
NEUROMUSCULAR FUNCTION

1. Background and Rationale

Direct assessments of physical performance have become standard measurements in epidemiological studies in the elderly. These assessments generally tap multiple domains of physiological performance, including lower extremity strength, balance, coordination, and flexibility. The assessment techniques used in SOF have been derived from several previous studies, are reliable when performed in a standardized fashion, and are well tolerated by elderly participants. The following assessments are included in the SOF performance battery: single and multiple chair stands, short walk tests, and grip strength.

2. Equipment and Supplies

- Digital stopwatch (repeated chair stands, short walk test)
- Standard chair: straight back, flat, level, firm seat; seat height 45 cm at front (single and repeated chair stands).
- Walking course (See drawing included in description of narrow walk)
- Dynamometer (Preston Grip Dynamometer or TEC Dynamometer)

2.1 Use of the Stopwatch



The stopwatch will be used to measure the time it takes to complete a task from the beginning of the activity until the conclusion. Press the middle (mode) button to make sure you are in stopwatch mode. The display should read **0:0000**. To time the task, just press the right-hand button (labeled STA/STP) at the top of the stopwatch to begin, and press again when the task is completed. The time is digitally displayed on the stopwatch. To get the display to read **0:0000** again, press the left (lap) button.

3. Safety Issues and Exclusions

Walking aids may not be used in the chair stand tests. The vast majority of participants should be able to attempt the performance tests. Exclusion from the performance tests will be based on an individualized assessment of impairments and safety concerns. The examiner will describe each test, and then discuss with the participant whether they should attempt that test given any physical problems or disabilities present. Refusal, or inability to perform a test will be recorded on the data form.

Obstructions in the exam area that could cause accidents should be removed. The detailed protocols describe how to administer the tests safely, including instructions on how to support the participant if required. For all test items where loss of balance is a possibility, you should use the following safety precautions. Position yourself standing at the participant's side, slightly behind them. Your hands should be positioned very close to either side of the participant's trunk at the hip or waist level but not touching the participant. Be ready to place both hands on the participant to stabilize them if necessary. If the participant loses balance, immediately hold onto the participant with both hands at the trunk and stabilize them. If the participant begins to fall do not try to catch them; reach under the participant's shoulders from behind and slowly ease them down to the floor. This will protect the participant and examiner from injury.

If the participant falls and is not injured, help them up by first having the participant get on their knees or on all fours, place a chair next to the participant, and have the participant support themselves on the chair as you help lift under the shoulders. Do not try to lift the participant from the floor by yourself.

4. Participant and Exam Room Preparations

- Footwear: To eliminate the effect of different footwear on test performance, these tests should be performed in tennis shoes or comfortable walking shoes with minimal or no heels. The participant may perform the tests in socks / stocking or bare feet if appropriate footwear is not available. Clinics may want to purchase a few sizes of inexpensive tennis shoes to have available.
- The standard chair should be placed on a nonslip surface (low pile carpeting works well) with the back of the chair against a wall for stability. There should be adequate room in front and on the sides of the chair for the examiner and the participant to maneuver freely.
- Walking course layout: The walk will be conducted on a six meter path in a corridor at least 122 cm wide, without obstructions or irregularities in the floor. The start and finish lines will be marked by tape on the floor. (See figure on page 9).

5. Detailed Measurement Procedures

5.1 Approach to Standardization

The performance based measurements are administered by a certified examiner. Since motivation and level of understanding can have large impacts on performance, each component of the exam should be administered strictly according to the protocol and in the following sequence:

- Explain the procedure to the study participant making sure that key points from the suggested script are conveyed.
- Demonstrate the procedure using suggested script.
- Ask the participant if they have any questions.
- Re-explain the procedure briefly using suggested script.
- Ask the participant to perform the procedure.
- Begin all timed procedures with the words, "Ready? Go!"

5.1.1 Instructions and encouragement: Use the script provided to make sure that all key points are covered when you describe the test and how to perform it properly. You should not provide additional description or encouragement beyond the key points provided by the standard scripts.

To some participants, detailed verbal instructions (especially for the 6th or 7th time) may seem unnecessary. Respond by telling them that you explain each test in detail since this is the best way to make sure that everyone does the test in a similar manner and same fashion as they did at previous visits.

5.1.2 Demonstration: Demonstrate each maneuver for the participant. Remind the participant not to begin to do the maneuver until after you have demonstrated it.

It is very important that the examiner demonstrate each exercise correctly. Experience has shown that participants follow more closely what the examiner does rather than what they say. If the position or exercise is demonstrated incorrectly, the participant following the example will do the exercise incorrectly and be scored as "Unable" even though they may actually have been able to perform it correctly.

If the participant indicates that they do not understand the exercise, demonstrate it again rather than relying on repeated verbal instructions. Repeat the demonstration only once. If the participant still does not understand, go on to the next component of the test.

5.1.3 Practice trial: Practice trials for each test should be limited to those described in the individual measurement procedures.

5.1.4 Rest: The participant should be allowed to rest between tasks if out of breath or fatigued during the assessments.

5.2 General Scoring Issues

5.2.1 Not attempted/refused: If a test is not attempted because the participant refuses or the examiner deems the test unsafe for the participant, for whatever reason, record “not attempted/refused” on the scoring form. Where indicated, record a reason for the refusal.

5.2.2 Unable: If a test is attempted but cannot be completed or scored, record “unable” on the scoring form.

5.3 Introductory Script and Exclusions for Performance Tests

The participant should be encouraged to perform each test if possible. However, they should also be instructed not to attempt a test if they feel it would be unsafe.

Script: “I’m going to ask you to try to do several different movements of your body. I will first describe and show each movement to you. Then I’d like you to try to do it. If you cannot do a particular movement or you feel it would be unsafe to try to do it, tell me and we’ll move on to the next one. Let me emphasize that I would like you to try each exercise. But I don’t want you to try to do any exercise that you feel might be unsafe.”

Screen for health status:

Script: “Do you have any problems from recent surgery, injury, or other health conditions that might prevent you from standing up from a chair or walking?”

If the answer is “yes,” record on the form. Tell the participant who says “yes” that after you describe each test to them, you will discuss whether they should attempt the test given their physical problems. If no problems are mentioned by the participant, mark “no.”

5.4 Record Impairments/Appliances

Script: “Do you use any walking aids, such as a cane?”

Record use on the form.

Identify and record the following:

- a) Participant use of a lower extremity orthosis

Orthosis - an orthopedic appliance or apparatus used to support, align, prevent or correct deformities or to improve the function of moveable parts of the body. In this exam we are specifically checking for lower extremity orthoses; plastic or metal leg braces at or above the ankle.

- This refers to the participant's current use of such an aid. They will be wearing the device at the clinic for the exam. An orthosis used at other times (at night, for instance) is not recorded here.
- An orthosis worn below the ankle (for example, a device worn in the shoes for fallen arches) does not qualify in this definition. If you cannot determine whether the participant uses an orthosis ask them.

b) Missing limb

Major limbs only are considered here: arms (including hands) and legs (including feet). A missing finger or other digit does not constitute a missing limb. A limb is considered missing whether or not an artificial limb is replacing the natural body part.

c) Participant use of a prosthesis

Prosthesis - an artificial substitute for a missing body part, such as an arm or leg, used for functional or cosmetic purposes, or both.

If the participant is missing a limb, the use of an artificial limb or prosthesis is to be recorded here. This refers to the participant's current use of such an aid. They will be wearing the device at the clinic for the exam. If the participant has mentioned owning a prosthesis but is not currently wearing it, it is not to be recorded here. If you cannot determine whether the participant is wearing a prosthesis ask them.

NOTE: Use of appliances or missing limbs are not exclusion criteria for these tests.

d) Paralysis of an extremity or side of body.

If the participant is unable or has difficulty moving an arm and/or leg due to weakness or spasticity, record this here. Only obvious impairment need be recorded. The examiner is not expected to elicit subtle neurologic signs.

5.5 Single Chair Stand: Administration

This is a test of ability to stand up from a standard chair without using arms. This task is also used to screen for the ability to do repeated chair stands. Walking aids such as canes, walker, or crutches may not be used.

- a) A straight-backed chair without arms, with seat height of 45 cm, should be used for this test and placed against a wall for added stability. The participant's feet should be placed squarely on the floor in front of them. The participant should be

seated in a position which allows them to place their feet on the floor with knees flexed to slightly greater than 90° so that their heels are somewhat closer to the chair than the back of the knees.

During the test, the examiner may stand in front of the participant (with arms extended, if appropriate) for the participant's safety during the chair stands.

- b) Describe the test.

Script: *"This is a test of strength in your legs in which you stand up from sitting without using your arms."*

- c) Demonstrate the procedure. Do two full chair stands using the correct form and count as you stand up each time.

Script: *"Fold your arms across your chest, like this, and stand, keeping your arms in this position. Do you understand?"*

- d) Ask the participant to stand.

Script: *"Can you stand and sit one time for practice? Ready, Go!"*

If the arms unfold, or the participant puts one or both hands down on the chair to push up, remind them to keep their arms folded snugly across their chest and ask them to repeat the chair stand.

It is OK for the participant to move part-way forward in the chair before standing, but knees and hips should be flexed to approximately 90° before standing.

- e) If the participant cannot rise without using arms, say.

Script: *"OK. Try to stand up using your arms to push off."*

- f) Score as follows:

If the procedure was not performed for safety reasons or refused for other reasons, score "Did not attempt/refused." Skip the repeated chair stands.

If participant attempted but was unable to arise even using their arms, score as "unable to stand."

If the participant uses arms to stand up, score as "rises using arms."

If they stood up all the way without using arms, score as "Stands without using arms." Go on to Repeated Chair Stands.

5.6 Repeated Chair Stands: Administration

This is a test of lower extremity strength in which the participant stands up from a seated position five times as quickly as possible. The time it takes to stand five times is recorded.

- a) If the participant can arise from the chair without using arms, attempt the five stands.

Script: *"This time, I want you to stand up 5 times as quickly as you can keeping your arms folded across your chest."*

- b) Demonstrate the test.

Cross your arms over your chest and then rise while emphasizing "full standing position", and sit while emphasizing "all the way down."

Script: *"First I will show you. When you stand up, come to a full standing position each time, and when you sit down, sit all the way down each time. I will demonstrate two chair stands to show you how it is done."*

Rise two times as quickly as you can, counting as you stand each time.

- c) Begin the test.

Script: *"When I say 'Go' stand five times in a row, as quickly as you can, without stopping. Stand up all the way, and sit all the way down each time."
"Ready, Go!"*

Start timing as soon as the examiner says "Go." Count: "1, 2, 3, 4, 5" as the participant stands each time. Stop timing when the participant has straightened up completely the 5th time.

- d) If the participant is unable to complete the chair stands correctly (e.g. is not coming to a full stand), abort the procedure, repeat the demonstration, wait 1 minute, and begin the procedure again.
- e) If the participant stops before completing five stands, confirm that they cannot continue by asking:

Optional script: *"Can you continue?"*

If they say yes, continue timing and record time when finished. Otherwise, stop the stopwatch.

- f) For ALL participants who completed all 5 stands ask “*Do you think that was as fast as you can do it while still feeling safe?*”

If participant says no, then ask her to repeat the test emphasizing that she should stand *as fast as she can while still feeling safe*.

- g) Record the time for the second trial.

- h) Score as follows:

If the procedure was not performed for safety reasons or refused for other reasons, score “Did not attempt/refused.”

If participant attempted but was unable to complete five stands, score as “unable” and record the number completed.

If all five were completed, record the number of seconds, to a tenth (0.1) of a second, required to complete five stands.

5.7 Six Meter Usual Pace and Rapid Pace: Administration

This is a modification of the short walk test used in many epidemiological and clinical studies. The time to walk 6 m at the participant’s usual pace is measured, along with the number of steps.

In addition to the standard walk, this test also includes a rapid pace walk. There will be two scored trials for the usual pace walk and one trial for the rapid pace walk.

The 6 m walk tests will be conducted in the following order: usual pace and rapid pace.

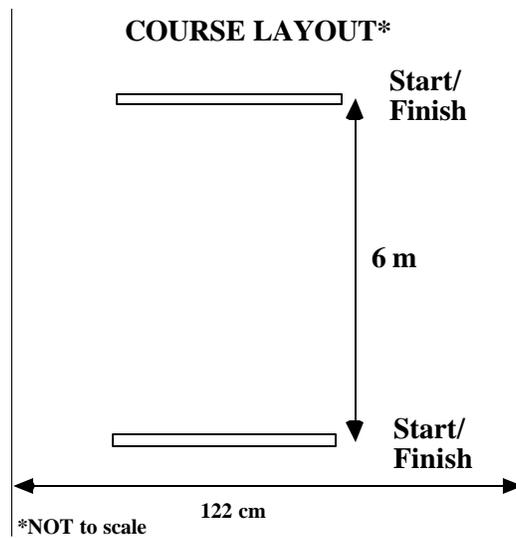
The 6 m walking course is laid out on the floor as indicated in the figure below. The course must be free of obstacles.

Starting Each Walk Test:

The participant should stand with toes just touching the starting line. Hold your arm up, say “Ready, Go”. If you think it is helpful for the participant you can drop your arm when you say “Go”. Start timing when you say “Go”.

Scoring the Walks:

Stop timing with the first footfall (complete or partial) crosses the finish line. Time is recorded to the nearest 0.1 second. For both the usual and rapid pace walks, count all steps. Steps are counted by counting both right and left steps and include the initial starting step and the step that first touches the floor across the finish line (or that touches the line, depending on how you have recorded this in previous SOF visits).



Introduction

Describe the usual pace and rapid pace walk.

Script: *“This is the usual and rapid pace walk test. First I want you to walk down the hall normally, at a comfortable pace. For the second walk, I will ask you to walk as quickly as you feel comfortable with. The first walk will be done twice.”*

a) Usual pace walk

- 1) Demonstrate the test: Say the following, while demonstrating where to place the feet and where to walk.

Script: *“Place your feet with your toes behind, but touching the starting line. Wait until I say ‘GO.’ Remember, I want you to walk at a comfortable pace.”* (Demonstrate and return.) *“Walk a few steps past the finish line each time. Any questions.”* (Make sure you continue walking past the line as you demonstrate.)

- 2) Hold your arm up. To start the test, drop your arm and say,

Script: *“Ready, Go.”*

Start timing when you say *“Go”*. Follow along a few paces behind the participant. Count each step (NOT aloud), both left and right. Hit the start button on the stopwatch as you say *“Go”*. Stop timing with the first footfall (complete or partial) crosses the finish line.

- 3) Have the participant repeat the usual pace walk.

Script: “OK, fine. Now turn around and when I say go, walk back the other way at a comfortable pace. Ready, GO.”

b) Rapid pace walk

1) Explain the rapid pace walk.

Script: “Now for the second walk, I want you to walk as quickly as you can.”

2) Demonstrate the walk.

Script: “I’ll demonstrate. Be sure to walk a few steps past the finish line. Any questions?” (Demonstrate the walk, continuing past the line at a rapid pace.)

3) Begin test. Time as before, and count steps. Drop your arm and say,

Script: “Ready, GO.”

4) Record time and number of steps.

5.8 Grip Strength: Administration

Grip strength is a measure of hand muscle strength that also is a good representation of upper body muscle strength. It is one of the most widely used measures of strength because of its simplicity and ease of measurement.

5.8.1 Calibration: At the beginning of the study the grip dynamometer should be sent to the manufacturer to be calibrated. After that it should be calibrated weekly by hanging at least 2 different weights (5 lb, 10 lb, 15 lb, etc) from the handle and recording the measure. The weights can be attached using velcro or any other means that works. Record the weight used and the result in a log book. Deviations of more than ± 2 kg should be reported to the Coordinating Center and the company should be called for repair.

5.8.2 Scoring: The scoring categories are mutually exclusive, so either each hand is tested and has a value or the participant refused or is unable. If a participant reports weakness in the wrists they will still complete the procedure and the value will be identified as a weakened measurement based on their answer to question 2. There should not be a score and a box checked - this will result in logic errors.

5.8.3 Measurement: Grip strength will be measured in both arms unless the participant has had a recent flare-up of extreme arthritis - in this case the unaffected side is not tested (see below). If the participant has a history of stroke or injury causing weakness (this injury occurred in the past and is not the cause of acute pain presently), still measure

BOTH sides. Even though one side may be weaker, it does not have acute pain and thus can be tested.

- a) For each hand, determine if the subject has an acute flare-up of arthritis in the hand, or surgery in the hand or wrist in the past 3 months (12 weeks). If the subject has had an acute flare-up of arthritis or is less than 13 weeks post fusion, arthroplasty, tendon repair, synovectomy, etc. then do not test grip on the affected side (mark "unable, did not attempt" on the form).

"Have you had a recent worsening of pain or arthritis in your hands, or have you had surgery on your hands in the past 3 months (12 weeks)?"

If yes, test grip strength in unaffected side only. Mark "unable, did not attempt" on the form for the affected side only.

"This device measures your arm and upper body strength. I will demonstrate how it is done. Bend your elbow at a 90° angle, with your forearm parallel to the floor. Don't let your arm touch the side of your body. Lower the device slowly, taking about 3 seconds, squeezing as hard as you can. Once your arm is fully extended, release your grip."

- b) Place the dynamometer in the right hand with the dial facing the palm. The arm should be flexed 90° at the elbow and the forearm parallel to the floor. As you demonstrate, instruct the individual to squeeze the hand maximally while simultaneously lowering the arm on a three second count. The grip should be released when the arm is completely extended, hanging straight at the side. If the participant can do the procedure while standing conduct the measurement in a standing position. If the participant is unable to do this standing, have them sit in a chair without arms with their back perpendicular to the floor and their arm hanging at their side.
- c) Allow one submaximal practice trial using the right arm.

"Does that feel like a comfortable grip?"

Adjust the handgrip, if necessary.

"Now try it once just to get the feel of it. For this practice, just squeeze gently. Don't let your arm touch the side of your body. One, two, three."

- d) Perform two trials on the right side.

"Good. Now this time it counts. We'll repeat this twice on the right side and then twice on the left side. Be sure to squeeze as hard as you can.

Ready? Ok. Squeeze as hard as you can! One, two, three (count out loud for the participant as she lowers her arm) "

Record the kilograms from the dial to the nearest 1 kg. Reset the dial.
Perform the second trial.

- e) Repeat the procedure for the left arm. No practice trial is needed for the left, but ask the subject if the grip is comfortable.

Precautions: The arm should not contact the body. The gripping action should be a slow sustained squeeze rather than an explosive jerk.

- f) On the scoring form, there should either be a value for strength attained OR one of the two boxes – refused or unable, should be checked.
- g) Indicate whether the participant completed the measurement standing or sitting on the form.

6. Procedures for Performing the Measurement at Home

The chair stand, walk tests, and grip strength can be performed at home. See home visit protocol.

7. Alert Values/Follow-up/Reporting to Participants

These test results have no alert values and are not reported to the participant or physician.

8. Quality Assurance

8.1 Training and Certification

The examiner requires no special qualifications or experience to perform this assessment. Training should include:

- Read and study manual
- Attend SOF training session on techniques (or observe administration by experienced examiner)
- Practice on other staff or volunteers
- Discuss problems and questions with local expert or QC officer

8.2 Certification Requirements

- Complete training requirements
- Recite exclusions
- Conduct exam on 2 volunteers:
 - According to protocol, as demonstrated by completed QC checklist
 - Times within ± 1 s of QC officer, step counts agrees with QC officer

8.3 Quality Assurance Checklist

- Performance tests
- Asks participant about problems which might prevent testing
- Correctly assesses impairments/appliances (records lower-extremity orthosis, prosthesis, missing limb, or paralysis, if present)

Chair stands

- Back of chair against a wall
- Script correctly and clearly delivered for each test
- Correctly demonstrates single stand, emphasizing keeping arms tight across chest
- Correctly demonstrates two stands, emphasizing full stand and return to complete sit
- Says “ready, go.” for each test
- Counts each chair stand, and stops timing after participant stands up on fifth stand
- Records and explains unusual values
- If task was not performed, codes and explains reasons

Short walks

- Script correctly and clearly delivered
- Correctly demonstrates
- Toes touching start line
- Timing started coincident with saying “Go”
- Correct number of steps counted, and time stopped with first footfall over the finish line (partial or full)
- Repeat (second trial)

Grip strength

- Weakness and arthritis checked
- If stroke, test both sides
- Elbow kept near 90° ($\pm 15^\circ$)
- One practice given on right side
- Comfortable grip checked

- Instructed to "Squeeze as hard as you can"
- Slow sustained (3 second) extension
- Arm does not touch side of body
- Both right and left sided completed twice
- Calibration logs up to date (weekly or biweekly)

9. References

1. Ferrucci, Luigi: Unpublished data.