

PERFORMANCE-BASED ASSESSMENTS OF LOWER-EXTREMITY FUNCTION

1. Background and Rationale

Direct assessment of physical performance has become standard practice in epidemiologic observational studies of health and disease processes. The most commonly used assessments were initially designed to differentiate function in older adults,^{1,2} but modifications in administration and scoring³ can improve the utility of these assessments to discriminate meaningful differences and change in functional capacity in most middle-age persons, as well. Although the measurement ceiling of these tests may be low for young and some middle-age adults (i.e., they can easily achieve the maximum possible performance on all tests), repeat assessment following standardized procedures over subsequent BLSA visits can aid in identifying the approximate point at which meaningful loss of functional capacity begins to emerge.

1.1 Objective

The primary objectives for including this set of performance-based assessments of lower-extremity function are to: (1) provide data on the functional status of BLSA participants comparable to what has been collected in other U.S. and international studies of middle-age and older adults; and (2) estimate lower-extremity functional capacity over a critical range, determine the presence of functional deficits, track change in capacity over time over a critical range, and identify when meaningful loss in capacity has occurred.

1.2 Recommended Protocol(s)

The recommended protocol constitutes a modification of the physical performance battery originally used in the Established Populations for Epidemiologic Studies of the Elderly (EPESE)² and Women's Health and Aging Study (WHAS), developed for and used in the Health, Aging and Body Composition (Health ABC) study.³ To further improve discrimination of functional capacity at the higher end of the functional spectrum, the number of repeated chair stands is increased from 5 to 10, as has been done in a few other studies.^{4,5} By taking a split time after 5 completed chair stands, comparability with previous batteries will be maintained.

Usual gait speed over a short course – 6 meters

Fast gait speed over a short course – 6 meters

Narrow (20cm –wide) walk – 6 meters

Single and 10 repeated chair stands, with a split time taken after 5 stands

Standing balance test – side-by-side, semi- and full-tandem and single leg stands,

each held for 30 seconds, if possible. Capacity to hold each stand for 10 seconds will be recorded to retain comparability with the EPESE battery.

1.2.1 Strengths and weaknesses of selected approach

The test battery is commonly administered and has demonstrated reliability and criterion and predictive validity in older adults.^{2,3,6-8} Enhanced administration and scoring procedures raises the measurement ceiling,³ while also capturing data required to compute the original Summary Physical Performance Battery score.² The primary weakness is the low ceiling for some middle-age and exceptionally fit older adults.

1.2.2 Analogous (past) measures used in the BLSA (including time periods covered)

The Walk-Turn-Walk test, consisting of a 50 foot walk with one half turn followed by a return 50 foot walk performed at both usual and rapid normal walking pace, was administered to all BLSA participants seen between 1996 to 2002.

1.2.3 Reliability/Validity Studies

Several studies have been conducted. See references 2, 3, and 6 through 8.

1.2.4 Key Variables (*to be obtained*)

Continuous: usual and rapid gait speed over a short course, usual gait speed over a narrow short course, chair-rise (sit-to-stand) speed, and Health ABC summary performance score.

Categorical: standing balance capacity, capacity to walk a narrow course, EPESE summary physical performance score and component scores.

2. Equipment and Supplies

- Digital stopwatch (repeated chair stands, standing balance, short walk tests)
- Standard chair: straight back, flat, level, firm seat; seat height 45 cm at front (single and repeated chair stands).
- Colored tape to mark walking course (see drawing included in description of walking tests)

2.1 Use and Maintenance of Stopwatch

For easy access, the examiner should wear the stopwatch around his/her neck. To use the stopwatch (pictured below), first press the middle (mode) button at the top to get into stopwatch mode. The primary or large display should read **00'00"00**. The secondary or top, smaller display should read [**0**]00'00"00. To begin timing, depress the right-hand button labeled **START/STOP** at the top of the stopwatch and press again to stop. The total time will appear on the primary display as minutes'seconds''hundredths of a second. Record this time. When taking a split time (as needed for the repeated chair stands (see below)), depress the left-hand button labeled **SPLIT/RESET**. The split time will flash for 10 seconds on the primary display before the running time reappears. After the flashing stops, the top/secondary display will show the running time for the current split (e.g., chair stands 6-10). The top display should have the number 2 in the brackets [**2**]. To stop timing, depress the **START/STOP** button. The total time will appear in the primary/large display on the stopwatch. Record this time for the full test (all 10 chair stands). To get the time for the first part of the test (e.g., chair stands 1-5), depress the mode button at the top center of the stopwatch. The secondary/top display should have the number 1 in the brackets [**1**]. Record this time for the first part of the testing (e.g., time to complete 5 chair stands). To get the display to read **00'00"00** again, depress the mode button repeatedly until you get back to the lap time and then press **SPLIT/RESET**.



2.2 Calibration

Not applicable

3. Safety Issues and Exclusions

The vast majority of participants should be able to attempt each performance test. Walking aids may not be used for the chair stand or standing balance tests. Exclusion from any performance test shall be based on examiner assessment or participant concerns that the test would be unsafe. In the latter case, the examiner should describe the test and discuss with the participant his/her specific concerns about attempting the test including physical problems and known disabilities. Refusal, reason for not attempting a test, or inability to perform a test should be recorded on the data form (see instructions below).

The detailed protocols describe how to administer the tests safely, including instructions on how to support the participant, if required. For the walking and balance tests, the examiner should stand next to and slightly behind the participant and position his/her hands very close to either side of the participant's trunk at the hip or waist level without touching the participant. The examiner should be ready to place both hands on the participant to stabilize them if necessary. If the participant loses balance, the examiner should grab/catch the participant with both hands at the trunk to stabilize them. If the participant begins to fall, the examiner should reach under the participant's shoulders from behind and slowly ease them down to the floor, rather than try to catch the participant while standing still. This strategy should protect both the participant and examiner from injury.

If the participant falls and is not injured, the examiner should have 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 he/she helps lift the participant under the shoulders. The examiner should not try to lift the participant from the floor by him/herself.

4. Participant and Exam Room Preparation

- Footwear: To reduce effects of different footwear on test performance, the participant should wear tennis shoes or comfortable walking shoes with minimal or no heels. The participant may perform the tests in stocking or bare feet if appropriate footwear is not available.
- The standard chair should be placed on a non-skid surface (e.g., low pile carpeting) 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 participant to move freely.
- The standing balance test should be performed with the participant standing a little less than an arm's length from a wall to provide an additional source of support if a loss of balance does occur.
- Walking course: The short walks should be conducted on a 6-meter path laid-out in an uncarpeted, unobstructed, low traffic corridor at least 122 cm wide. The start and

finish lines will be marked by tape on the floor. The narrowed path will be marked at 20 cm, using tape. (See figure below).

5. Detailed Measurement Procedures *(include estimated preparation and administration time and frequency of repeat administration (e.g. every visit, every 3 to 4 years))*

The estimated administration time for all tests combined including instructions and examiner demonstration is within 20 minutes for the majority of participants. The complete battery should be repeated every BLSA visit.

5.1 General Instructions

Since motivation and level of understanding can have a significant impact 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 to convey key points from the suggested script.
- Demonstrate the procedure using the suggested script.
- Ask the participant if they have any questions.
- Re-explain the procedure briefly using the suggested script.
- Ask the participant to perform the procedure.
- Begin all timed procedures with the words, "Ready? Go!"

Use the script provided to assure that all key points are covered when you describe each test and how to perform it properly. Do not provide additional description or encouragement beyond the key points provided by the standard scripts.

Demonstrate each maneuver correctly. Experience has shown that participants follow more closely what the examiner does rather than what he/she says. If the participant indicates they do not understand the test maneuver, demonstrate it again rather than solely relying on repeating the verbal instructions.

Limit practice trials for each test to those described in the individual measurement procedures.

Allow the participant to rest between tests if out of breath or fatigued during the assessments.

If a test is not attempted because the participant refuses or cannot understand the instructions, record "Participant refused". If you or the participant considers the test unsafe, record "Not attempted/unable" on the scoring form. If a test is attempted, but cannot be completed or scored, record "Attempted, unable" on the scoring form.

5.2 Single Chair Stand: Administration

This is a test of ability to stand up from a standard chair without using one's arms. This task is also used to screen for the ability to do repeated chair stands. Walking aids including canes may not be used.

1) For this test, use a straight-backed chair without arms, with seat height of 45 cm, placed against a wall for added stability. Make sure the participant's feet are 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 slightly more than 90 degrees so that their heels are somewhat closer to the chair than the back of their knees.

During the test, stand in front of the participant (with arms extended, if appropriate) to increase the participant's safety when performing the chair stands.

2) Describe the test.

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

3) Demonstrate the procedure.

Script: "Fold your arms across your chest, like this, and stand when I say GO, keeping your arms in this position. OK?"

4) Ask the participant to stand.

Script: "Ready? Go!"

If the participant's arms unfold, or they put 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 a little forward in the chair before standing, but knees and hips should be flexed to approximately 90 degrees before standing.

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

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

6) Score as follows:

If the participant refuses to do the test or cannot understand the instructions, score "Participant refused."

If the procedure was not attempted because the participant was unable to perform the test, score "Not attempted/unable," and comment about why the participant was unable to perform the test.

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

5.3 Repeated Chair Stands: Administration

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

1) If the participant can arise from the chair without using arms, attempt ten stands.

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

2) 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: “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’ll demonstrate two chair stands to show you how it is done.”

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

3) Begin the test

Script: “When I say ‘Go’ stand ten 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 you say “Go.” Count: “1, 2, 3, 4, 5, 6, 7, 8, 9, 10” as the participant sits down each time. After the participant sits down for the fifth time, glance at the time and depress the split button on the stopwatch (see instructions above).

4) If the participant is unable to complete the chair stands correctly (e.g., is not coming to a full stand), stop the procedure, repeat the demonstration, wait 1 minute, and begin the procedure again.

5) 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. Otherwise, stop the stopwatch.

6) If the participant stops before completing ten stands, confirm they cannot continue by asking:

Optional script: “Can you continue?”

If they say yes, continue timing. Otherwise, stop the stopwatch.

7) Score as follows:

If the participant refuses to do the test or cannot understand the instructions, score “Participant refused.”

If the procedure was not attempted because the participant was unable to perform the test, score “Not attempted/unable,” and comment about why the participant was unable to perform the test.

If participant attempted but was unable to complete five stands without using their arms, score as “Attempted, unable to complete five stands without using arms” and record the number completed without using arms.

If five chair stands were completed, record the number of seconds, to a hundredth of a second, required to complete five stands.

If participant completed five stands but was unable to complete ten stands without using their arms, score as “Attempted, unable to complete ten stands without using arms” and record the number completed without using arms.

If ten chair stands were completed, record the number of seconds, to a hundredth of a second, required to complete ten stands.

5.4 Standing Balance: Administration

This is a series of timed, progressively more difficult, static balance tests. The level of difficulty increases as the lateral base of support decreases. The time (up to 30 seconds) the participant can hold each position (side-by-side (10 seconds only), semi-tandem, tandem, and single-leg stands) is recorded. Walking aids such as a cane, may not be used.

Script: “I’m going to ask you to stand in several different positions that test your balance. I’ll demonstrate each position and then ask you to try to stand in each position for up to 30 seconds. I’ll be near you to provide support, and the wall is close enough to prevent you from falling if you lose your balance. Do you have any questions?”

For each stand, describe the position to the participant and then demonstrate it while facing the participant. After demonstrating, approach the participant from the front and off to the side away from the wall. Offer them your arm (the one away from the wall) for support while they get in position.

If the participant feels it would be unsafe to try, probe for the reason, and reassure the participant that you will help them into the position and that they can use the wall for additional support. If they still feel they should not attempt it, record, "Participant refused" or "Not attempted, unable" (whichever is appropriate) for this and the more difficult stands and go on to the next test.

If the participant attempts the stand incorrectly, demonstrate it again. Time each stand. After 10 seconds for the side-by-side stand and 30 seconds for the other stands, tell the participant to stop. If the participant loses balance before the designated time (10 or 30 seconds), record the number of seconds for which the stand was held. See figures for placement of feet for each type of stand.

1) Side-by-side stand

a) Describe the position.

Script: "First I would like you to try to stand with your feet together, side-by-side, for about 10 seconds. Please watch while I demonstrate."

b) Demonstrate and say:

Script: "You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your feet. Try to hold your feet in this position until I say stop."

c) Begin the test. Allow the participant to hold onto your arm to get balanced. Say:

Script: "Hold onto my arm while you get in position. When you are ready, let go."

Start timing when the participant lets go.

(If the participant does not hold onto your arm, start timing when they are in position.)

Optional script: "Ready? Begin.")

Stop the stopwatch if they take a step or grab for support.

Record to 0.01 second the time the participant could hold this position.

Say, "STOP" after 10 seconds.

2) Semi-tandem stand



a) Describe the position.

Script: “Now I would like you to try to stand with the side of the heel of one foot touching the big toe of the other foot for about 30 seconds. Please watch while I demonstrate.”

b) Demonstrate and say:

Script: “You may put either foot in front, whichever is more comfortable. You can use your arms and body to maintain your balance. Try to hold your feet in position until I say stop. If you lose your balance, take a step like this.”

c) Begin the test. Allow the participant to hold onto your arm to get balanced. Say:

Script: “Hold onto my arm while you get in position. When you are ready, let go.”

Start timing when the participant lets go.

(If the participant does not hold onto your arm, start timing when they are in position.)

Optional script: “Ready? Begin.”)

Stop the stopwatch if they take a step or grab for support.

Record to 0.01 second how long participant is able to hold this position.

Say, “STOP” after 30 seconds.

d) If the participant is unable to hold the semi-tandem stand for at least 10 seconds, do not attempt the other standing balance tests (the tandem or single-leg stand). Go to the walking tests.

Based on the results from the semi-tandem stand, if you reason it would be unsafe for the participant to proceed to the more difficult positions, record “not attempted” on the form for the more difficult stands and continue to the walking tests.

3) Tandem stand



a) Describe the position.

Script: “Now I would like you to try to stand with the heel of one foot in front of and touching the toes of the other foot. I’ll demonstrate.

b) Demonstrate, and say:

Script: “Again, you may use your arms and body to maintain your balance. Try to hold your feet in position until I say stop. If you lose your balance, take a step, like this.”

c) Begin the test. Allow the participant to hold onto your arm to get balanced. Say:

Script: “Hold onto my arm while you get in position. When you are ready, let go.”

Start timing when the participant lets go.

(If the participant does not hold onto your arm, start timing when they are in position.
Optional script: “Ready? Begin.”)

Stop the stopwatch if they take a step or grab for support. Record to 0.01 second how long participant is able to hold this position.

Say, “STOP” after 30 seconds.

d) If the participant holds the position for 30 seconds, go to the Single Leg Stand. If the participant attempts the Tandem Stand and is unable or cannot hold it for at least one second, perform a second trial of the Tandem Stand.

Script: “Now, let’s do the same thing one more time. Hold onto my arm while you get into position. When you are ready, let go.”

4) Single leg stand

a) Describe the position.

Script: “For the last position, I would like you to try to stand on one leg for 30 seconds. You may stand on whichever either leg is more comfortable. I’ll demonstrate.”

b) Demonstrate the single leg stand by lifting the opposite leg so that the toes are about 2 inches off the floor. The knee should be flexed. While demonstrating say:

Script: “Try to hold your foot up until I say stop. If you lose your balance put your foot down.”

c) Allow the participant to hold onto your arm to get balanced. Say:

Script: “Hold onto my arm while you get in position. When you are ready, let go.”

Start timing when the participant lets go.

Stop the stopwatch if they take a step or grab for support. Record to 0.01 second how long participant is able to hold this position.

Say, “STOP” after 30 seconds.

d) If the participant holds the position for 30 seconds, go to the walking tests. Otherwise, perform a second trial of the Single Leg Stand.

Script: “Now, let’s do the same thing one more time.”

5) Score as follows:

If the participant refuses to do the test or cannot understand the instructions, score “Participant refused.”

If you do not allow the participant to attempt a stand for safety reasons, score “Not attempted, unable.”

If the participant cannot attain the position at all or cannot hold it for at least one second, score “Unable to attain position or cannot hold for at least one second.”

Record to 0.01 second how long participant is able to hold each position.

5.5 Six Meter Usual, Rapid Pace and Narrow Walk: Administration

These timed walks are similar to the short walk tests used in many epidemiological and clinical studies. Time to walk 6 meters at the participant’s usual and rapid pace is measured.

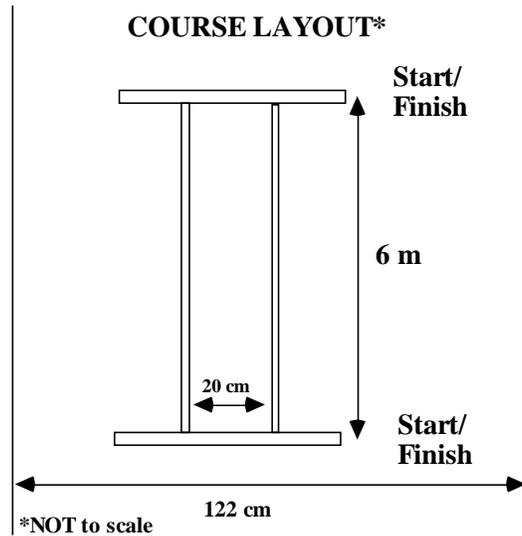
In addition to the standard walks, this test also includes one walk along a narrow path, which requires increased motor control. There are two scored trials for the narrow walk.

The 6-meter walk tests will be conducted in the following order: usual pace, rapid pace and narrowed to 20 cm.

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

Starting Each Walk Test: Have the participant stand with toes just touching the starting line. Hold your arm up, say “Ready? Go,” and then drop your arm. Start timing with the first footfall over the starting line (participant’s foot touches the floor on the first step).

Scoring the Walks: Stop timing with the first footfall (complete or partial) across or touching the finish line. Record the time to the nearest 0.01 second.



The narrow walk is scored for time if there are no more than two deviations from the path. A path deviation is defined as stepping on, or going outside of, the colored tape or touching the wall. If there are more than two deviations, the trial is scored as “No” in answer to the question: “Did the participant stay within the lines?” Each participant should be given up to three chances to perform the narrow walk with two or fewer deviations. If they successfully perform the walk in the first two trials, a third trial will not be needed.

1) Introduction

Describe the three walks.

Script: “This next test consists of three short walks. First, I want you to walk down the hall, between the tape lines that mark the beginning and end of the course at your normal walking pace, ignoring the colored lines along the side. For the second walk, I want you to walk the same course, but as quickly as you can. For the third walk, I want to walk at your normal pace again, trying to keep your feet within the colored lines along the side. Each walk will be done at least twice.”

2) Usual pace walk

a) Demonstrate the test and say the following:

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 ignoring the colored lines.” (Demonstrate and return.) “Walk a few steps past the finish line each time. Any questions?”

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

Script: “Ready? Go.”

Start timing with the participant’s first footfall. Follow along a few paces behind the participant. Count each step (NOT aloud), both left and right. Depress the start button on the stopwatch as you count the first step. Stop timing with the first footfall touching or across the finish line.

c) 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.”

3) Rapid pace walk

a) Demonstrate the test and say the following:

Script: “Place your feet with your toes behind, but touching the starting line. Wait until I say “GO.” Remember, I want you to walk as quickly as you can, ignoring the colored lines along the side.” (Demonstrate and return.) “Walk a few steps past the finish line each time. Any questions?”

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

Script: “Ready? Go.”

Start timing with the participant’s first footfall. Follow along a few paces behind the participant. Stop timing with the first footfall touching or across the finish line.

c) Have the participant repeat the rapid pace walk.

Script: “OK, fine. Now turn around and when I say go, walk back the other way as fast as you can. Ready? Go.”

4) 20 cm narrow walk

a) Explain the 20 cm narrow walk.

Script: “Now for the third walk, please keep your feet inside the lines. It is important that you try your best to keep your feet inside the lines.”

b) Demonstrate the walk.

Script: “I’ll demonstrate. Keep your feet inside the lines. Be sure to walk a few steps past the finish line. Any questions?”

c) Begin the test. Time as before. Drop your arm and say,

Script: “Ready? Go.”

d) Record the time only if the participant’s feet do not deviate from the path more than twice, otherwise score “No” in answer to the question: “Did the participant stay within the lines?” Perform up to three trials to obtain two valid times.

6. Procedures for Performing the Measurement at Home

The chair stand and standing balance tests can be performed at home. The usual and rapid walks may be performed at home, but over a shorter course, 3 to 4 meters.

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

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

8. Quality Assurance

8.1. Training Requirements

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

- Read and study manual
- Attend BLSA training session on performance test administration 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 two volunteers:
 - According to protocol, as demonstrated by completed QC checklist
 - Times agree within ± 1 second of QC officer
 - Assessment of “deviations” on narrow walk agrees with QC officer

8.3. Quality Assurance/Certification Checklist

Chair stands

- Back of chair against a wall
- Script correctly and clearly delivered
- 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, takes a split time after participant sits down on the fifth stand and records final time after participant sits down on the tenth stand
- Records and explains unusual values
- If task was not performed, codes and explains reasons

Standing balance

Side-by-side stand

- Script correctly and clearly delivered
- Correctly demonstrates position
- Timing started coincident with participant release and stopped when participant takes a step or holds on

- If task was not performed, codes/records reasons

Semi-tandem stand

- Script correctly and clearly delivered
- Correctly demonstrates position
- Timing started coincident with participant release and stopped when participant takes a step or holds on
- If task was not performed, codes/records reasons

Tandem stand

- Script correctly and clearly delivered
- Correctly demonstrates position
- Timing started coincident with participant release and stopped when participant takes a step or holds on
- If task was not performed, codes/records reasons
- Repeat (second trial), if necessary

Single-leg stand

- Script correctly and clearly delivered
- Correctly demonstrates position
- Timing started coincident with participant release and stopped when participant takes a step or holds on
- If task was not performed, codes/records reasons
- Repeat (second trial)

Short walks

Usual pace

- Script correctly and clearly delivered
- Correctly demonstrates
- Toes touching start line
- Timing started coincident with participant's first footfall
 - Time stopped with first footfall over the finish line
- Repeat (second trial)

Rapid pace

- Script correctly and clearly delivered
- Correctly demonstrates
- Toes touching start line
- Timing started coincident with participant's first footfall
 - Time stopped with first footfall over the finish line
- Repeat (second trial)

Narrow walk

- Script correctly and clearly delivered
- Correctly demonstrates
- Toes touching start line
- Timing started coincident with participant's first footfall
- Timing stopped at with first footfall over the finish line
- Ability to stay "in bounds" on narrowed walk correctly assessed
- Correct number of trials allowed

9. References

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