



# National Health and Nutrition Examination Survey (NHANES)

National Youth Fitness Survey (NYFS)  
Muscle Strength (Grip)  
Procedures Manual



July 2012

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# 1. OVERVIEW OF THE MUSCLE STRENGTH COMPONENT

## 1.1 Background

In October 2008, the Federal Government issued its first-ever Physical Activity Guidelines for Americans to provide science-based guidance on the types and amounts of physical activity that provide substantial health benefits for Americans. The Guidelines recommend that adults complete muscle strengthening activities in conjunction with general recommendations to obtain 150 minutes or more of physical activity. Similar guidelines exist for school-age children. Muscle strength refers to the maximum force that can be generated by a specific muscle or muscle group. Recent studies indicate that higher muscular strength was significantly and inversely associated with overall mortality rates and morbidity and mortality due to various chronic diseases. These associations have been demonstrated to be independent from other major risk factors and cardiorespiratory fitness.

The NHANES muscle strength component is developed in collaboration with the National Cancer Institute (NCI). The goals of this component are to provide: (1) nationally representative data on muscle strength; (2) prevalence estimates of persons with poor muscle strength; and (3) data to study the association between muscle strength and other health conditions and risk factors, such as obesity, cardiovascular disease, diabetes, hypertension, and activity and dietary patterns.

One of the most common methods of measuring muscle strength is the isometric grip strength test. We will measure isometric grip strength using a handgrip dynamometer. The participant will be asked to squeeze the dynamometer as hard as possible with each of his or her hands in a standing position.

## **2. EQUIPMENT**

### **2.1 Description of Examination Rooms**

Both examination rooms on the MC have been equipped to test handgrip muscle strength. If the SP is fitted and tested in exam room 1, the lower body muscle strength testing chair (LBMS) should be used. Exam room 2 is equipped with a fold-down bench on the wall for the SP to sit on. The bench has a 350 pound weight capacity. If the SP exceeds the weight limitation for the fold-down bench, move the SP to exam room 1 and use the LBMS chair.

### **2.2 Description of Equipment and Supplies**

The following equipment and supplies are used for the Muscle Strength component of the NYFS.

Nonconsumable items include:

- Takei Digital Grip Strength Dynamometer, Model T.K.K.5401 (Figure 2-1) with hard plastic carrying case.
- Small plastic jewelry container
- Plastic dynamometer tray with foam bottom
- Foot rests
- Support pad
- Digital timer



Figure 2-1. Dynamometer and carrying case

Consumable supplies include:

- Purell sanitizing wipes – pop-up bottle
- AAA batteries
- Cartoon stickers
- Black wet erase pen
- Dynamometer repair kit (1 roll of black tape, 1 bottle of finger nail polish)
- Lotion

## **2.3 Start of Stand Procedures**

### **2.3.1 Room Setup Procedures**

At the beginning of the stand, these procedures are followed to prepare the equipment for use. The FES will connect the workstation computer, keyboard, mouse, and barcode wand that are used for all exam components in both rooms.

1. Remove supplies, including the plastic dynamometer tray and jewelry container from the designated storage bins for each exam room and place them on the storage shelves in the two rooms.
2. Remove both dynamometers from the carrying cases and put the batteries in them. Put the carrying cases back in the appropriate storage bins.
3. Press the “ON/C” button to make sure the dynamometer comes on. If the dynamometer does not come on or the “battery low” light is on, replace the batteries.
4. After calibration is complete (Section 2.3.2), place the dynamometer in the plastic tray and return it to its assigned exam room.

### **2.3.2 Dynamometer Calibration Procedures**

Calibration checks are performed at the start of each stand to confirm that the dynamometer is working properly. A record of these checks is kept as part of the Quality Control (QC) procedures. The calibration is done using the equipment located in the body measures room on the NHANES MEC. Two members of the NYFS exam team should do the calibration together. Record the calibration measurements for each of the dynamometers on a piece of paper so the data can be entered into the computer upon return to the NYFS MC.

Items needed for the calibration procedures:

- Both dynamometers
- Hanging calibration weights (4, 10kg slotted weights and 1, 1kg hanging base weight) (Figure 2-2).
- Sitting box (body measures room)
- Two metal rails
- Pen and paper





Figure 2-2. Calibration weights

Both dynamometers are calibrated, one at a time, at the beginning of the stand. Follow the procedures outlined below for calibrating the dynamometers. The QC screens indicate the tolerance ranges.

1. Get all of the items needed for calibration out and within reach.
2. Choose one of the dynamometers and write the ID number on a piece of paper.
3. Turn the sitting box upside down so that the open hole is facing up.
4. Sit the hanging base weight in the center of the bottom of the box (Figure 2-3). (The center is marked.)



Figure 2-3. Hanging base weight placed in center of box

5. Adjust the dynamometer handle to the mark “5”.
6. Place the two rails parallel to each other over the opening on the sitting box. The open part of the rail should sit on the sitting box and the flat part of the rail should face up.
7. Insert the metal rails in the opening by the adjustment knob on the dynamometer. Each metal rail should fit against the outer edge of the dynamometer.
8. Position the dynamometer so that it hangs directly over the stem of the hanging base weight (Figure 2-4).

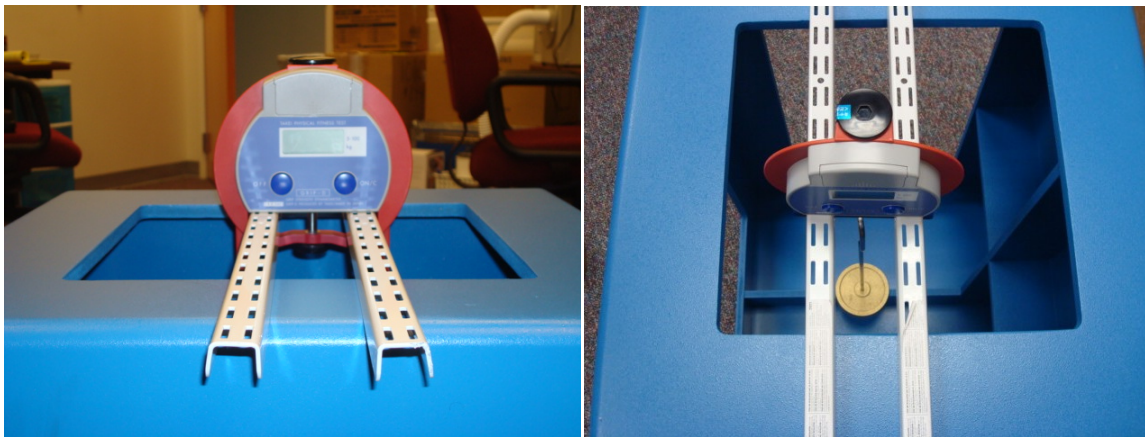


Figure 2-4. Positioning the dynamometer for calibration

9. When one of the NYFS staff begins hanging the weights on the dynamometer handle, the other staff member needs to keep the hanging base from moving as the weights are added to it. When picking up a weight, grab it by the indentation located on each side of the weight (Figure 2-5).

**NOTE:** The person holding the hanging bases in place should be careful not to pull down on the base. The dynamometer reading only goes up. Pulling down on the hanging base can give a false reading.

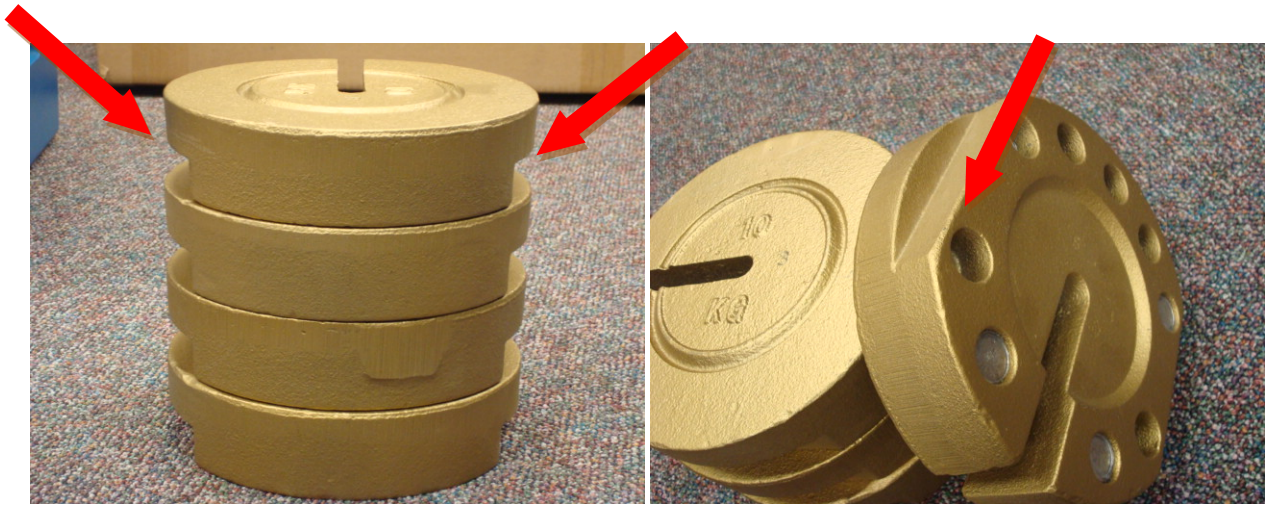


Figure 2-5. Indentation in weights for lifting

10. Turn the dynamometer on and carefully hang the base weight in the middle of the handle. The base weighs 1kg; however, it is too light to register on display.
11. Carefully and gently add a 10kg slotted weight to the base through the side of the sitting box. The stem of the base should be flush with the back of the weight's slot (Figure 2-6). Ensure that the slot is centered on the stem of the base. The position of the weight will affect the reading.



Figure 2-6. Positioning the stem in the center of the weight's slot



12. If the rails or the dynamometer moved as the weight was added, carefully readjust it (Figure 2-7).



Figure 2-7. Weights hanging from the dynamometer handle

13. The reading must fall between 9-13 kg. This is  $\pm 2$ kg of the slotted weight (10 kg) plus the weight of the base (1 kg).
  - If the measurement falls within the range, record the reading associated with the dynamometer's identification number.
  - If the reading does not fall within the range, follow the troubleshooting tips in Section 2.3.2.1.
14. After recording the reading, add another 10kg slotted weight to the stem by following the procedures in steps 10 and 11. There will be a total of 21kgs of weight hanging from the dynamometer.
  - The second reading should fall within the range of 19-23 kg.
  - If the measurement falls within the range, record the reading.
  - If the reading does not fall within the range, follow the troubleshooting tips in Section 2.3.2.1.
15. After recording the second reading, add two more 10kg weights to the base in the same manner indicated in steps 10 and 11. There will now be a total of 41kgs of weight hanging from the dynamometer.
  - The third reading should fall within the range of 39-43 kg.

- If the measurement falls within the range, record the reading.
  - If the reading does not fall within the range, follow the troubleshooting tips in Section 2.3.2.1.
16. After recording the final reading, carefully remove the slotted weights and the base from the handle and turn the dynamometer off. Do not leave the weights hanging from the handle any longer than absolutely necessary.
  17. Calibrate the second dynamometer in the same manner (Steps 4-16).
  18. Store all calibration items. (Put the calibration weights back in the cardboard boxes before storing them.)
  19. Turn the sitting box over and return it to its proper place.
  20. Upon return to the NYFS MC, enter the calibration readings for both dynamometers into ISIS.

### **2.3.2.1 Troubleshooting Tips**

If any of the measurements for any of the weights are outside of the tolerance range, take all the weights off the handle and turn the dynamometer off. Turn the dynamometer back on, perform the procedure again for that weight, and verify if the result is in the acceptable range. Check the positioning of the slotted weight on the base. The stem of the base should be flush with the back of the weight's slot and centered. The position of the weight will affect the reading.

If the result is still outside of the acceptable range, take all the weights off the handle, turn the dynamometer off and then have the other staff member repeat the calibration procedure. If the second tech cannot get the reading within its acceptable range, send an Unusual Field Occurrence (UFO) to notify the home office component person that a dynamometer has malfunctioned. A dynamometer cannot be used if it does not calibrate properly. A replacement dynamometer will be sent to the MC.

### **2.3.3 Recording Quality Control Results**

Record the results of the start of stand calibrations under the Start of Stand tab in the Muscle Strength QC application. Type the Identification number for the dynamometer that will be used in exam room 1 (the LBMS room) in the box under "Results" and the number for the dynamometer that will be used in exam room 2 in the box under "Comment." Then enter the data for each of the three calibrations in the

appropriate column for the dynamometer. Click the “Done” check box at the beginning of each row (Exhibit 2-1).

Exhibit 2-1. Start of Stand Quality Control Screen

QC Check	Done	Result	Comment
Dynamometer Serial Number	<input type="checkbox"/>		
Calibrate dynamometer - 11kg (Acceptable range 9 - 13 kg)	<input type="checkbox"/>		
Calibrate dynamometer - 21kg (Acceptable range 19 - 23 kg)	<input type="checkbox"/>		
Calibrate dynamometer - 41kg (Acceptable range 39 - 43 kg)	<input type="checkbox"/>		

## 2.4 Changing Equipment after Start of Stand

If the dynamometer is changed for any reason during a stand, enter the calibration readings for the replacement dynamometer into ISIS in the “Result” column under the Equip Swap section (Exhibit 2-2). In the first “Comment” field, indicate which dynamometer is being replaced (i.e., dynamometer in exam room 1 was replaced). The QC tabs in the Equip Swap section are identical to the tabs in the Start of Stand section.

Exhibit 2-2. Equipment Swap Quality Control Screen

QC Check	Done	Result	Comment
Dynamometer Serial Number	<input type="checkbox"/>		
Calibrate dynamometer - 11kg (Acceptable range 9 - 13 kg)	<input type="checkbox"/>		
Calibrate dynamometer - 21kg (Acceptable range 19 - 23 kg)	<input type="checkbox"/>		
Calibrate dynamometer - 41kg (Acceptable range 39 - 43 kg)	<input type="checkbox"/>		

## 2.5 End of Stand Procedures

### 2.5.1 Room Teardown

1. Remove the batteries from both dynamometers.
2. Put the dynamometers in the carrying cases.
3. Once the dynamometer is in the carrying case put the batteries in one of open spaces at the top of the dynamometer between the foam and the dynamometer (Figure 2-8).
4. Secure the dynamometers for travel in the storage bins designated for the appropriate exam room.

NOTE: Do not store the dynamometers in the belly.

5. Put loose supplies in a large zip lock bag and place in the storage bin.
6. Put the folding bench in room 2 in the “down” position.



Figure 2-8. Storing dynamometer batteries



## 3. PROTOCOL

### 3.1 Eligibility Criteria

All sample persons (SPs) aged 6–15 are eligible for the Muscle Strength component. The component consists of two sections, a pretest questionnaire and an isometric grip strength test using a handgrip dynamometer. This chapter will review the procedures for completing both of these sections.

### 3.2 Pre-examination Procedures

1. Introduce yourself to the SP.
2. Wand the SP into the ISIS system.
3. Have the SP sit down on the bench and give a brief introduction to the component.

#### ***SUGGESTED SCRIPT:***

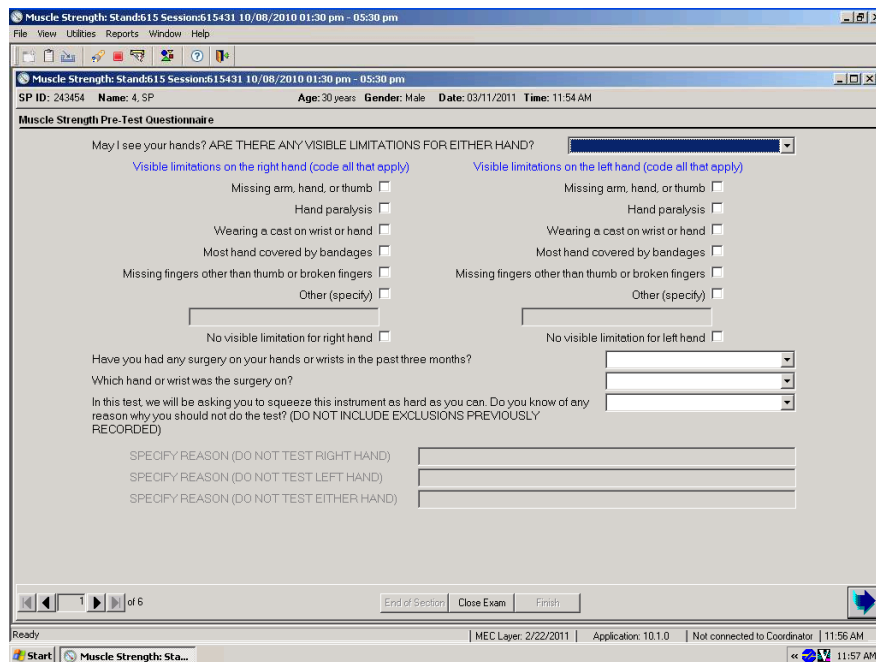
*In this exam, we want to get some information about your muscle strength. We will be asking you to squeeze as hard as possible with each of your hands. I will explain this in more detail in a few minutes but first I want to ask you a few questions.*

### 3.3 Pretest Questionnaire

Before beginning the grip strength testing procedures, the study participant is asked a series of questions to determine if he or she should be excluded from parts of the exam and to collect information on items that may influence the results. All questions used for exclusion are displayed on the first screen. ISIS will prompt you to ask each question. Responses are entered directly into the computer. In most cases, responses are entered from drop-down menus. Most pretest questions for SPs are completed with the parent/guardian during the nurse review exam. These responses are uploaded and displayed in a read-only format in the muscle strength application.

Ask the questions exactly as they appear on the screen. Do not omit or add anything. If the SP is unsure how to answer, use the explanations in the manual below each question to help the SP determine the answer. Listen carefully to the SP's responses, and make certain he or she is providing the information the question is asking. If you think the SP has misunderstood the question, probe to clarify by repeating the question with a preface such as "Just to make sure I have this correct . . ."

Exhibit 3-1. Pretest Questionnaire screen 1



1. May I see your hands? ARE THERE ANY VISIBLE LIMITATIONS FOR EITHER HAND?
  - Yes
  - No
  - Refused
  - a. Visible limitations on the right hand (CODE THAT ALL APPLY.)
    - Missing arm, hand, or thumb
    - Hand paralysis
    - Wearing a cast on wrist or hand

- Most of hand covered by bandages (See Figure 3-1 for examples.)
- Missing fingers other than thumb or broken fingers
- Other (specify) \_\_\_\_\_
- No visible limitation for right hand

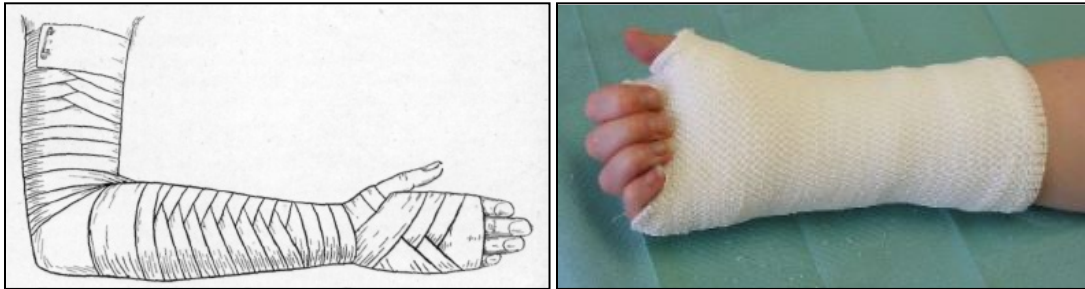


Figure 3-1. Example of hand mostly covered by bandages

- b. Visible limitations on the left hand (CODE THAT ALL APPLY.)
- Missing arm, hand, or thumb
  - Hand paralysis
  - Wearing a cast on wrist or hand
  - Most of hand covered by bandages (See Figure 3-1 for examples.)
  - Missing fingers other than thumb or broken fingers
  - Other (specify) \_\_\_\_\_
  - No visible limitation for left hand

Examine the SP's hands. If you determine that one or both hands has/have visible limitation(s), the system will prompt you to answer the follow-up questions to identify the observed limitations. Code **all** visible physical limitations that will affect the test. Once you chose "Yes" for the first question, you are not allowed to mark "no visible limitation" for both hands in the follow-up portions. In this case, an error message will be displayed to prompt you to change your response(s) in questions 1, 1a, or 1b.

Only use the "Other (specify)" code if you observed an unlisted reason on the SP's hand(s) that will definitely prevent him or her from holding or squeezing the dynamometer. Do not record minor abnormalities such as a minor paper cut in this field because this code will trigger the hand indicated to be excluded.

If one of the SP's hands is coded as "Missing arm, hand, or thumb," "Hand paralysis," "Wearing a cast on wrist or hand," "Most hand covered by bandages," or "Other (specify)," he or she will be excluded from testing that specific hand. If an SP is missing fingers other than the thumb on the right or left hand, he or she is still eligible to complete the exam. If there is a visible physical limitation that excludes both hands or if the SP refuses to let you see his or her hands, the exam will end.

2. Have you had any surgery on your hands or wrists **in the past three months**?

- Yes
- No
- Refused
- Don't know

a. Which hand or wrist was the surgery on?

- Right hand/wrist
- Left hand/wrist
- Both hands/wrist
- Refused
- Don't know

If the SP has had surgery on his or her hands or wrists in the past 3 months, ISIS will prompt you to ask which hand(s) or wrist(s). This is a safety exclusion question. The hand(s) or wrist(s) indicated will be excluded from the exam. If the SP has had any other surgeries that will affect his or her ability to complete the test, it will be recorded in question 3.

3. In this test, we will be asking you to squeeze this instrument as hard as you can. Do you know of any reason why you should not do the test? (DO NOT INCLUDE EXCLUSIONS PREVIOUSLY RECORDED.)

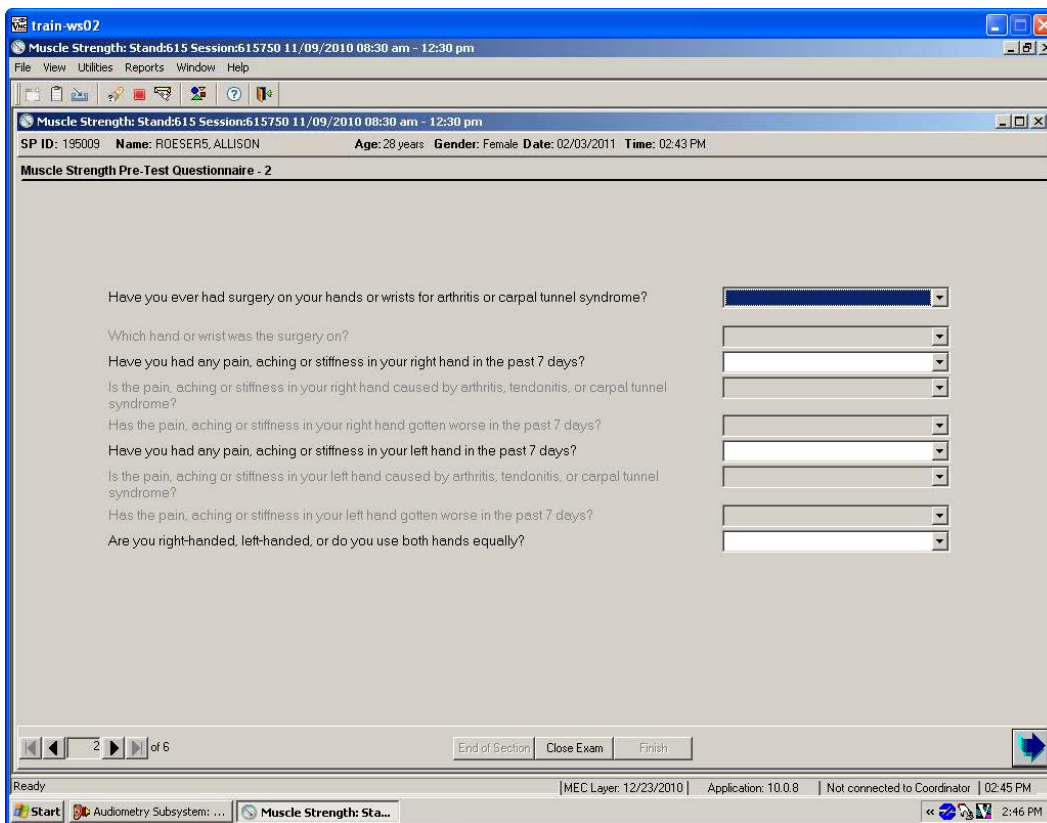
- No
- Yes; should not test right hand
- Yes; should not test left hand
- Yes; should not test either hand

- Refused
  - Don't know
- a. Specify reason \_\_\_\_\_

This is the last exclusion question. Only note exclusions that were not recorded in the two previous questions. If the SP indicates that one or both hands should not be tested, you will be prompted to specify a reason. Type the reason the SP gives into the computer.

Based on the responses given to the safety exclusion questions, ISIS will determine which hand(s) should be tested. The remaining questions will be used to help interpret the data. Responses to these questions will not exclude an SP from the test.

Exhibit 3-2. Pretest Questionnaire screen 2



4. Have you **ever** had surgery on your hands or wrists for **arthritis** or **carpal tunnel syndrome**?

- Yes
- No
- Refused
- Don't know

a. Which hand or wrist was the surgery on?

- Right hand/wrist
- Left hand/wrist
- Both hands/wrist
- Refused
- Don't know

If the SP has had surgery on his or her hands or wrists for arthritis or carpal tunnel syndrome, ISIS will prompt you to ask which hand(s) or wrist(s).

5. Have you had any pain, aching or stiffness in your **right** hand in the **past 7 days**?

- Yes
- No
- Refused
- Don't know

a. Is the pain, aching or stiffness in your **right** hand caused by **arthritis**, **tendonitis**, or **carpal tunnel syndrome**?

- Yes
- No
- Refused
- Don't know

b. Has the pain, aching or stiffness in your **right** hand **gotten worse** in the past 7 days?

- Yes
- No
- Refused
- Don't know

This set of questions is only asked to the SP if his or her right hand has been determined as eligible for the grip test. If the SP's right hand is excluded from the test, the system will block these questions and the entry fields will be grayed out on the screen.

If the SP has had pain, aching or stiffness in his or her right hand in the past 7 days, ISIS will prompt you to ask two follow-up questions. The first follow-up question asks whether the pain, aching, or stiffness is caused by arthritis, tendonitis, or carpal tunnel syndrome. The second question is used to ascertain whether there is any acute flare-up on the SP's right hand.

6. Have you had any pain, aching or stiffness in your **left** hand in the **past 7 days**?

- Yes
- No
- Refused
- Don't know

a. Is the pain, aching or stiffness in your **left** hand caused by **arthritis, tendonitis, or carpal tunnel syndrome**?

- Yes
- No
- Refused
- Don't know

b. Has the pain, aching or stiffness in your **left** hand **gotten worse** in the past 7 days?

- Yes
- No

- Refused
- Don't know

The same questions are repeated here for the left hand. Similar to the previous set of questions, these questions are only asked to the SP if his or her left hand has been determined as eligible for the grip test. If the SP's left hand is excluded from the test, the system will block these questions and the entry fields will be grayed out on the screen.

7. Are you right-handed, left-handed, or do you use both hands equally?

- Right-handed
- Left-handed
- Use both hands equally
- Refused
- Don't know

This question is used to identify the SP's dominant hand. This information will be used to determine which hand the test will start with. If the SP has trouble identifying his or her dominant hand, probe for his or her writing hand. If the response from the nurse review application for this question is "Don't Know," ISIS will prompt you to ask the child SP directly.

### **3.4 Handgrip Testing Procedures**

#### **3.4.1 SP Preparation and Warm-Up**

Once all of the pretest questions have been completed, prepare the SP for the test. The SP will remain seated during the preparation and warm-up.

At the top of the pretest screen (Exhibit 3-3) is a reminder to ask the SP to remove hand and wrist jewelry. Hand and wrist jewelry could interfere with the SP's ability to grip the dynamometer or become damaged from squeezing the dynamometer. To prevent damaging the SP's jewelry, ask the SP to remove hand and wrist jewelry and place it in the small plastic container on the counter. If the SP does not want to remove his or her jewelry, the test will still continue.

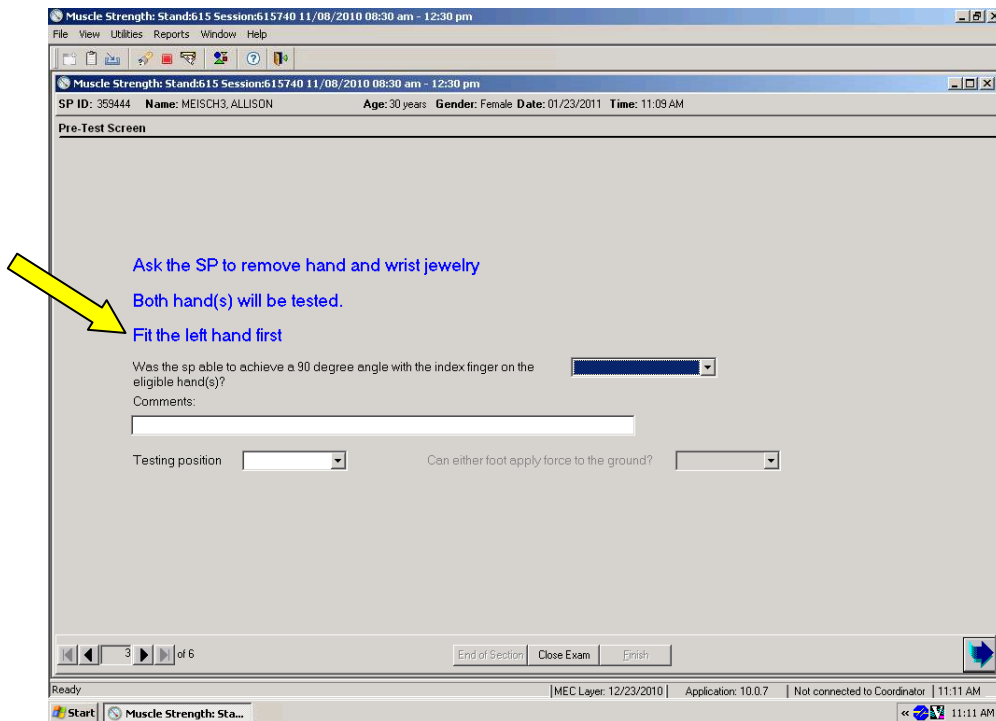


To loosen up the hands and fingers, the SP will complete two warm-up exercises. The warm-up exercises include shaking both hands three times and bending and stretching all fingers three times. Demonstrate each exercise and ask the SP to do the exercise.

### 3.4.2 Adjusting the Dynamometer Grip Size

The SP will remain seated when the dynamometer is adjusted for grip size. Tell the SP “*Next I am going to adjust this device to fit your hand(s). Please hold this with your (right/left) hand.*” The screen indicates if the right, left, or both hands will be tested. If one hand has previously been excluded, the message on the screen will indicate which hand will be tested as a reminder that you only need to fit one hand. If both hands will be tested, the pretest screen also indicates which hand to fit first (Exhibit 3-3). The starting hand is always fitted first.

Exhibit 3-3. Pretest screen



Place the support pad on the SP’s lap. Set the dynamometer on the pad and place it in the SP’s hand that will be fitted first with the front of the dynamometer facing out as indicated in Figure 3-2. Adjust the grip to the SP’s hand size.

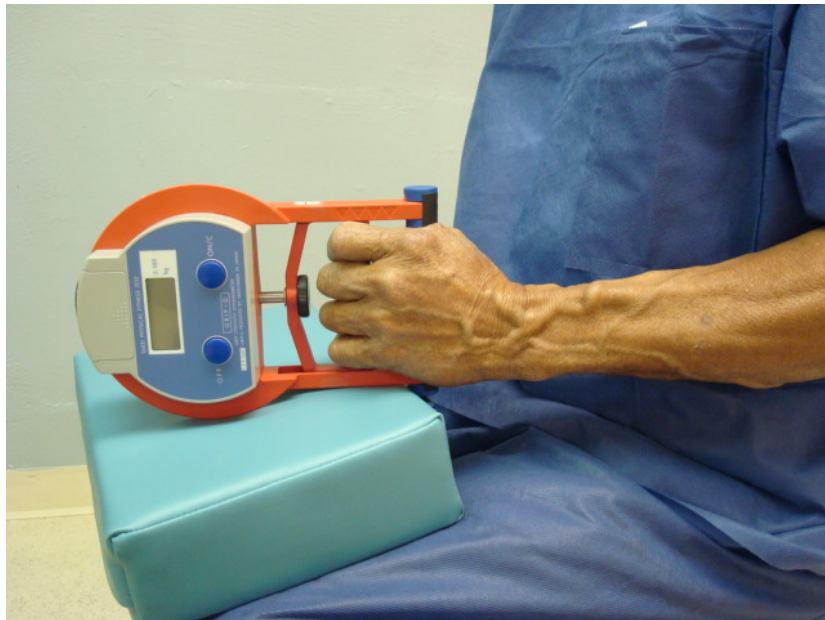


Figure 3-2. Dynamometer resting on support pad

When adjusting the grip size, follow these guidelines:

- Adjust the grip size of the dynamometer until the second joint of the index finger is at a 90 degree angle on the handle (90° flexion between proximal and middle phalangeal joint). See Figure 3-3. When adjusting the grip size, the hand should be in line with the wrist and forearm.

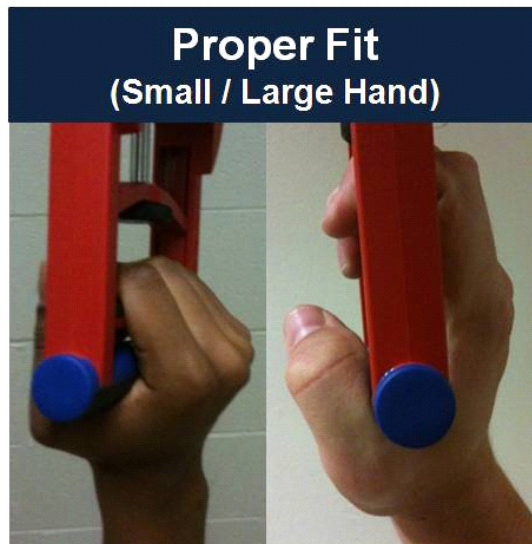


Figure 3-3. Proper handgrip fit

- If the second joint of the index finger is less than 90 degrees, increase the grip size by turning the adjustment knob clockwise.
  - a. If the SP's finger nails are hitting the palm, adjust the dynamometer to a larger grip size.
- If the second joint of the index finger is more than 90 degrees, decrease the grip size by turning the adjustment knob counterclockwise.
  - a. A line on the handle indicates the minimum grip size. The handle should never be placed lower than this line (Figure 3-4).

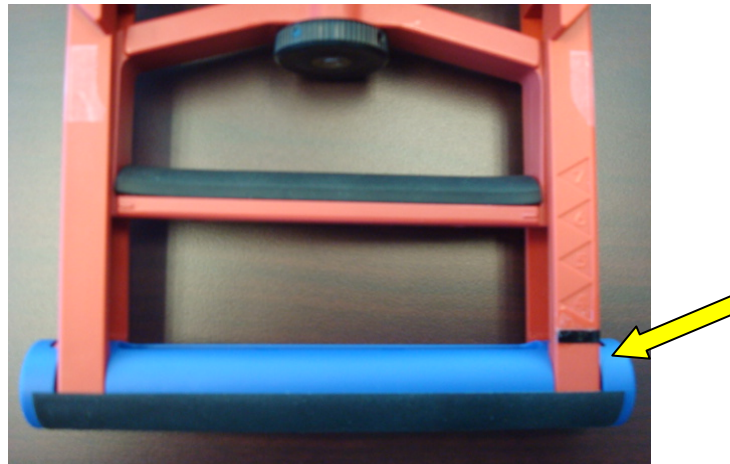


Figure 3-4. Minimum grip size line

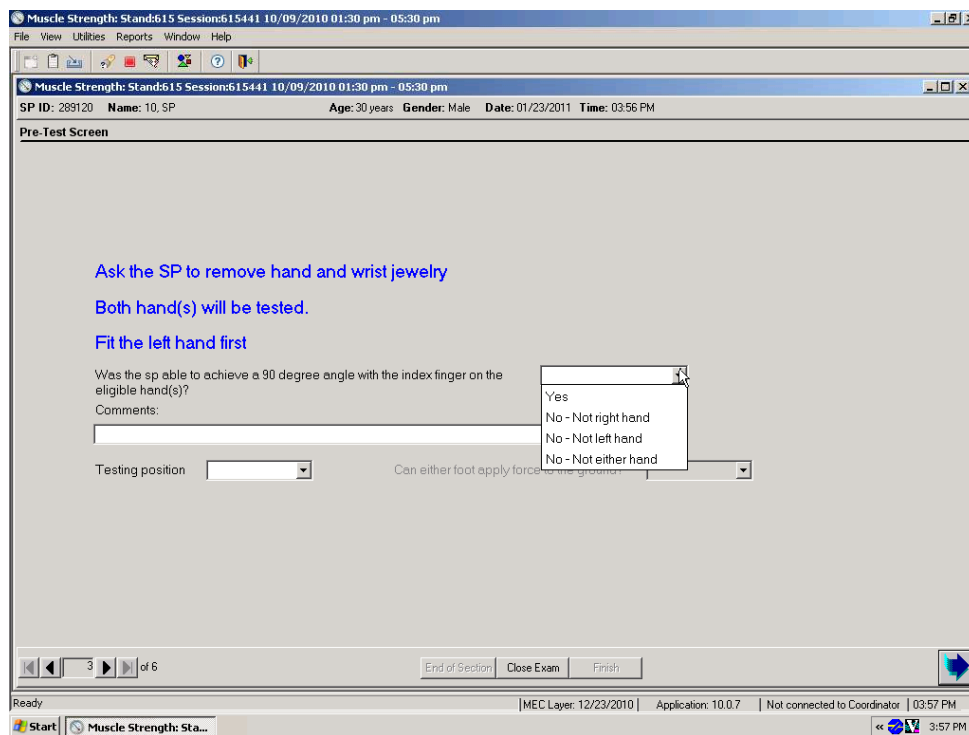
- When adjusting the grip size, the tech will look down on the SP's hand to see the angle of the index finger (Figure 3-5).



Figure 3-5. Checking angle of index finger

- If the second joint of the SP’s index finger cannot bend enough to achieve the 90 degree angle for any reason (i.e., arthritis, long nails, large or small hand), adjust the grip size to be as close to the 90 degree angle as you can and proceed with the exam.
  - On the pretest screen, indicate whether or not the SP was able to bend his or her index finger to achieve the 90 degree angle (Exhibit 3-4).
  - If the SP was not able to achieve a 90 degree angle at the second joint of the index finger, specify the hand (right, left or both) in the drop-down box and enter the reason why in the “Comments” field (i.e., both hands too small, both hands too large, R arthritis, L nails too long).

Exhibit 3-4. Pretest screen – 90 degree angle on index finger



Record any additional comments regarding the SP’s hand or fingers in the “Comments” field (Exhibit 3-4). Use the following abbreviations to record your comments:

- R: right hand – use capitalized letter “R” to refer to the right hand
- L: left hand – use capitalized letter “L” to refer to the left hand

- D: digit – use 1D, 2D, 3D, 4D, and 5D to refer thumb, index finger, middle finger, ring finger, and pinky, respectively
- P: phalange

For example, “missing 1P in L2D” means “missing 1 phalange in the index finger on left hand.”

After the grip size is adjusted for the first test hand, put the dynamometer in the opposite hand in the same manner. This will be the practice hand. Check the grip to see if the same grip size fits both hands. Most of the time, the grip size will be the same for both hands. If the grip size is not the same for both hands, follow the guidelines below to make adjustments:

- Use the wet erase pen to mark the placement of the handle for the first hand. The mark should be made on the back of the dynamometer in line with the indicator mark on the handle (Figure 3-6).
- Adjust the grip size for the second hand (the practice hand). Mark the handle placement for the second hand. Proceed with the demonstration.
- Make proper adjustments for each hand between each of the six measurements.

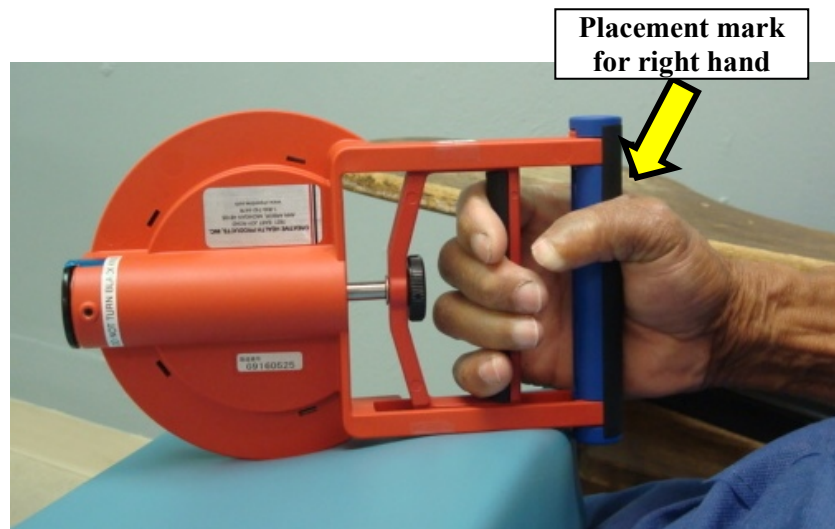
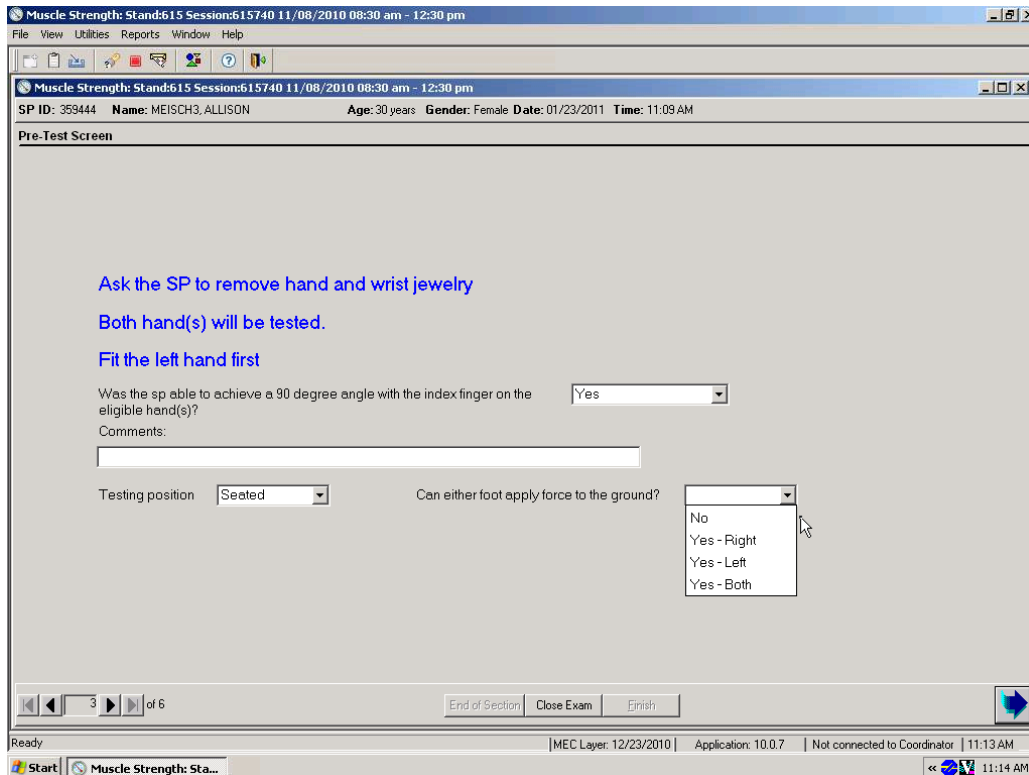


Figure 3-6. Proper marking of the handle placement

The SP will only perform the exam in the seated position if he or she cannot stand unassisted (see Section 3.4.5). Record if the SP will stand or sit for the exam on the pretest screen. If the exam will be completed in a sitting position, the system will prompt you to indicate whether either of the SP’s feet

can apply force to the ground. The options are listed in the drop-down box as “No,” “Yes – Right,” “Yes – Left,” or “Yes – Both” (Exhibit 3-5). If it is not obvious, check the SP’s leg function by placing your hand under the SP’s foot/feet and ask the SP to apply force to your hand. The test will still continue regardless of the SP’s leg function; however, this information is important for data analysis.

Exhibit 3-5. Pretest screen – testing position



### 3.4.3 Tech Demonstration of Exam

After the grip size is adjusted, take the dynamometer from the SP and explain the exam to the SP using the suggested scripts below. During the demonstration, the SP can remain sitting while you stand to demonstrate.

***SUGGESTED SCRIPT:***

*For the test, I will ask you to squeeze this hand grip as hard as you can. You will stand with your feet hip width apart and your toes pointing forward like this. You will hold your hand so that it's not touching your body and squeeze the handle. I want you to stand tall and try not to lean when you squeeze. You will take a breath in, then blow out while you squeeze. You will squeeze as hard as you can until you can't squeeze any harder. Like this.*

*(Do the squeeze demo now.)*

*We will test each hand 3 times.*

While explaining the test to the SP, demonstrate the test as indicated below.

- Grasp the dynamometer between the fingers and the palm at the base of the thumb.
- Hold the dynamometer in line with the forearm at the thigh level so that it's not touching the body.
- Emphasize that the SP should stand with the feet hip width apart with their toes pointing forward.
- Instruct the SP that neither the hand nor dynamometer should touch the body or any other object during the test.
- Instruct the SP not to hold his or her breath. (Take a breath in before starting the squeeze, then blow out the air during the squeeze.)
- Emphasize the quickness and hardness of the squeezing motion (with fist slightly shaking).

Figure 3-7 shows an example of the proper testing form. Notice that the elbow is straight and fully extended at the side. The head is straight and the eyes are looking straight ahead. The wrist is not flexed or extended and the feet are hip width apart and even.

If the SP will perform the test in a seated position because he or she cannot stand unassisted for the entire grip strength portion of the test, the test should be demonstrated in the seated position.



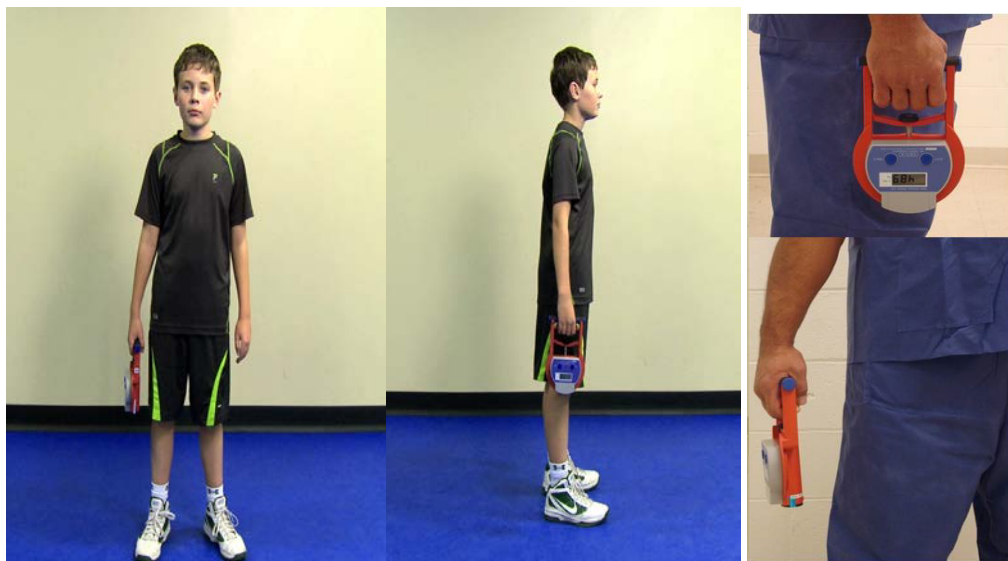


Figure 3-7. Proper testing form

#### 3.4.4 Positioning the SP and Conducting the Practice Trial

After completing the demonstration, you are ready to conduct a practice trial on one hand with the SP to determine if the procedure is understood. **This should only be done at a submaximal effort.** The hand to be used for the practice trial is indicated on the data collection screen. It is usually the opposite hand that you will start the test on. If the SP only has one hand that is eligible for the test, the practice trial will be on that hand with a reminder on the screen to wait 60 seconds before starting the test. Use the digital timer provided to make sure you wait 60 seconds before you start the test.

Have the SP stand unassisted. Fold the sitting bench back to the wall position. See Section 3.4.5 for positioning SPs who cannot perform the test standing. Follow the steps below to position the SP for the trial.

- Make sure the SP is in the proper stance.
  - Standing with the feet hip width apart and even, toes pointing forward
  - Knees comfortable but not bent
  - Shoulders back and chest up
  - Head is level



- Eyes straight ahead
- Arm at side with palm facing leg
- Turn the dynamometer on by pressing the “ON/C” button.
- Hand the dynamometer to the SP.
- SP will grasp the dynamometer between the fingers and the palm at the base of the thumb.
- SP will hold the dynamometer in line with the forearm at the thigh level so that it’s not touching the body.
- Remind the SP that neither the hand nor dynamometer should touch the body or any other object during the test.
- See Appendix A for examples of incorrect positions.

After the SP is positioned correctly, remind the SP to only squeeze the dynamometer at a submaximal effort and not to hold his or her breath. Below is the suggested script for this practice:

***Suggested Script:***

*“Now try it once just to get the feel of it. For this practice, just squeeze gently. Ready, take a breath in, let it out, squeeze gently.”*

Some natural movement or change in the SP’s stance may occur when the SP squeezes the handle. This is okay as long as the SP doesn’t completely lose the testing form. See Section 3.6 for examples of when the test would need to be repeated.

**3.4.5 Positioning SPs Who Cannot Stand Unassisted**

If an SP cannot stand unassisted for the entire grip strength portion of the exam, he or she can still perform the test but in the seated position. Both feet should be placed on the ground. If necessary, place SP’s feet on the stackable foot rests to allow the feet to apply force to the surface. If the SP does not have function in his or her legs (i.e., paralyzed), it is okay to leave the nonfunctional foot or feet off of the ground or in the foot rest of the wheelchair. Ensure that the SP is sitting straight up on the bench (back not resting against the wall) and not holding on to anything. The arm should be at the side (Figure 3-8). If the SP is in a wheelchair, it is okay if the arm is touching the arm rest; however, the SP should not use the

arm rest for leverage. If the SP is not able to obtain the proper testing form in the seated position, he or she will be excluded from the grip test portion of the exam.

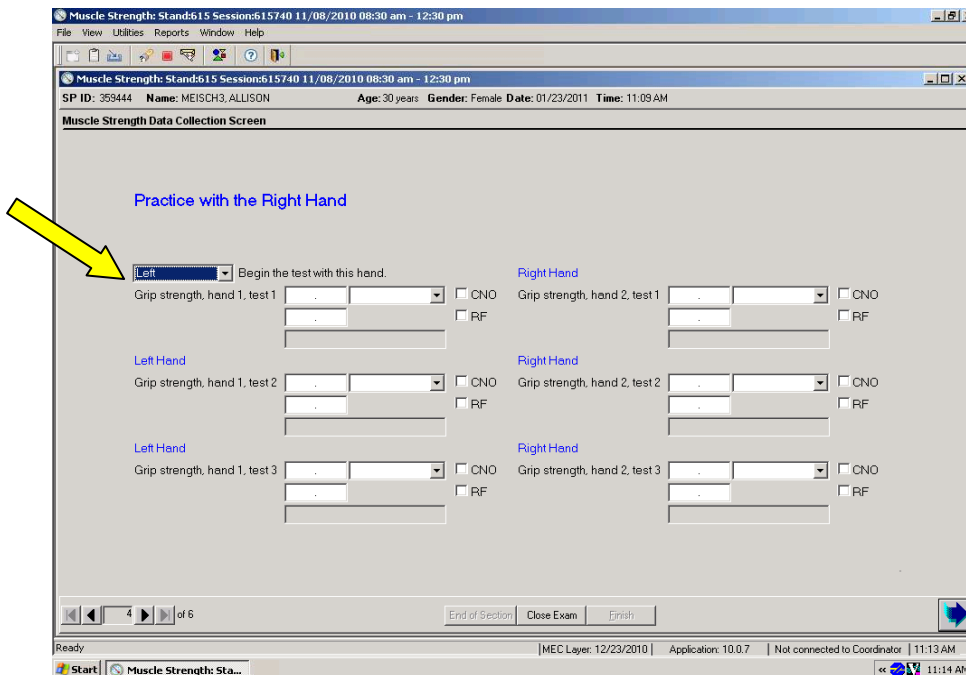


Figure 3-8. Arm position for seated exam

### **3.4.6 Start the Exam**

After the practice trial is completed and the SP understands the test, you are ready to begin the exam. For the exam, each hand will be tested three times, alternating hands between trials with a 60-second rest between measurements on the same hand. The order of the tests is randomized by the SP's ID number and the SP's dominant hand (i.e., odd number ID starts with his or her dominant hand; even number ID starts with his or her non-dominant hand; people with unidentifiable dominant hand randomly assigned by ID). The ISIS application indicates which hand to test first on the screen (Exhibit 3-6). It is shown as a drop-down box, prefilled with "right" or "left." If you inadvertently start with the incorrect hand, change the selection in the drop-down box and all of the data entry fields will automatically be relabeled accordingly.

Exhibit 3-6. Data Collection screen – first test hand



Always double check the testing position before each test. SPs often move their feet between each test so it is important to double check the SP's feet each time. Press the "ON/C" button (Figure 3-9) on the dynamometer before the start of each test. This will reset the dynamometer reading to zero and disable the dynamometer from calculating and display the average grip strength reading automatically. For each test, once the SP finishes squeezing, take the dynamometer from the SP and enter the reading into the ISIS application. The 60-second timer on the screen will start to countdown. Do not return the dynamometer to the SP until all 60 seconds have elapsed. Remember to set the dynamometer to zero by pressing the "ON/C" button prior to returning it to the SP.



Figure 3-9. Dynamometer "ON/C" button

Reminder: If the SP's grip size was different between their two hands, you will need to adjust the handle size each time based on the marks you made earlier.

### **3.4.6.1 Coaching the SP**

When the SP is squeezing the dynamometer, encourage him or her by using a neutral, instructive, and upbeat tone. The SP will squeeze the dynamometer as hard as possible. Instruct the SP by saying:

***Suggested Script:***

*When I say "squeeze," squeeze as hard as you can until you can't squeeze any harder.*

*Remember to blow out when you squeeze.*

*READY, TAKE A BREATH IN, LET IT OUT, SQUEEZE!*

*SQUEEZE AS HARD AS YOU CAN UNTIL YOU CAN'T SQUEEZE ANY HARDER.*

After the first squeeze, do not repeat the entire coaching script unless it is necessary. For subsequent squeezes, say:

*READY, TAKE A BREATH IN, LET IT OUT, SQUEEZE!*

*SQUEEZE AS HARD AS YOU CAN UNTIL YOU CAN'T SQUEEZE ANY HARDER.*

SPs may have different coaching needs. It is acceptable to adjust your coaching accordingly. For example, if the SP is holding his or her breath or starting to lean while squeezing, you may need to remind the SP to breathe out or to stand tall.

### **3.4.7 Recording the Results**

Enter the reading on the dynamometer screen into the data entry field on the screen. Double data entry is required. Entering the reading on the screen will trigger a 60-second timer. The next test on that hand cannot begin until the 60 seconds have elapsed. On the right of the data entry fields for each reading is a drop-down box. Click the drop-down box and rate your impression of the effort exerted by the SP as maximal or questionable (Exhibit 3-7). Only rate the effort as maximal if you notice the SP's fist slightly shaking when they squeeze.

Exhibit 3-7. Data Collection screen – effort exerted

The screenshot shows the 'Muscle Strength Data Collection Screen' for a subject named '10, SP'. The screen is titled 'Practice with the Right Hand'. It displays three rows of data for 'Grip strength, hand 1' and 'Grip strength, hand 2'. Each row has a dropdown menu for the hand (Left or Right), a numerical input field, a dropdown for effort level (Maximal, Questionable), and checkboxes for 'CNO' and 'RF'. The first test on the right hand shows a value of 25.2 with 'Maximal' effort. Below the data entry fields, there are two large blue text labels: '30 seconds' and '46 seconds'. At the bottom, there are navigation buttons: 'End of Section', 'Close Exam', and 'Finish'.

If a particular measurement could not be obtained, click “CNO” for that measurement. A data entry field will open. Indicate why the measurement could not be obtained. If the SP refuses to complete a measurement, click, “RF” (Exhibit 3-8).

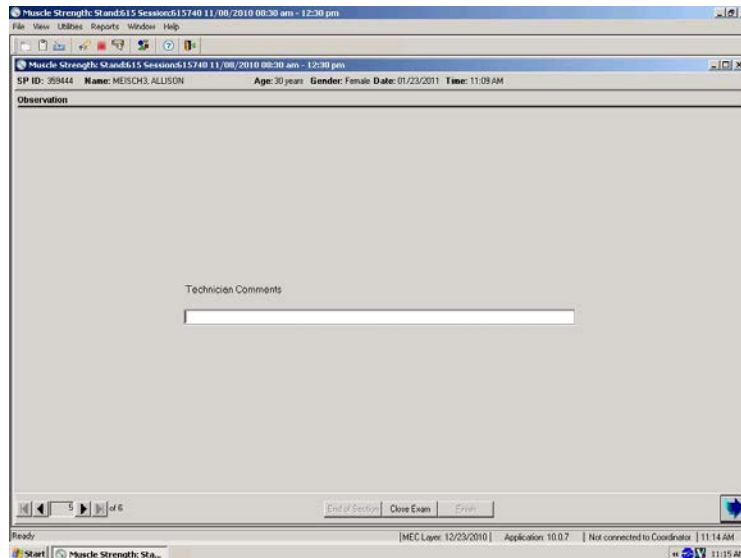
Exhibit 3-8. Data Collection screen – CNO and refused

This screenshot shows the same 'Muscle Strength Data Collection Screen' as Exhibit 3-7. In this instance, the 'Grip strength, hand 1, test 3' measurement is marked as 'CNO' (Could Not Obtain) with a text box containing the reason: 'SP felt severe pain in hand'. The 'Grip strength, hand 2, test 2' measurement is marked as 'RF' (Refused). The '30 seconds' and '46 seconds' labels are no longer present. The bottom navigation buttons and status bar are identical to the previous screenshot.

### 3.5 Observations

The final screen is the observation screen (Exhibit 3-9). Record any additional comments about the exam that were not previously recorded under “Technician Comments.”

Exhibit 3-9. Observation screen



### 3.6 Unusual Testing Situations

If an SP cannot stand up completely straight (i.e., osteoporosis), the exam will continue if this is normal for the SP. The SP will stand as straight as possible.

If the SP bends or twists his or her body while squeezing the dynamometer (Figure 3-10), do not record the results. Illustrate again the proper position to the SP and repeat the measurement. If this is the first test of the exam, change the starting hand field and start the exam on the other hand. Use the digital timer to make sure you wait 60 seconds before testing the hand again. If this is not the first test, move on and test the opposite hand, then come back and repeat the measurement. It is important to wait 60 seconds between measurements on the same hand so use the digital timer whenever necessary to make sure you wait the allotted time.



Figure 3-10. Positioning mistakes

Some SPs may experience pain due to arthritis or tendonitis when squeezing the dynamometer. Make sure the pain is not caused by inappropriate grip size or grip position. Encourage the SP to complete the exam. Grip strength test is a common functional assessment that is routinely used in clinical setting for arthritis, tendonitis, or carpal tunnel syndrome patients. There should be no more than minimal risk associated with the grip test. If the SP experiences pain when squeezing the dynamometer and cannot continue the test, stop the test on that hand. Enter “CNO” and indicate the reason why the measurement was not obtained.

If you forget to record the measurement, either redo it immediately after waiting 60 seconds or wait until the end.

If the dynamometer is dropped, send an Unusual Field Occurrence (UFO) to report the accident and do not use it until it has been recalibrated. After recalibration, send the results in a UFO. If it does not recalibrate correctly, send another UFO and a replacement will be sent to the MC.

If a dynamometer is swapped out, calibrate the new one and record the results under the Equip Swap tab (see Section 2.4).

### **3.7 Post-Exam Procedures**

#### **3.7.1 Component Status**

The component status for the Muscle Strength component is considered **“Complete”** if the SP completes the entire pretest questionnaire and responses are entered for all six tests on the data collection screen. The component status for the Muscle Strength component is considered **“Not Done”** if the SP does not complete any part of the exam (pretest questions nor dynamometer readings). In all other cases, the status will be **“Partial.”** Table 1-1 explains when to use each comment code for exams with a status of “Not Done” or “Partial.”



Table 1-1. Comment Code descriptions

Comment Code	Use When
Communication problem	SP did not appear to understand or follow instructions; cognitive deficit; other communication impairment.
Equipment failure	Problem with test equipment or the ISIS system.
Interrupted	Exam is interrupted, usually for a MC-wide emergency, and cannot be completed by the SP.
Language barrier	Exam could not be accomplished because of a language barrier; SP does not speak English and interpreter unavailable.
No time	Session ended.
Other, specify	Reason cannot be coded under any other category; reason is a safety type issue; issue is a physical limitation not covered in the pretest questions. A brief explanation in the comment field is required.
Physical limitation	ISIS will preselect this code if the SP was excluded based on responses to the pretest questions. If there is a physical limitation not covered in the pretest questions, code it under “Other, specify” and indicate the specific limitation.
Safety exclusion	This code should <b>not</b> be used. Code any safety type issues under “Other, specify” and indicate the specific issue.
SP ill/emergency	SP had to leave abruptly due to a serious, unforeseen circumstance.
SP refusal	SP physically able to undertake the component, but refused or was uncooperative.

### 3.7.2 Directions to the SP

When the entire test is complete and the SP has been closed out of the component, return any items that the examinee may have removed at the beginning of the exam (i.e., rings, watch, bracelets, etc.). Thank the examinee and direct him or her to the next exam. If the SP inquires about the results of the exam, explain to him or her that you simply conduct the tests and that the results will be given to him or her with some explanatory materials at the end of the MC exam. Never interpret the results of the exam for the SP.

### **3.7.3 Final Procedures**

At the end of each exam, turn the dynamometer off, and wipe the hand grip portion of the dynamometer with a Purell wipe. Make sure all the handle placement marks made during the exam are wiped clean.

### **3.8 Report of Findings**

A Report of Findings will be provided to the participants at the end of the MC exam. Appendix B shows an example of this report by age group.

## Appendix A

### Proper Testing Form Wall Cards

# PROPER TESTING FORM

## Head

- ✓ Straight
- ✓ Eyes Facing Forward

## Arm

- ✓ Straight Down Side

## Wrist

- ✓ Neutral Position  
(Not Flexed or Extended)

## Feet

- ✓ Hip Width Apart
- ✓ Even



## Shoulder

- ✓ Slightly Abducted (~10°)

## Torso Posture

- ✓ Upright
- ✓ "Shoulders Back, Chest Up"

## Forearm

- ✓ Neutral Position

# Proper Testing Form

## Head

- ✓ Straight
- ✓ Eyes Facing Forward

## Arm

- ✓ Straight Down Side

## Wrist

- ✓ Neutral Position  
(Not Flexed or Extended)

## Feet

- ✓ Hip Width Apart
- ✓ Even



## Shoulder

- ✓ Slightly Abducted (~10°)

## Torso Posture

- ✓ Upright
- ✓ "Shoulders Back, Chest Up"

## Forearm

- ✓ Neutral Position

# Proper Testing Form

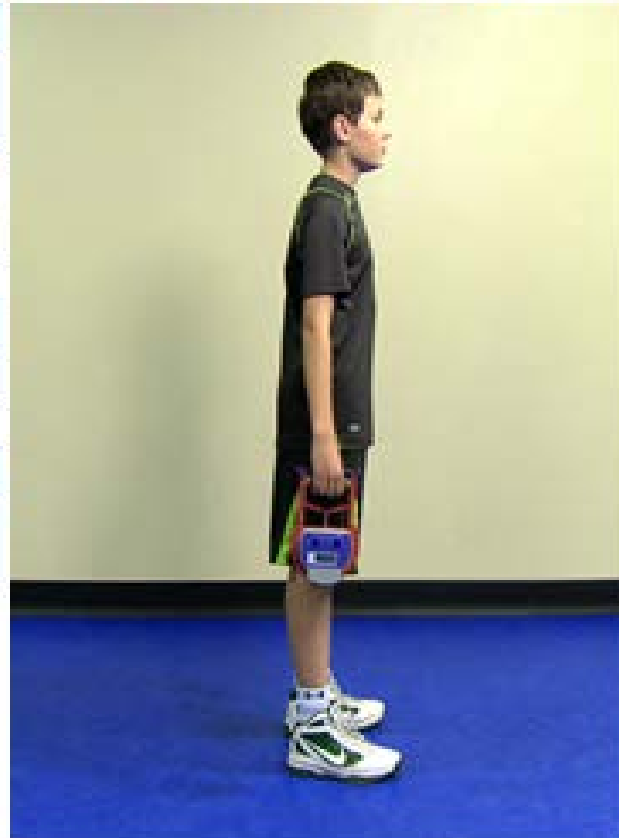
- Head**
- ✓ Straight
  - ✓ Eyes Facing Forward

- Arm**
- ✓ Straight Down Side

- Forearm**
- ✓ Neutral Position

- Wrist**
- ✓ Neutral Position  
(Not Flexed or Extended)

- Hand**
- ✓ Neutral Position
  - ✓ Comfortable Fit
  - ✓ 90° Flexion of Index Finger



- Shoulder**
- ✓ Slightly Abducted (~10°)

- Torso Posture**
- ✓ Upright
  - ✓ "Shoulders Back, Chest Up"

- Elbow**
- ✓ Fully Extended

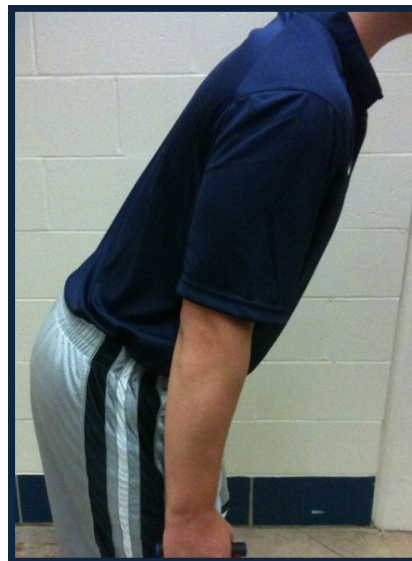
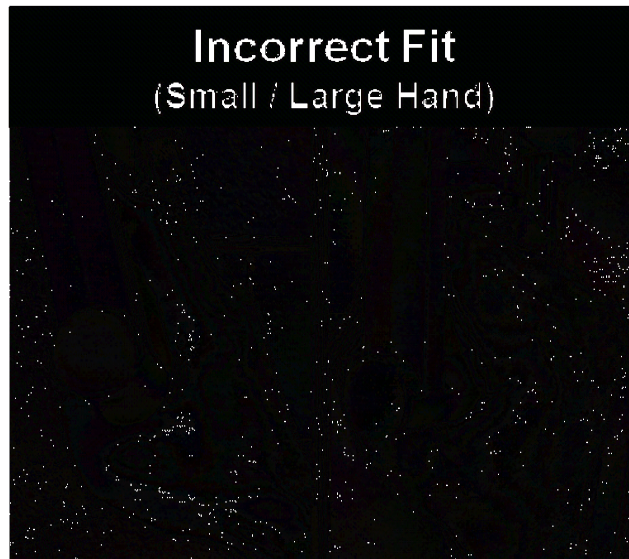
- Knees**
- ✓ "Comfortable Stance"

- Feet**
- ✓ Hip Width Apart
  - ✓ Even

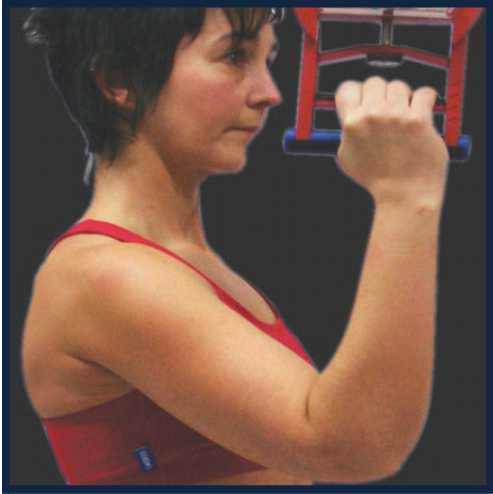
## Appendix B

### Examples of Incorrect Positions

**EXAMPLES OF INCORRECT POSITIONS**









## Appendix C

### Overview of Procedures with Scripts – English and Spanish

## Overview Of Muscle Strength Procedures With Scripts

<b>1. Log in to Component and Wand SP into ISIS</b>
<b>2. Introduce the Component - SP Seated</b> <b>Suggested script for SPs 6-11 years old:</b> <i>In this exam, we want to get some information about your muscle strength. We will be asking you to squeeze as hard as possible with each of your hands. I will explain this in more detail in a few minutes.</i> <b>Suggested script for SPs 12 years and older:</b> <i>In this exam, we want to get some information about your muscle strength. We will be asking you to squeeze as hard as possible with each of your hands. I will explain this in more detail in a few minutes but first I want to ask you a few questions.</i>
<b>3. Complete Pre-test Questions - SP Seated</b>
<b>4. SP Preparation and Warm Up - SP Seated</b> <ul style="list-style-type: none"><li>• Ask SP to remove hand &amp; wrist jewelry to prevent damage.</li><li>• Demonstrate warm-up and ask SP to stretch his/her hands and fingers to warm up for the test.<ul style="list-style-type: none"><li>○ Shake both hands three times</li><li>○ Bend and stretch all fingers three times</li></ul></li></ul>
<b>5. Adjust Dynamometer Grip Size - SP Seated</b> <b>Suggested script:</b> <i>Next I am going to adjust this device to fit your hand(s). (Place support pad on SP's lap.) Please hold this with your (right/left) hand.</i> <ul style="list-style-type: none"><li>• Place the support pad on the SP's lap &amp; place dynamometer on the arm rest.</li><li>• Put dynamometer on the support pad &amp; place it in SP's first test hand with the front facing out.</li><li>• Adjust the dynamometer. (Second joint of the index finger at a 90 degree angle on the handle.)</li><li>• Check grip size on practice hand to see if grip size is the same. If different, <b>mark position</b> with dry erase pen, then re-adjust for practice hand and <b>mark the position again</b>.</li><li>• Remove dynamometer from SP's hand.</li></ul>
<b>6. Tech Demonstration of Exam - SP Seated, Tech Standing</b> <ul style="list-style-type: none"><li>• Reminder: Emphasize the quickness and hardness of the squeezing motion during your demonstration.</li></ul> <b>Suggested script:</b> <i>For the test, I will ask you to squeeze this hand grip as hard as you can. You will stand with your feet hip width apart and your toes pointing forward like this. You will hold your hand so that it's not touching your body and squeeze the handle. I want you to stand tall and try not to lean when you squeeze. You will take a breath in, then blow out while you squeeze. You will squeeze as hard as you can until you can't squeeze any harder. Like this.</i> (Do the squeeze demo now.) <i>We will test each hand 3 times.</i>
<b>7. Position SP in proper stance and practice - SP Standing (if possible)</b> <ul style="list-style-type: none"><li>• Practice at <b>submaximal</b> effort on <u>opposite hand that will test first</u>.</li><li>• Turn dynamometer on &amp; hand it to SP.</li></ul> <b>Suggested script:</b> <i>Now try it once just to get the feel of it. For this practice, just squeeze gently. Ready, Take A Breath In, Let It Out, Squeeze Gently.</i>
<b>8. Perform exam - SP Standing (if possible)</b> <ul style="list-style-type: none"><li>• Check stance.</li><li>• Check grip size.</li><li>• Clear dynamometer between each maneuver.</li></ul> <b>Suggested script:</b> <i>When I say "squeeze", squeeze as hard as you can until you can't squeeze any harder. Remember, to blow out when you squeeze.</i> <i>Ready, Take a breath in, Let it out, Squeeze! Squeeze as hard as you can until you can't squeeze any harder.</i>

## Overview Of Muscle Strength Procedures With Scripts – Spanish

### 1. Log in to Component and Wand SP into ISIS

### 2. Introduce the Component – SP Seated

#### Suggested script for SPs 6-11 years old:

*En este examen, queremos obtener información acerca de la fuerza de tus músculos. Te pediremos que aprietes lo más fuerte que puedas con cada mano. Te explicaré esto en más detalle dentro de unos minutos.*

#### Suggested script for SPs 12 years and older:

*En este examen, queremos obtener información acerca de la fuerza de sus músculos. Le pediremos que apriete lo más fuerte que pueda con cada mano. Explicaré esto en más detalle dentro de unos minutos, pero primero le quiero hacer algunas preguntas.*

### 3. Complete Pre-test Questions – SP Seated

### 4. SP Preparation and Warm Up – SP Seated

- Ask SP to remove hand & wrist jewelry to prevent damage.
- Demonstrate warm-up and ask SP to stretch his/her hands and fingers to warm up for the test.
  - Shake both hands three times
  - Bend and stretch all fingers three times

### 5. Adjust Dynamometer Grip Size – SP Seated

#### Suggested script:

*A continuación, voy a ajustar este aparato para adaptarlo a su(s) mano(s). (Place support pad on SP's lap.) Por favor sujete esto con la mano (izquierda/derecha).*

- Place the support pad on the SP's lap & place dynamometer on the arm rest.
- Put dynamometer on the support pad & place it in SP's first test hand with the front facing out.
- Adjust the dynamometer. (Second joint of the index finger at a 90 degree angle on the handle.)
- Check grip size on practice hand to see if grip size is the same. If different, **mark position** with dry erase pen, then re-adjust for practice hand and **mark the position again**.
- Remove dynamometer from SP's hand.

### 6. Tech Demonstration of Exam – SP Seated, Tech Standing

- Reminder: Emphasize the quickness and hardness of the squeezing motion during your demonstration.

#### Suggested script:

*Para la prueba, le voy a pedir que apriete esta asa tan fuerte como pueda. Párese con los pies separados a lo ancho de las caderas y con los dedos del pie apuntando hacia delante, así. Levante la mano de modo que no toque su cuerpo y apriete el asa. Quiero que se pare derecho/a, con la cabeza en alto y trate de no inclinarse cuando apriete. Tome aire, después suelte el aire mientras aprieta. Apriete lo más fuerte que pueda hasta que no pueda apretar más. Así.*

(Do the squeeze demo now.) *Haremos una prueba 3 veces en cada mano.*

### 7. Position SP in proper stance and practice – SP Standing (if possible)

- Practice at **submaximal** effort on opposite hand that will test first.
- Turn dynamometer on & hand it to SP.

**Suggested script:** *Ahora hágalo usted una vez para que vea cómo se hace. Para esta práctica, apriete suavemente. Listo(a), tome aire, deje salir el aire, apriete suavemente.*

### 8. Perform exam – SP Standing (if possible)

- Check stance.
- Check grip size.
- Clear dynamometer between each maneuver.

#### Suggested script:

*Cuando yo diga "apriete", apriete lo más fuerte que pueda hasta que ya no pueda apretar más. Recuerde soltar el aire mientras aprieta.*

*Listo(a), tome aire, deje salir el aire, ¡apriete! Apriete tan fuerte como pueda hasta que no pueda apretar más.*

## Appendix D

### Reference Data for Grip Strength and Examples of Report of Findings

## REFERENCE DATA FOR GRIP STRENGTH

The grip strength result provided to the SP in the report of findings is the sum of the largest reading from each hand. ISIS converts the results from kilograms to pounds and indicates if the result is above average, average, or below average. Below is the reference data for the report of findings.

### Ages 7-14 years old

Age (y)	Female Grip Strength (lb)			Male Grip Strength (lb)		
	Above Average	Average	Below Average	Above Average	Average	Below Average
7-9	>61	61-58	<58	>70	70-62	<62
10-12	>88	80-88	<80	>103	95-103	<95
13-14	>123	115-123	<115	>151	135-151	<135

**Reference:** Canadian Fitness and Lifestyle Research Institute (1988). *Canada Fitness Survey Longitudinal Study: Reference Booklet*. Canadian Fitness and Lifestyle Research Institute Ottawa: ON.

### Age 15 years old

Age (y)	Female Grip Strength (lb)					Male Grip Strength (lb)				
	Excellent	Very Good	Good	Fair	Poor	Excellent	Very Good	Good	Fair	Poor
15	≥149	132-148	116-131	105-115	≤104	≥237	215-236	198-214	173-197	≤172

**Reference:** Canadian Society for Exercise Physiology, 2004 (CSEP). *The Canadian Physical Activity, Fitness and Lifestyle Approach (CPAFLA) 3rd edition*. Ottawa, Canada: Canadian Society for Exercise Physiology, 2004.

## EXAMPLES OF REPORT OF FINDINGS

A final Report of Findings will be provided to the participants at the end of the MEC exam. The report is age specific.

### **For 6-year-olds:**

Your grip strength measured by a dynamometer was \_\_\_\_ lbs. Researchers are still trying to learn more about muscle strength in your age group. Data collected in our survey, including your participation today, will help us to better understand this topic.

### **For 7- to 11-year-olds:**

Your grip strength measured by a dynamometer was \_\_\_\_ lbs. Compared with other people of your age and sex, your muscle strength level is \_\_\_\_\_. (above average, average, or below average).

The classification is based on reference data from the Canada Fitness Survey Longitudinal Study.

*[For those with results as “below average,” include following additional text in the report]*

These test results are just for your personal information. They cannot be used to diagnose any disease. The results depend on how you did today, and on your level of physical fitness. Sometimes reduced hand muscle strength may be caused by pain or arthritis in the hands or other health problems.

### **For 12- to 14-year-olds:**

Your grip strength measured by a dynamometer was \_\_\_\_ lbs. Compared with other people of your age and sex, your muscle strength level is \_\_\_\_\_. (above average, average, or below average).

The classification is based on reference data from the Canada Fitness Survey Longitudinal Study.



*[For those with results as “below average,” include following additional text in the report]*

These test results are just for your personal information. They cannot be used to diagnose any disease. The results depend on how you did today, and on your level of physical fitness. Sometimes reduced hand muscle strength may be caused by pain or arthritis in the hands or other health problems.

**For 15-year-olds:**

Your grip strength measured by a dynamometer was \_\_\_\_ lbs. Compared with other people of your age and sex, your muscle strength level is \_\_\_\_\_. (excellent, very good, good, fair, or poor).

The classification is based on reference data from the Canadian Physical Activity, Fitness and Lifestyle Approach (CPAFLA).

*[For those with results as “poor,” include following additional text in the report]*

These test results are just for your personal information. They cannot be used to diagnose any disease. The results depend on how you did today, and on your level of physical fitness. Sometimes reduced hand muscle strength may be caused by pain or arthritis in the hands or other health problems.

**For participants who only have completed data on one hand:**

Your grip strength measured by a dynamometer on your (right/left) hand was \_\_\_\_ lbs. Data collected in our survey, including your participation today, will help researchers to better understand this topic.