regular adult size cuff on the right ankle.
   (c) Place one regular adult size cuff on the left ankle.

2. Apply the ankle cuffs with the midpoint of the bladder over the posterior tibial artery, with the lower end of the bladder approximately 3 cm above the medial malleolus. Rarely, the Velcro will not hold due to the ankles being very thin or large. In these cases, use pediatric or large adult cuffs or spiral the cuffs to get a snug fit.

3. Apply ultrasound gel on each limb over the artery.

Detailed Measurement Procedures

Determining the Maximal Inflation Level (MIL). The maximal inflation level will be automatically determined by the Omron 1300 for each extremity.

- If the MIL is 300 mmHg, terminate the blood pressure measurements and select "Unable to Occlude" on Panel 9, Q10g. On the Report of Findings, indicate the blood pressure at the level heard. Refer the participant to see their doctor based on the seated blood pressure taken with Omron monitor. The Doppler will always be higher.

Performing the Measurement:

1. Reference Arm Systolic Blood Pressure Measurement

   - Attach the cuff tubing to the manometer.
   - Turn unit on.
   - Locate the brachial artery by palpation. If you need to, you can also locate the brachial artery by using the Doppler.
   - Apply more ultrasound jelly over brachial artery, if needed.
   - Sit next to the participant’s reference arm

- Locate brachial artery using Doppler.
- Measure the systolic blood pressure using the Doppler:
- Press the start button on the Omron
- The Omron will deflate at 4 mmHg per second (will need to check)
- Press the stop button 10 mmHg below the appearance of systolic pressure.
- Deflate the cuff quickly and completely.
- Record systolic blood pressure in space provided for brachial (arm) on form in Q7a.

2. Ankle Systolic Blood Pressure Measurement
   - Move to the end of the table

3. Right Ankle Systolic Blood Pressure Measurement
   - Connect right ankle cuff to the manometer.
   - Locate the posterior tibial artery by palpation. If the posterior tibial pulse is difficult to locate, the dorsalis pedis pulse (located on the top, center of the foot) may be used, however this should be documented in Q9a.
   - Apply more ultrasound jelly over posterior tibial artery, if needed.
   - Measure the systolic blood pressure using the Doppler
   - The Omron will deflate at 4 mmHg per second (check if that is true)
   - Press the stop button 10 mmHg below the appearance of systolic pressure.
   - Deflate cuff quickly and completely.
   - Record the systolic value from the first reading in the space provided for right posterior tibial on the form in Q7b.

4. Left Ankle Systolic Blood Pressure Measurement
   - Connect left ankle cuff to the manometer.
   - Repeat systolic blood pressure measurement as for right leg.
   - Record the systolic value from the first reading in the spaces provided for left posterior tibial on the form.

5. Repeating the Ankle-Arm
   - Repeat the sequence in the reverse order:
     - left ankle (Record in Q8a)

- right ankle (Record in Q8b)
- reference arm (Record in Q8c)

- Review the form for completeness.
- Remove cuffs and conducting jelly.

6. Please document whether the ankle-arm blood pressure measurement was completed successfully (i.e., measurements made on both sides) in Q10a. If no, please complete Q10g.

7. Calculate the AAI as follows and complete Q10b-Q10f).

Calculation of Ankle-Arm Blood Pressure Ratio. The ankle-arm blood pressure ratio is calculated in the manner described below. The fields for calculating these measures in the home/clinic are

Questions 10b-10f.

Q10b. The average brachial systolic blood pressure is determined

(Brachial Measurement #1 + Brachial Measurement #2)/ 2

Q10c. The average right posterior tibial systolic blood pressure is determined

(Right Posterior Tibial Measurement #1 + Right Posterior Tibial Measurement #2) / 2

Q10d. The average left posterior tibial systolic blood pressure is determined

(Left Posterior Tibial Measurement #1 + Left Posterior Tibial Measurement #2) / 2

Q10e. Ankle-Arm Blood Pressure Ratio for Right Side:

Measurement 1 = (average right posterior tibial / average brachial)

Q10f. Ankle-Arm Blood Pressure Ratio for Left Side:

Measurement 2 = (average left posterior tibial / average brachial)

Q10g. If ankle-arm blood pressure measurements are not completed for one or both sides, please check all the reasons that apply in Q10g.

Results. This is a screening test for atherosclerotic obstruction in the lower legs. Participants will receive a report (at the discretion of each field center) of the ankle-arm index in each leg after these results have been hand-entered on the Ankle-arm Blood Pressure Results form that includes the information described below:

The ankle-arm blood pressure index is the ratio of the ankle to the arm blood pressure. It is a screening test for peripheral arterial disease. A low ratio may mean that there is an obstruction or blockage.

Normal ratio is ankle-arm ratio >0.9 and <1.30. Results outside of that range should be indicated as Out of Range on the results report. The participant results report can be found in the Appointment Documents Manual of Procedures, Chapter 5.

Staff Alert. An extremely low AAI could indicate severely restricted blood flow to the leg, however, a clinical intervention to restore flow would only be done if there were severe symptoms (i.e., severe pain at rest, or ulceration or gangrene). The staff is not expected to be able to diagnose these conditions but should encourage participants who ask them about any symptoms to consult their physician.

Tips for the Ankle-Arm Measurements:

- Mark the location of maximal pulse or Doppler signal on the brachial artery and both posterior and tibial arteries with an eyeliner pencil to improve the speed and accuracy of localizing them the second time and to help maintain position.
- Hold the Doppler pen absolutely still while inflating and deflating the cuff; moving a few millimeters will lose the pulse.
- Always use enough gel to ensure good contact.
- The systolic value is the pressure level at which you hear the first of two or more swishing sounds in the appropriate rhythm. (Note: A single sound heard in isolation [i.e., not in rhythmic sequence] before the first of the rhythmic sounds [systolic] does not alter the interpretation of blood pressure).

Calibration of the Blood Pressure Equipment. Follow the manufacturer's recommendations for the calibration of the Omron 1300.

Quality Assurance

Training Requirements. Staff performing the ankle-arm index measurements should be research technicians or clinicians previously trained in taking research blood pressure measurements. In addition, training should include:

Pre-certification:

- Each Research Assistant will need to complete approximately 10 practice tests (with 2-3 being on those >60 years old) before certification readiness for them is considered. **This will be monitored by the site coordinator only.**
- Site coordinator will monitor certification readiness for each Research Assistant and select one person to be certified by the trainer. This Research Assistant will become the person who certifies subsequent Research Assistants once she/he is certified once they are deemed ready by their site coordinator.

Certification:

- 5 ABI tests will be completed by both Research Assistant (trainee) and trainer (1 should be >60 years old although this requirement is flexible; 1-2 is optimal)
- **For the first Research Assistant certified at each site, trainer will observe the first of the 5 tests and provide immediate feedback after testing of volunteer is completed (allow extra time for the first one because of this feedback).**

- Panel 9 (ABI section) needs to be completed during the certification process for each test and provided to site coordinator to assess for completeness/accuracy.
- Send electronically copies of paperwork (from both the trainee and trainer) to Nancy Glynn (epidnwg@pitt.edu) to calculate ABI and reliability between trainer and trainee
- 90% of differences in ABI between trainer and trainee should be <0.10

- Discuss problems and questions with local expert, QC coordinator, or on a field operations call.

QC Reports. Monthly reports of the distribution of final digits for each technician will be reviewed by the QC Officer. Trends toward digit preference will be discussed with the technician without revealing which digit and retraining/re-certification may be required.

References:

1. Newman AB; Siscovick DS; ManolioTA; Plak J; Fried LP; Borhani NO; Wolfson SK. Ankle-arm index as a marker of atherosclerosis in the Cardiovascular Health Study. Cardiovascular Health Study (CHS) Collaborative Research Group. Circulation, 1993 Sep, 88(3):837-45.

2. Newman AB, Shemanski L, Manolio TA, Cushman M, Mittelmark M, Polak JF, Powe NR, Siscovick D. Ankle-arm index as a predictor of cardiovascular disease and mortality in the Cardiovascular Health Study. The Cardiovascular Health Study Group. Arterioscler Thromb Vasc Biol. 1999;19:538-45.

3. Newman AB, Arnold AM, Naydeck BL, Fried LP, Burke GL, Enright P, Gottdiener J, Hirsch C, O'Leary D, Tracy R; Cardiovascular Health Study Research Group. Successful aging": effect of subclinical cardiovascular disease. Arch Intern Med. 2003;163:2315-22.

4. Newman AB, Fitzpatrick AL, Lopez O, Jackson S, Lyketsos C, Jagust W, Ives D, DeKosky ST, Kuller LH. Dementia and Alzheimer's disease incidence in relationship to cardiovascular disease in the Cardiovascular Health Study cohort. JAGS. 2005;53:1101-1107.

MEASURE: STANDING HEIGHT

Standing Height Measurement: Record the standing height in Questions 11a-11f after measurement by the following procedure outlined below. If participant is unable to complete standing height, mark the form with a "N" for not applicable, subject is unable to perform the procedure. However, if the participant is unable to complete the procedure because they were unable to sufficiently follow instructions to complete the measurement, then enter "U" for measurement 1 (Q11a) and then proceed to Q12a.

Home Visit Protocol

MEASURE: STANDING HEIGHT

Standing Height Measurement: Record the standing height in Questions 11a-11f after measurement by the following procedure outlined below. If participant is unable to complete standing height, mark the form with a "N" for not applicable, subject is unable to perform the procedure. However, if the participant is unable to complete the procedure because they were unable to sufficiently follow instructions to complete the measurement, then enter "U" for measurement 1 (Q11a) and then proceed to Q12a for all NEW participants and Q15 for RETURNING participants.

Home Visit Protocol:

1. Use a hard, flat floor that is even and without carpet. Measurement may be inside a doorway, against a closed door, or in a hallway. Use an area that does not have a baseboard, threshold, or other protrusion.

2. Explain the procedure to the participant. Ask him/her to remove shoes or slippers. Ask him/her to stand with feet flat on the floor, heels together, with heels, hips, shoulders directly against the wall. Keep the head in a Frankfort plane (Figure 2) as close to the wall as possible. [Note: if the participant has a kyphotic posture, measure the height with the participant standing in a sideways position, preferably in a doorway.]

   Script: *Now I am going to measure your standing height. Please remove your shoes. Stand with your feet flat on the floor, heels together, with heels, hips, shoulders directly against the wall."*

3. Ask the participant to tilt the head forward so you can place a piece of painter's tape or large post-it note securely vertically on the wall in the area where the height will be measured. Place the tape loosely, with one end folded over so that it will be easy to remove without damaging the wall. Now ask the participant to look straight ahead.
4. Rest the wooden base of the set square against the wall above the participant's head with the right angle toward the floor. Slide down slowly until it touches the top of the participant's scalp, carefully centered with their nose. Make sure one wooden edge is flat and held steadily against the wall. Mark the tape exactly where the corner of the right angle touches the tape. Be sure to mark the tape from underneath the set square with the pencil angled upward.
5. Remove the square and ask the participant to step away from the wall. Open the metal measuring tape and make sure it is straight. Secure it against the wall by pressing it with your foot at the "0" end, or by taping it. Keeping the tape flat against the wall, and vertical read the measurement closest to the mark on the tape and record to the nearest 0.1 cm. If necessary, stand on the folding stool to be at eye level with the mark. It may be necessary to solicit assistance from the second technician or the participant if you use a stool.
6. Record the height measurement. If the two measurements differ by $\geq$ 0.4 cm, two additional measurements should be taken. After the result has been recorded, convert the height to feet and inches for the participant.
7. Remove the tape carefully from the wall and discard.

Clinic Protocol: If the visit is done in the clinic, follow the procedures above, but use a stadiometer in lieu of the handi-stat set square. See sitting height below for stadiometer instructions. If participant is unable to complete standing height, mark the form with an "N" for not applicable, subject is unable to perform the procedure. However, if the participant is unable to complete the procedure because they were unable to sufficiently follow instructions to complete the measurement, then enter "U" for measurement 1 (Q6a) and then proceed to Q7.

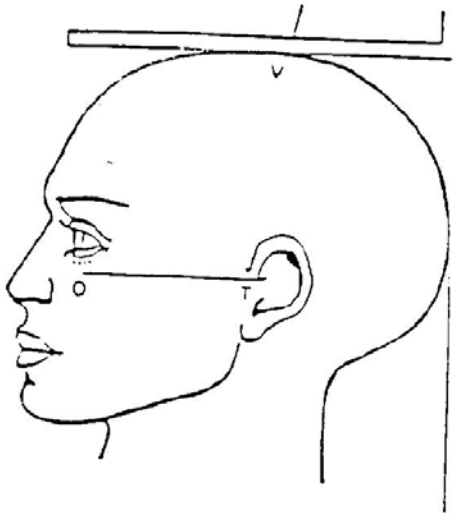

Figure 2

MEASURE: BODY WEIGHT MEASUREMENT

Scale Weight: The SECA Integra 840 or 841 digital scale is to be brought to the home visit for weighing the participant.

Record the weight in Question 15 after measurement, using the following guidelines outlined below. If participant is unable to complete the weight measurement, mark the form with an "N" for not applicable, participant is unable to perform the procedure. However, if the participant is unable to complete the procedure because they were unable to sufficiently follow instructions to complete the measurement, then enter "U" for this measurement (Q15) and then proceed to Q16a.

Note: If the measured body weight is over 300 lbs, the scale will not register. If the individual has a home scale and they are weighed on it, please enter the weight from the non-LLFS approved equipment. If they do not have a home scale, you can ask them for their self-reported body weight. If the scale malfunctions and you are unable to get a measurement, you can ask for their self-reported body weight. For all situations, flag this form for data entry as this value should be marked in REDCap as an estimated value. There is an associated comment field for this questionnaire item where you can make the notation.

1. Check the scale prior to the visit to verify that the batteries are operational. If necessary, remove the digital display head from the base to open the battery compartment underneath, and replace with a new standard 9 volt alkaline battery. After connecting the battery terminals, insert the battery and close the cover. Replace the head on the base of the scale.
2. After carrying the scale into the home, place it on a hard floor surface rather than on a carpet.
3. The participant should be wearing light indoor clothing. Remove shoes as well as any heavy sweater, coat, etc. prior to the weigh-in.

   Script: *In order to measure your weight, please remove your shoes and heavy jewelry, and empty your pockets. Please step forward onto the center of the scale.*

4. To weigh the participant:
   - Select "kg" measurement using the switch on the underside of the digital display.
   - Turn the scale "on" by stepping one foot on the scale for 0.5 seconds. The number 0.0 will appear on the digital display.
   - The participant may step onto the scale as soon as the number 0.0 appears on the display.

- Wait about four seconds for the numbers to stabilize. Record the weight viewed on the digital display onto the anthropometry form or data-enter into the computer. This scale is accurate to 1 kg over the entire weighing range.
- If two values are displayed alternately in the 1 kg range, then the exact weight is between these values. Round to the nearest whole number.
- The scale switches off automatically after 30 seconds.

5. Problems:
   - If no weight display appears under the load - Remove the person from the scale, press the ON button and wait for the display to read 0.0.
   - If "----" appears in the display - Press the ON button and wait for the display to read 0.0.
   - If "ERR" appears on the display - Remove the person from the scale, press the ON button and wait for the display to read 0.0.
   - IF "BAT" appears on the display - Change the battery.

MEASURE: ABDOMINAL (WAIST) CIRCUMFERENCE

Measured waist circumference should be recorded in Questions 16a-16c. If participant is unable to complete abdominal circumference, mark the form with a "N" for not applicable, subject is unable to perform the procedure. However, if the participant is unable to complete the procedure because they were unable to sufficiently follow instructions to complete the measurement, then enter "U" for measurement 1 (Q16a) and then this form is completed.

1. The measurements will be taken over bare skin. Participants should be dressed in comfortable or light clothing (or ask them to lower their underwear to below hip level to allow measurement on bare skin) so that appropriate landmark can be located and should be instructed prior to the visit not to wear restricting or compressing undergarments, such as girdles or panty hose, which could interfere with the measurement.

2. Detailed Measurement Procedures:

- Ask the participant to stand with their weight equally distributed on both feet, arms hanging at their side, and head facing straight ahead. They should relax their abdomen and breathe normally. The examiner should be sitting or squatting at the side of the participant so that their eyes are at the evel of the waist.
- Measure the abdominal circumference directly over bare skin. If necessary, lower pants so that waist bands do not produce a bulge in tissue.
- Pull the tape around the participant's middle at the level of the umbilicus with the tape in a horizontal plane.
- Use a wall mirror hanging at waist level to be sure the tape is in the same horizontal plane all around. An assistant may sometimes be needed to help position the tape behind the participant. Alternately, have the participant help hold the tape in position. Bending their arm slightly should not affect the measurement as long as they maintain an erect posture.
- Hold the tape snug against the skin, without compressing the tissue, and with its zero end below the value to be recorded.
- Make the measurement at the end of a normal expiration to the nearest 0.1 cm.
  Record the first two measurements in Q16a-Q16b.

Script: *"I'd like to take a measurement around your middle at your bellybutton. I may need to move some of your clothing out of the way. Breathe normally. Don't hold your stomach in. Just relax."*

- Remove and reposition the tape. Calculate the difference between Q16a and Q16b in

Q16c. Repeat the measurement if the difference between the measurements is > 1 cm, a third and fourth measurement should be obtained. Record all of those measurements in Q16d-e. The computed value will be the mean of the two or four recorded values.

- If circumference at the umbilicus was obstructed (e.g., ostomy bag, bandages, hernia, etc.) during measurement, then mark 'yes' in Question 16f and explain in Question 16g.

For ALL NEW ENROLLEES, including Grandchildren:

MEASURE: ARM SPAN

Arm Span: Record the arm span in Question 12a after measurement by the following procedure:

Locate a wall in the home that can be used to measure the participant's arm span. The easiest would be a corner in the room. With the participant standing with their back to the wall, ask him/her to reach out with the arm fully until the longest fingertip touches the corner of the wall at shoulder height. Ask the participant to stretch out their other arm fully. Place a piece of painter's tape or large post-it note approximately at shoulder height and approximately at finger tips.

> Script: *In this test I will measure the length of your arm span from fingertip to fingertip. Please stand with your back to the wall and fully extend your right/left arm at shoulder height, just until your fingertip touches the corner of the wall. Now extend your other arm also at shoulder height. I will place a piece of tape at the outstretched fingertip and mark the tape.*

A carpenter's square or other straight edge will be used to determine the length to measure. Holding the square perpendicular to the wall at the longest fingertip, mark the tape where the square crosses the tape. Ask the participant to step away from the wall. Using a measuring tape, measure the distance between the 2 marks, on the tape, to the nearest half centimeter, rounding down.

If a corner is not available, measure against an open stretch of wall. It should be wide enough to allow the participant to stretch out his/her arms fully. Ask the participant to stand with his/her back against the wall. Ask the participant to stretch out their right arm fully. Place a piece of painter's tape approximately at shoulder height and approximately at finger tips. Repeat for the left arm. The participant is asked to step away from the wall. Using a measuring tape, measure the distance between the two marks, on the tape, to the nearest half centimeter, rounding down.

*Important Note***:** If the participant is unable to stand, the measurement can be done in a seated position. Also, if the participant can not fully extend both arms at shoulder height, do not measure arm span. Full extension means that both arms are extended to a 90° angle from the trunk. If participant is unable to complete arm span, mark the form with an "U" for not applicable, subject is unable to perform the procedure.

Height as Young Adult: The participant is asked to report in Question 12b their height as a young adult, that is, during their mid-twenties. This height may or may not be different than present height. Record the response given in feet and inches (or cm for the Danish cohort).

MEASURE: SITTING HEIGHT

Sitting Height: Record the sitting height in Questions 13a-13f after measurement by the following procedure:

Home Visit Protocol: Follow the procedures above for standing height. Proper positioning for this measure can be found for the clinic instructions below.

Clinic Protocol:

1. Have the participant sit on the seat with the legs hanging unsupported over the edge and with the hands resting on the thighs in a cross-handed position. If the feet are touching the floor, weight should be on the buttocks and not the feet. If the participant is uncomfortable in this position, i.e. feels that they are slipping forward, they can rest their feet on the rungs of the seat, again, with their weight on the buttocks and not on the feet. The knees should be directed straight ahead, and the back of the knees should be near the edge of the seat but not in contact with it. The muscles of the thighs and buttocks should be relaxed.

   Script**:** *"Please sit on this seat with your knees facing forward. Place your hands on your thighs in a cross-handed position. Sit up as straight as possible with your buttocks and back touching the backboard. (Optional: Do not support your body weight on your feet. All your weight should be on the buttocks.) Relax the muscles of your legs and buttocks."*

2. Ask the participant to sit as erect as possible with the buttocks, spine, and back of the head against the wall.
3. The participant should face straight ahead with their head in the Frankfort position (see **Figure 2**).

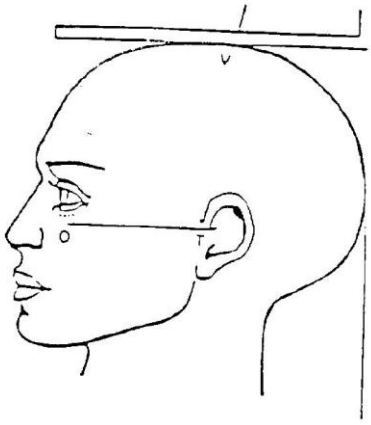

Figure 3

4. Place the horizontal wall plate firmly on the top of the head. (Place a weight, of about 0.5 kg, on the headboard. This weight presses down on the hair, thus flattening any hairstyle and overcomes the natural

friction of the machine so that any upward or downward movement during the measurement is recorded on the counter).

5. Have the participant breathe in deeply.

   Script: *"Take a deep breath."*

   Record the reading in mm on the stadiometer just before the participant exhales.

   Script: *"Breathe out."*

6. The participant should step away from the stadiometer, and the procedure should be repeated for the second measurement. If the two measurements differ by > 0.4 cm, two additional measurements should be taken.

7. Deviations/exceptions to standard positioning:

   - For participants with extremely kyphotic (stooped) posture, it may not be possible to obtain contact between the headboard and scalp when the participant's buttocks are against the wall-plate. In this case, measure sitting height with the participant sitting sideways (side of arm against the wall-plate) and positioned so the headboard contacts the scalp. Record that the participant was measured in the sideways position on the scoring form so that follow-up measurements will be made in the same position.

MEASURE: KNEE HEIGHT

Knee Height: Loss of height occurs frequently in the elderly. Knee height is independent of age among adults and does not appear to decrease over time (Chumlea, 1985).

Record the knee height in Questions 14a-14c after measurement by the following procedure:

1. Knee height is measured on the right leg, using a sliding broad-blade caliper, with the subject in the seated position (see **Figure 3**) (Chumlea, 1985). The patient's shoes and socks are removed, and pants rolled up past the knee.

   Script: *Please remove your shoes and socks from your right foot and roll up your pant leg past your knee. In this test, we will measure the length of your leg from heel to knee. Place the heel of your right foot on this measuring caliper and this other arm will rest on your knee.*

2. To obtain the measurement, the participant sits on a chair/examination table with both legs dangling. The participant may require the assistance of the examiner to help him onto the table.

3. The examiner places the fixed blade of the large sliding caliper under the heel of the right leg just below the lateral malleolus of the fibula. **Please Note:** If the participant has had a knee replacement on the right knee, the measurement may be taken on that leg as long as the participant can bend the replaced knee to a 90 degree angle. If the participant is unable, the left leg will be used to measure knee height. If the participant is unable to bend either knee, this measurement will not be taken.

4. From a squatting position, the examiner raises the leg so that the knee and ankle are both at a 90 degree angle (see **Figure 3**). This is best accomplished by resting the participant's foot in the palm of the examiner's hand.

5. The moveable blade of the caliper is placed on the anterior surface of the right thigh, above the condyles of the femur at the edge of the patella.

6. The shaft of the caliper is held parallel to the shaft of the tibia so that the shaft of the caliper passes over the lateral malleolus of the fibula and just posterior to the head of the fibula. Pressure is applied to compress the tissue.

7. The recorder checks the positioning of the leg and the caliper. Knee height is recorded to the nearest 0.1 cm. Measurements to the nearest 0.1 cm are obtained and then repeated.

8. The mean of the 2 measurements is used in the analysis

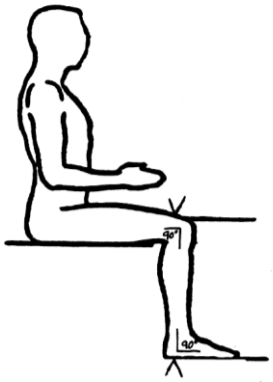

Figure 4

Reference: Chumlea WC, Roche AF, Steinbaugh ML. Estimating stature from knee height for persons 60 to 90 years of age. J Am Geriatr Soc 1985; 33: 116-20.

Study Documents Referred to in this Chapter:

- Panel 9: Blood Pressure, Ankle-arm index, Height, Weight and Waist Circumference Data Collection Form