CHAPTER 8

Testing Functional Performance

Current clinical practice presents a growing need to emphasize the relationship between strength and functional movement, especially in older adults. Each person has a threshold of strength that is minimal for the performance of activities of daily living (ADLs). The larger or taller the person is, for example, the more strength will be needed. Third-party payers require that therapists show a relationship between strength and function in their treatment plans, frequently denying payment if their assessments fail to show this relationship. It has always been important for therapists to show that patients have strength deficits, but it is now critical for them to show that strength deficits are tied to the patient's ability, or lack thereof, to independently complete ADLs, perform a job task (such as bricklaying), or play with their children or grandchildren. This chapter presents a series of functional tests, particularly relevant to older individuals, that require strength to be of a minimum threshold. Once a specific weakness is pinpointed, a strengthening program can be designed to help patients achieve their functional goals.

The functional assessment tests described in this chapter have been correlated to specific essential muscles. The list of muscles for each task is not comprehensive, but it provides a starting point for the beginning therapist to design a plan for muscle tests when a functional deficit is observed. Normative values are provided when available. Specific exercises for each muscle are listed after each muscle test in Chapters 5 and 6. In some cases, patients may be able to accomplish a task by compensating for a specific muscle weakness, so the therapist should be observant to accurately identify specific muscle weaknesses.

Introduction

Functional abilities represent a broad range of movements that require muscles to act in highly specific ways to achieve a desired purpose. These abilities include ADLs such as dressing, eating, bathing, transferring, and walking, as well as other tasks of mobility such as rising from a chair, climbing stairs, lifting, and rising from the floor. These functional activities are basic tasks of mobility that are required for all individuals to be independent in the home and community. Functional activity performance is especially important for older adults who may be at risk for institutionalization. An inability to independently perform specific functional tasks may lead to institutionalization. Many higher-level functional abilities such as those required for sports and work are discussed in Chapter 7, Alternatives to Manual Muscle Testing.

The Nagi Model of Disablement[1] and the newer International Classification of Functioning (ICF) disablement model[1] describe the impact of disease and pathology within the context of both function and societal roles and provide a conceptual model to guide clinical practice. In these models, diminished muscle strength is an impairment that affects a person's ability to perform functional tasks or to fulfill societal roles. Muscle strength testing takes place at the impairment level, whereas testing functional task performance occurs at the function level. One goal of this chapter is to integrate impairment (strength deficit) and physical performance (function).

It is generally accepted that in the normal person, performance of basic functional tasks requires a relatively small amount of muscle strength in relation to the total amount of strength that existed before the injury, before a lifestyle of inactivity, or before the passage of years. The minimum amount of strength required is referred to as a "functional threshold." If patients have strength above the required threshold amount, they are unlikely to show deficits in performance. The relationship of strength to function up to a functional threshold is illustrated in Fig. 8.1. According to the principle illustrated in this graph, if the patient's strength sufficiently improves to the point at which the curve flattens out, the patient should be strong enough to perform the task. For example, about 45% of one's body weight is required to rise from a chair without using the arms.[2] If a person is unable to rise from a chair unassisted because of weakness in the lower extremities, strengthening will help to improve that function. Further strengthening will allow the person to rise more quickly and efficiently and will create a strength reserve to help preserve the ability to perform the task in the future.

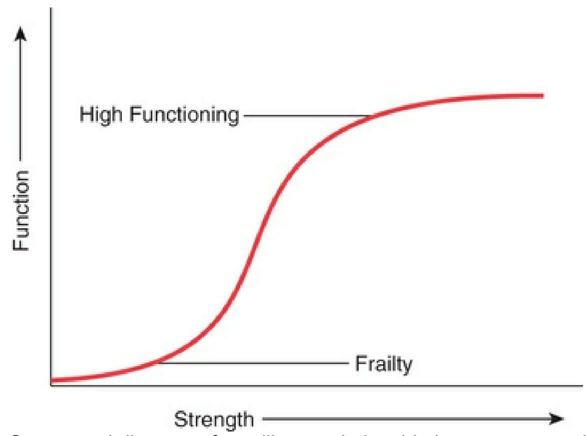

FIGURE 8.1 Conceptual diagram of curvilinear relationship between strength and function.

Functional Testing

An analysis of any functional task shows that movements are multiplanar and asymmetrical, incorporate rotation, and are speed and balance dependent. Therefore, simply testing a muscle's maximum ability to generate force will not accurately represent its functional ability. Observation of the individual performing the functional task is the only way to accurately test functional ability. Such observation provides information about the quality of the performance, which in turn informs the therapist's clinical decision making. Inferring that a specific muscle has functional strength without direct observation of the functional task is incorrect and should be avoided as noted in Chapter 2. Table 8.1 shows the key muscles required for some basic functional tasks.

Table 8.1

KEY MUSCLES ESSENTIAL FOR FUNCTIONAL MOVEMENTS

Functional Movement	Key Muscles
Bed mobility	Abdominals, erector spinae, gluteus maximus
Transfers and squats	Gluteus maximus, medius, and obturator externus, piriformis, quadriceps
Ambulation and stair climbing	Abdominals, erector spinae, gluteus maximus and medius, obturator externus, piriformis, quadriceps, and anterior tibialis and gastrocsoleus
Floor transfers	Abdominals, erector spinae, gluteus maximus and medius, obturator externus, piriformis, quadriceps and gastrocsoleus
Fast gait and jumping	Gastrocsoleus, gluteus maximus and medius, quadriceps

Measurement

Functional task performance is measured in several ways. Ordinal scales showing hierarchical levels of performance are commonly used in both manual muscle testing and in some functional tests. In ordinal scales, numbers are sequentially and hierarchically assigned in accordance with the difficulty of the task. However, ordinal scales are limited by their susceptibility to subjectivity and their lack of responsiveness to small changes in performance. Therefore, using ratio scales, such as time, to measure individual patient performance, is the preferred method. Timing task performance provides a strong measure of reliability and responsiveness. However, when a functional task is timed, such as when a patient is instructed to rise from a chair as quickly as possible, it should be noted that power is a component in addition to strength. Ratio measures such as time and distance allow the therapist to compare an individual patient's performance against available normative data of similar individuals. This comparison aids in clinical decision making.

Chair Stand

Purpose:

The chair stand test is a test of mobility specifically targeting the force production of the leg muscles. There are two versions: the number of completed sit-to-stand motions (chair rises) completed in 30 seconds (30s STS) and the time required to complete five chair rises (5T-STS).

Essential Muscle Movements for Task Performance:

Hip extension, hip abduction from a flexed position, hip external rotation, knee extension, ankle plantar flexion, ankle dorsiflexion and inversion,[3] and trunk extension and flexion.

Reliability:

Test-retest reliability for all versions of the Chair Stand Test ($r = 0.89$).[4]

Validity:

The 30s STS test correlates with measures of lower extremity strength, walking speed, stair-climbing ability, and balance[5,6] and correlates with one-repetition maximum (1-RM) leg press ($r = 0.78$ for men, 0.71 for women).[4] The 5T-STS is a valid measure of dynamic balance and functional mobility in older adults.[7] Inability to complete the 5T-STS in less than 13.7 seconds is highly predictive of future mobility disability.[8]

Equipment:

A standard, armless chair, 17 in. (43 cm) high, and a stopwatch.

Testing Procedure:

Both test versions are *always* done without the use of the patient's arms. Assess the ability of the patient to stand without the use of arms. If able, proceed to testing. If indicated, the therapist should demonstrate the sit-to-stand movement before testing.

30-Second Version:

The patient rises from a sitting position and stands to a fully erect position as many times as possible in 30 seconds. The therapist starts timing when the patient begins to move (rather than on "Go!").

Timed Five-Repetition Version:

The patient comes to a full standing position 5 times as quickly as possible. The therapist begins timing on the command "Go!" The therapist times the effort from the command "Go!" until the patient returns to a seated position after five repetitions.

Position of Patient:

Sitting with arms crossed over the chest. Feet are planted on the floor in the position chosen by the patient (Fig. 8.2).

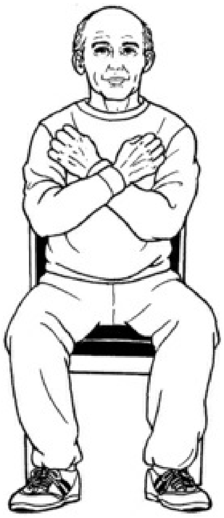

FIGURE 8.2

Therapist Position:

Stand to fully view the patient's quality of movement (Fig. 8.3).

FIGURE 8.3

Patient Position

30-Second Version:

“When you're ready, stand up as many times as you can in 30 seconds without using your arms. I'll keep count. Make sure you stand all the way up.”

Timed Five-Repetition Version:

“When you are ready, stand up 5 times, as quickly as you can without using your arms. I will be timing you. Make sure you stand all the way up.”

Scoring

30-Second Version:

The number of repetitions is the patient's score. Count the repetition if the patient is more than halfway standing. If the patient cannot complete one repetition without the use of the arms, the score for the 30-second version is zero.

Timed Five-Repetition Version:

The time taken to complete five repetitions is the score. If 60 seconds elapse before five repetitions are accomplished, the test is terminated and the score of 60 seconds is recorded with a notation. The odds of being disabled increases 1.4 times for every one-second increase in the 5T-STS test. The minimal detectable change is 2.5 seconds.[7] Scores of greater than 10 s increase the risk of developing disability within 2 years.[9]

Helpful Hints

- Do not use a folding chair, a very soft chair, a deep chair, or a chair on wheels for the chair stand test. The chair should be placed against the wall for safety purposes.
- Chair heights from 80% to 90% of the patient's lower (tibia) leg length are optimal for the test.[10]
- Allow the patient to perform the sit-to-stand movement first, without coaching. If the patient has difficulty rising, then offer tips such as scooting to the edge of the chair, leaning forward, etc.
- It is useful to observe the position of the hips while the patient is attempting to stand and sit. If the hips are adducted and/or internally rotated, this may indicate weakness and specific muscle testing is indicated, especially of the gluteus medius (Fig. 8.4).

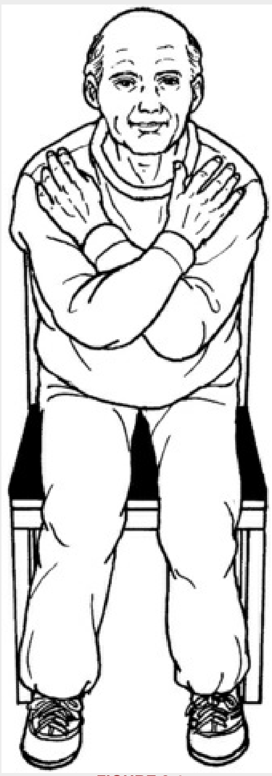

FIGURE 8.4

- Excessive bending forward of the trunk to stand may indicate that the patient has weak quadriceps (Fig. 8.5).

FIGURE 8.5

- Although it is preferable to have the patient cross the arms over the chest, some patients may need to extend their arms forward to help them stand. If this occurs, it could indicate that the patient's legs are weak or balance is impaired (Fig. 8.6).

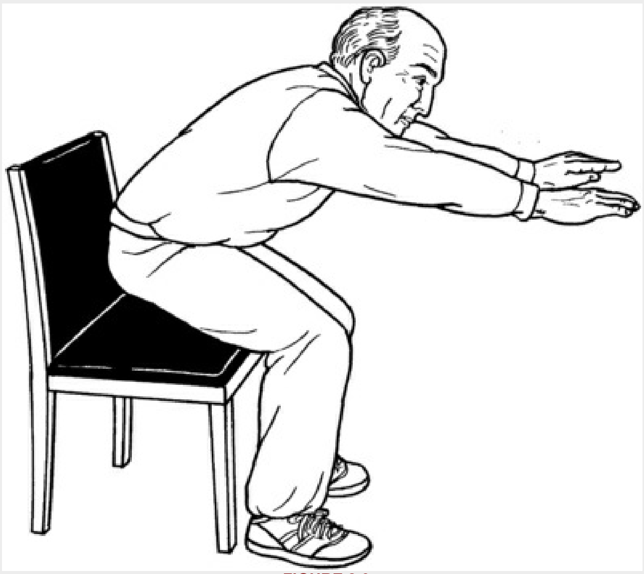

FIGURE 8.6

- If you suspect the patient will not be able to complete five repetitions, the 30s STS version is the preferred test because the patient is required to only complete a minimum of one repetition for a successful test.

Tables 8.2 and 8.3 show normative ranges for physically active older men and women. Eight repetitions may be the threshold for physical disability.[4]

Table 8.2

NORMAL RANGE OF CHAIR STANDS BY SEX AND AGE (MIDDLE 50% OF POPULATION)

Age	M	F
60–64	14–19	12–17
65–69	12–18	11–16
70–74	12–17	10–15
75–79	11–17	10–15
80–84	10–15	9–14
85–89	8–14	8–13
90–94	7–12	4–11

F, Female; *M*, male.

From Jones CJ, Rikli RE. Measuring functional fitness of older adults. *J Act Aging*. 2002;March–April:24–30.

Table 8.3

NORMATIVE DATA* FOR 30-SECOND CHAIR STAND TEST FROM 1000 AUSTRALIANS

Age	3–9		10–19		20–59		60+	
	M	F	M	F	M	F	M	F
Mean (SD)	23.1 (6.6)	23.4 (6.1)	25.5 (5.7)	24.2 (5.9)	24.2 (6.0)	22.6 (6.2)	18.3 (5.73)	15.9 (4.8)

*Each decade included 100 people (20 to 80+).

F, Female; *M*, male.

Data from McKay MJ, Baldwin JN, Ferreira P, Simic M, Vanicek N, Burns J. 1000 Norms Project Consortium. Normative reference values for strength and flexibility of 1,000 children and adults. *Neurology*. 2017;88(1):36–43.

Table 8.4 shows 5T-STS test normative ranges for moderately disabled women—that is, those who have difficulty performing two or more ADL tasks. The Women's Health and Aging Study (of moderately to severely disabled women) found a mean time of 15.3 seconds for women ages 65 to 85 and older.[11] The more time required, the more likely it is that the individual is frail.[12]

Table 8.4

CHAIR STAND PERFORMANCE FOR MODERATELY DISABLED WOMEN

5-Repetition Chair Stand	Total *N* = 1002	65–74 Years *N* = 388	75–84 Years *N* = 311	85+ Years *N* = 303
Unable to do (%)	25.2	17.8	25.9	44.9
Mean Time to rise 5 × (s)	15.3	14.7	15.7	16.3
5th percentile	24.5	21.9	25.5	24.1
25th percentile	17.4	16.7	17.5	18.5
50th percentile	14.2	13.9	14.4	15.0
75th percentile	12.3	12.1	12.4	12.7
95th percentile	10.0	9.6	10.3	10.0

Moderately disabled women were those with difficulty in two or more activities of daily living tasks.

Data from Guralnik JM, Fried LP, Simonsick EM, Kasper JD, Lafferty ME, eds. *The Women's Health and Aging Study: Health and Social Characteristics of Older Women with Disability*. Darby PA: Diane Pub Co; 1995:44.

Gait Speed

Purpose:

Gait speed is a functional test of one's ability to walk at a comfortable (usual) speed. A fast-paced walk can demonstrate available reserve and the ability to accelerate rapidly, such as in the need to get across a street. Possible gait speed times range from the fastest sprinters to the slowest possible gait, often seen in individuals residing in nursing homes. Gait speed has been called the sixth vital sign because of its validity in predicting functional ability, frailty, nursing home placement, and the ability to walk in the community.[13] It can be measured in any person who can walk, even those using assistive devices.

Essential Muscle Movements for Task Performance:

Core; hip extension, abduction, and adduction; quadriceps and hamstrings; ankle plantar flexion; and ankle dorsiflexion with inversion.[14,15] Hip flexion also contributes to walking velocity.[16] The reader is referred to the gait section of this chapter for a more specific list of muscles that are imperative for smooth and normal gait.

Reliability:

$r = 0.78$[17]

Validity:

Gait speed is related to age (Fig. 8.7) and muscle mass.[13,17] Gait speed at "usual pace" was found to be a consistent predictor of disability, cognitive impairment, institutionalization, falls, and/or mortality.[18] Fast gait speed is a robust predictor of disability when the annual decline exceeds −0.22 m/s.[19] A speed of less than 0.8 m/s is a predictor of 8-year mortality in predisabled women 75 years or older.[20] Women who had gait speeds of less than 0.60 m/s were 2.5 times more likely to die prematurely than those with faster gait speeds.[21] A speed of less than 1.2 m/s is highly predictive of future mobility disability.[8]

FIGURE 8.7 Self-selected walking speed categorized by gender and age.

Equipment:

A 4- to 8-m-long walkway and a stopwatch. It is helpful to have 1 to 2 m or so before and after the 4-m test course to allow for acceleration and deceleration, especially in people with stroke.[22] However, although this extra distance is desirable, it is not necessary to perform the test in people without pathology. However, each test administration should be performed the same way for consistency of results and accuracy of interpretation. The length of the walkway does not influence the consistency of results.[23]

Testing Procedure:

First, describe the test clearly to the individual. Assure the patient is safe to walk independently (without another person). Demonstrate the test if needed, taking care not to walk too fast. Then, have the patient perform two trials with adequate rest in between, scoring the faster one. Test both comfortable (usual) and fast gait speeds. Begin timing the individual when the first foot crosses the line at the beginning of the course (Fig. 8.8A) and stop timing when the first foot crosses the end line (Fig. 8.8B). Any part of the foot will do; it is just important to be consistent.

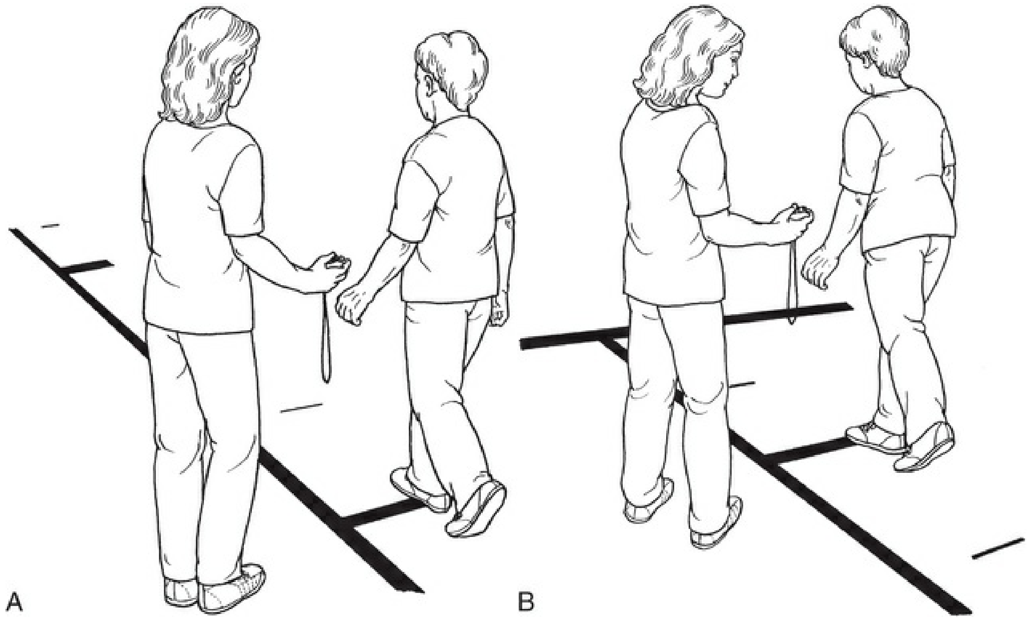

FIGURE 8.8

Position of Patient:

Standing, facing a marked-off walkway. Patient may use an assistive device if needed.

Therapist Instructions:

Stand and hold the stopwatch perpendicular to the starting line. The therapist should walk with the patient to obtain an accurate view of when the first foot crosses the finish line without pacing the patient. The therapist begins timing when the patient's first foot (or part of the first foot) crosses the start line of the 4-m walkway (see Fig. 8.8A).

Patient Instructions:

"Walk at your usual and comfortable speed from this line to (or past) the other line on the floor (indicate which line). I will be timing you. The first trial is for practice and then we'll time you. OK? Ready, Go!" Two trials are given. The same directions are given for the fast-paced walk, with the patient instructed to walk as quickly, but as safely, as possible. Adequate rest should be provided as needed between trials.

Scoring

To determine a result in meters per second (m/s), the walkway distance is divided by the time taken (in seconds) to cover that distance. There are many gait speed standards. Gait speeds of 1.75 to 2.25 m/s are normal in high-functioning older adults, whereas gait speeds slower than 0.5 m/s are common in nursing home residents. In one study, the mean gait speed used by 139 pedestrians was 1.32 (SD, 0.31) m/s.[24]

Table 8.5 indicates some conversions from meters/second to feet/second and miles/hour. Tables 8.6 to 8.9 list normative values for gait speed by age.

Table 8.5

CONVERSIONS FOR GAIT SPEED

Meters/Second	Feet/Second	Minutes/Mile	Miles/Hour
0.25	0.82	106.7	0.6
0.30	0.98	88.9	0.7
0.35	1.15	76.2	0.8
0.40	1.31	66.7	0.9
0.45	1.48	59.3	1.0
0.50	1.64	53.3	1.1
0.55	1.80	48.5	1.2
0.60	1.97	44.4	1.4
0.65	2.13	41.0	1.5
0.70	2.30	38.1	1.6
0.75	2.46	35.6	1.7
0.80	2.62	33.3	1.8
0.85	2.79	31.4	1.9
0.90	2.95	29.6	2.0
0.95	3.12	28.1	2.1
1.00	3.28	26.7	2.3
1.10	3.61	24.2	2.5
1.20	3.94	22.2	2.7
1.30	4.26	20.5	2.9
1.40	4.59	19.0	3.2
1.50	4.92	17.8	3.4
1.60	5.25	16.7	3.6
1.70	5.58	15.7	3.8
1.80	5.90	14.8	4.1
1.90	6.23	14.0	4.3
2.00	6.56	13.3	4.5

Table 8.6

MEAN FAST GAIT SPEED TIME FOR MEN AND WOMEN AGE 20 YEARS AND OLDER

	MAXIMUM GAIT SPEED (m/s)	
	MEAN AND SD	
Age	Men	Women
20s	2.53 (0.29)	2.47 (0.25)
30s	2.46 (0.32)	2.34 (0.34)
40s	2.46 (0.36)	2.12 (0.28)
50s	2.07 (0.45)	2.01 (0.26)
60s	1.93 (0.36)	1.77 (0.25)
70s	2.08 (0.36)	1.75 (0.28)

Data from Bohannon RW. Comfortable and maximum walking speed of adults aged 20–79 years: reference values and determinants. *Age Ageing*. 1997;26(1):15–19.

Table 8.7

NORMATIVE RANGES OF USUAL GAIT SPEED FOR HEALTHY ADULTS AGES 20–99

GAIT SPEED IN m/s		
Age	Men	Women
20–29	1.22–1.47	1.08–1.50
30–39	1.32–1.54	1.26–1.42
40–49	1.27–1.47	1.22–1.42
50–59	1.12–1.49	1.10–1.56
60–69	1.03–1.59	0.97–1.45
70–79	0.96–1.42	0.83–1.50
80–99	0.61–1.22	0.56–1.17

Data from Bohannon RW, Williams Andrews A. Normal walking speed: a descriptive meta-analysis. *Physiotherapy*. 2011;97(3):182–189.

Table 8.8

NORMS FOR USUAL GAIT SPEED TIME (M/S) FOR MODERATELY DISABLED WOMEN AGE 65 AND OLDER

	Total (*n* = 1002)	65–74	75–84	85+
Mean	0.6	0.7	0.6	0.4
5th percentile	0.2	0.3	0.2	0.1
25th percentile	0.4	0.5	0.4	0.3
50th percentile	0.6	0.6	0.6	0.6
75th percentile	0.7	0.7	0.8	0.6
95th percentile	1.1	1.1	1.1	0.8

m/s, Meters per second; *n*, number of subjects.

Moderately disabled women were those with difficulty in two or more activities of daily living tasks.

Subjects were asked to walk at their usual and customary pace for 4 m.

Modified from Ferrucci L, Guralnik JM, Bandeen-Roche KL, et al. Performance measures from the women's health and aging study. http://www.grc.nia.nih.gov/branches/ledb/whasbook/chap4/chap4.htm. Accessed 08.01.12.

Table 8.9

NORMS FOR FAST GAIT SPEED TIME (M/S) FOR MODERATELY DISABLED WOMEN AGE 65 AND OLDER

	Total (n = 1002)	65–74	75–84	85+
Mean	0.9	1	0.9	0.7
5th percentile	0.2	0.4	0.3	0.2
25th percentile	0.6	0.8	0.6	0.4
50th percentile	0.9	1	0.9	0.7
75th percentile	1.1	1.3	1.1	0.9
95th percentile	1.7	1.7	1.7	1.3

m/s, Meters per second; *n*, number of subjects.

Moderately disabled women were those with difficulty in two or more activities of daily living tasks.

Modified from Ferrucci L, Guralnik JM, Bandeen-Roche KL, et al. Performance measures from the women's health and aging study. http://www.grc.nia.nih.gov/branches/ledb/whasbook/chap4/chap4.htm. Accessed 08.01.12.

Helpful Hints

- Gait speed can be measured in patients who use an assistive device. When retesting performance in the same patient, retest using the same assistive device.
- Studies have shown that additional distance for acceleration and deceleration is not necessary; however, we recommend using a further end-point target to prevent patients from slowing down as they approach the finish line or the instructions, “walk past the line” (see Fig. 8.8B).
- Reliability improves with longer distances, up to 10 m.[17]
- If walking with the individual, be careful not to set the pace but walk slightly behind the individual. This will allow you to get a more realistic view of the patient's actual performance. While always maintaining a safe test situation, do not inhibit the individual by standing too close or providing too many instructions. Certainly, use a gait belt if it is warranted.
- Knowing when to start and stop timing requires skill and practice. It is recommended to use a specific “event,” such as when the first foot crosses the line, as the moment to begin and end timing but any such event will do; just be consistent!

Physical Performance Test and Modified Physical Performance Test

Purpose:

The physical performance test (PPT) measures aspects of physical function and ADLs in older adults using nine items that emphasize mobility tasks. There are two versions of the PPT test: one with seven items and one with nine; the nine-item version also includes stair-climbing tasks.

The Modified Physical Performance Test (M-PPT) includes most of the items of the PPT but substitutes three balance tests and a timed 5T-STS for the writing and eating task.

Essential Muscle Movements for Physical Performance Test Task Performance

Writing Task:

(If the arm is supported, only hand and wrist muscles may be essential.) Wrist flexion and extension, finger metacarpophalangeal (MP), proximal phalanges (PIP), and distal phalanges (DIP) flexion.

Eating Task:

Shoulder flexion, shoulder internal rotation, elbow flexion, forearm supination and pronation, wrist flexion and extension, and finger MP, PIP, and DIP flexion.

Essential Muscle Movements for Physical Performance Test and Modified Physical Performance Test Task Performance

Lifting a Book:

Scapular protraction and upward rotation; shoulder flexion; shoulder external rotation; elbow flexion and extension; forearm supination and pronation; wrist flexion and extension; and finger MP, PIP, and DIP flexion.

Putting On and Taking Off a Garment (Depending on Technique):

Scapular protraction and upward rotation; shoulder flexion; shoulder external rotation; elbow flexion and extension; forearm supination and pronation; wrist flexion and extension; and finger MP, PIP, and DIP flexion. Core stability (for sitting or standing). If the task is performed while standing: hip extension and abduction, knee extension, ankle plantar flexion, and ankle dorsiflexion with inversion.

Picking Up a Coin:

Back extension; hip extension, knee extension; ankle plantar flexion; elbow flexion and extension; forearm supination and pronation; wrist flexion and extension; and finger MP, PIP, and DIP flexion.

360° Turn:

Ankle dorsiflexion with inversion, plantar flexion, foot inversion, foot eversion with plantar flexion, knee extension, hip abduction and extension, and core stability.

Walking Task:

Hip extension and abduction, knee extension, ankle plantar flexion, and ankle dorsiflexion with inversion.[14] Hip flexion also contributes to walking velocity.[15] The reader is referred to the gait section of this chapter for a more specific list of muscles that are imperative for smooth and normal gait.

Stair Climb Tasks:

Ascent: hip flexion and extension, knee extension and flexion, ankle plantar flexion, ankle dorsiflexion, spine extension, and core stability. Descent: eccentric knee extension, hip flexion, and core muscles.[25] Balance is also a key component of successful stair ascent and descent.

Reliability:

The intraclass correlation coefficient (ICC) for interrater reliability is 0.96 for the eight-item version (omitting the last item of four flights of stairs).[26] The ICC of test-retest reliability in the eight-item version is 0.88.[26] There is no reliability data for the M-PPT.

Validity:

Predictive validity for classifying level of care as dependent or independent.[28] Construct validity based on self-reported ADL and instrumental ADL performance.[27] Predictive of major health outcomes such as death and nursing home placement.[29] Predictive of first time fall (within 12 months)[30] and recurrent falls.[31] The M-PPT can indicate whether an individual is frail.[32]

Equipment for Both Versions

- Scoring form
- Stopwatch
- Table and chair (PPT)
- Bowl (PPT)
- Spoon (PPT)
- Coffee can (PPT)
- Five dry (uncooked) kidney beans (PPT)
- 5.5-lb book
- Two adjustable shelves
- Patient's jacket or front-button sweater or extra-large lab coat, hospital gown, or other front-opening garment
- 25-foot walkway
- One flight of stairs (10 to 12 stairs)

Testing Procedure

Physical Performance Test and Modified Physical Performance Test:

Both versions take about 10 minutes to complete. The test items can be done in any order; however, they will be described here in the order in which they appear on the scoring forms. Each task is timed, except for the 360° turn and climbing four flights of stairs. Two trials of each task are performed, except for the stair-climbing task.

An assistive device can be used for the walking and stair-climbing tasks, but not for the other tasks. All tasks are to be completed unassisted and without support. As in all tests, the patient's safety should be assured. Although assistance from the therapist is not permitted during performance of the test, the therapist should be vigilant for balance problems. A gait belt is always recommended during test performance.

The nine PPT tasks are:

1. Writing a sentence
2. Simulated eating
3. Lifting a book onto a shelf
4. Putting on and taking off a garment
5. Picking up a coin from the floor
6. 360° turn
7. 50-foot walk
8. Climbing one flight of stairs
9. Climbing four flights of stairs

The nine M-PPT tasks are:

1. Standing static balance
    a. Side-by-side stance
    b. Semi-tandem stance

c. Full tandem stance
2. Chair stand (five repetitions)
3. Lifting a book onto a shelf
4. Putting on and taking off a garment
5. Picking up a coin from the floor
6. 360° turn
7. 50-foot walk
8. Climbing one flight of stairs
9. Climbing four flights of stairs

Physical Performance Test Tasks

1 Writing a Sentence

Testing Procedure:

The patient writes a sentence. The sentence can be written on the back of the test form so there will be a record of the result. The therapist writes the sentence first: "Whales live in a blue ocean." A period is placed at the end of the sentence. Then, on the command of "Go!" the patient writes the same sentence. Timing begins on Go! and ends when the period is placed at the end of the sentence. The therapist records the time it takes the patient to write the sentence legibly (Fig. 8.9).

FIGURE 8.9

Instructions to Patient:

"The first task is a writing task. I am going to write the sentence 'Whales live in a blue ocean.' Then I want you to write the same sentence while I time you. Are you ready? Go!"

2 Eating Task

Testing Procedure:

The second task is a simulated eating task. Five kidney beans are placed in a bowl 5 in. from the edge of the table in front of the patient. An empty coffee can is placed on the table at the patient's nondominant side. A teaspoon is placed in the patient's dominant hand. The therapist may demonstrate the task. The patient is asked on the command "Go!" to pick up the beans, one at a time with the spoon, and place them in the coffee can (Fig. 8.10). Timing begins with the command "Go!" and ends when the last bean is heard hitting the bottom of the can. The patient can use the nondominant hand to steady the bowl, but not to move it in any way. The nondominant hand cannot help steady the can or complete the task except to help pick up a dropped bean. If the patient drops a bean, timing continues while the patient picks up the bean.

FIGURE 8.10

Instructions to Patient:

"This next task is an eating task. When I say 'Go!' I want you to use your spoon to move one bean at a time from this can to the bowl. You cannot use your other hand except to steady the bowl. Are you ready? Go!"

PPT and M-PPT

3 Lifting a Book Onto a Shelf

Testing Procedure:

This task is done with the patient sitting on a chair (or other surface) (Fig. 8.11), or standing (Fig. 8.12), depending on whether you want to assess the patient's standing or sitting balance while lifting. It is handy to use an open cabinet with multiple and/or two adjustable shelves, usually available in a clinic. Having multiple or two adjustable shelves helps accommodate the patient's height. The countertop can serve as the starting position for the book placement.

FIGURE 8.11

FIGURE 8.12

Adjust the higher shelf so that it is 12 in. above the patient's shoulders. A 5.5-lb book, similar to a *Physicians' Desk Reference*, is placed on the edge of the counter, with the book hanging slightly off the edge of the counter to make it easy for the patient to grab. The patient is asked to lift the book from the lower shelf to the upper shelf while the effort is timed. The therapist should demonstrate this task to ensure understanding.

Timing is stopped when the patient's hand is removed from the book after it is placed on the top shelf. In the original PPT test, the patient is seated during the task (see Fig. 8.11). However, the task can be performed standing if desired (see Fig. 8.12). The time is recorded on the scoring form.

Instructions to Patient:

"For this task, I want you to lift this book to this shelf while I time you. Do you understand? Now, I'll demonstrate. OK, when I say 'Go!' you may begin."

4 Putting on and Taking Off a Garment

Testing Procedure:

This task involves putting on and removing a garment in a standing position. An extra-large bathrobe, front-buttoned shirt, or hospital gown can be used and put on so that it opens in the front. If the patient has a jacket or sweater that opens in the front, use that. Make sure the garment is large enough to put on over any clothes the patient is wearing. To start, the garment is held so the label inside the garment is facing the patient (Fig. 8.13).

FIGURE 8.13

The patient is instructed to start with arms at sides and on “Go!” to take the garment, put it on (Fig. 8.14), square it on the shoulders, and then remove it completely, holding it out to the therapist. Timing begins on “Go!” and ends when the patient hands the jacket to the therapist.

FIGURE 8.14

Instructions to Patient:

“This task involves putting on and taking off this jacket while I time you. When I say ‘Go!’ I want you to take the jacket from me, put it on so that it is square on your shoulders, and then take it off and hand it back to me. Now Go!”

5 Picking Up a Coin From the Floor

Testing Procedure:

This is a timed task of the patient's ability to pick up a coin from the floor. A coin is placed approximately 12 in. from the patient's foot (usually the dominant side). On the command “Go!” the patient picks up the coin from the floor and returns to a fully upright position (Fig. 8.15). The timing will begin with the command "Go!" and end when the patient is standing erect with coin in hand.

FIGURE 8.15

Instructions to Patient:

"I'm going to put a coin on the floor and on 'Go!' I want you to pick it up, completely stand up, and hand it to me. OK. Are you ready?"

Helpful Hint

If working with a patient with low vision, someone who may not be able to see a coin on the floor, substitute a larger-sized item such as a pencil or pen. Substituting a larger item obviates the need for a patient to spend excess time with their head down near the ground because they can't find the coin.

6 360° Turn

Testing Procedure:

The 360° turn task examines the patient's ability to turn in a complete circle in both directions (Fig. 8.16). This effort is not timed, but rather scored for the quality and safety of the effort.

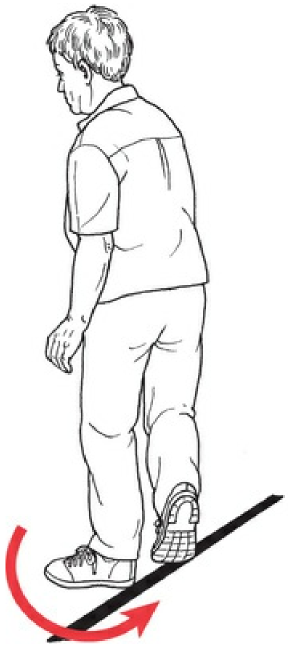

FIGURE 8.16

Demonstrate the task. The demonstration speed of turning should not be so fast that it encourages the patient to mimic it, thus compromising his or her safety. Ask the patient to turn 360° at a comfortable pace (in either direction) beginning with the toes pointed forward and ending when the toes are pointed forward again. The performance is evaluated for continuity of movement and steadiness.

Instructions to Patient:

"I want you to turn in a full circle so that your toes are back on this line. You can choose whichever direction you want to go toward first, since I will ask you to go in the other direction next. I will not be timing you." Upon completion, ask the patient to turn in the other direction, evaluating for continuity of movement and steadiness.

Helpful Hint

Both directions will be examined, so it does not matter which direction is performed first. Typically, the patient will choose his or her best direction to perform first.

7 Timed 50-Foot Walk

Testing Procedure:

This is a timed 50-foot walk task designed to examine the speed and observe the quality of the patient's gait. The patient stands at the start of a 50-foot walk test course that consists of a walkway 25 ft out and 25 ft back. No acceleration or deceleration distance is needed because of the distance. Timing begins with the command "Go!" and ends when the starting line is crossed on the way back. The time is recorded on the scoring form. An assistive device may be used, and the type of device should be documented. Typically, demonstration is not needed on this task because walking is a familiar task.

Instructions to Patient:

"I'd like you to walk out and back as quickly but as safely as you can. You will turn around at the end of the walkway and return to this spot. I will be timing you. Ready? Go!"

Helpful Hints

- Completing the 50 ft (15.24 m) distance in 15 s is equal to a 1.0 m/s pace. You can calculate the patient's gait speed by dividing the distance walked by the time.
- Gait speeds of more than 0.8 m/s are typically required for safe community ambulation.

Once the seven tasks are performed, the seven-item version of the PPT is complete. If you do not intend to have the patient perform stair climbing, add up the scores for the seven items now. If you are performing the M-PPT, the stairs are included.

8 Climbing One Flight of Stairs*

Testing Procedure:

Explain to the patient that he or she has the option of climbing up to four flights of stairs. Ask the patient if he or she feels comfortable and is willing to perform these tasks. Ask the patient to tell you of any symptom such as chest pain or shortness of breath, which should terminate the task. Vital signs should be monitored as indicated. Indications to monitor vital signs include evidence of more than ordinary effort expended in any previous task such as complaints of fatigue and the need to rest between tasks.

Ask the patient to climb one flight of stairs that has 9 to 12 steps. The timing starts with the command "Go!" and ends when the patient's first foot reaches the top of the top step. The patient may use a handrail and/or assistive device and this should be noted on the scoring form as well as the time taken to climb one flight of stairs.

Instructions to Patient:

"This task involves climbing a flight of stairs as quickly but as safely as you can (Fig. 8.17). You may use the handrail if you need to. For this task, you are only required to go up to the landing. Stair climbing may require more than usual effort, so please let me know if you experience any tightness or pain in your chest or if you are short of breath and need to stop. OK? Go!"

FIGURE 8.17

If the patient is willing, he or she may continue the stairs to achieve up to four flights. This effort is not timed.

9 Climbing Four Flights of Stairs

Testing Procedure:

The patient is asked to climb up to four flights of stairs. The scoring is based on how many flights, up and down, the patient completes. The patient descends the first flight of stairs, counted as one, and ascends the same flight up to four repetitions. This stair climbing and descent continues until the patient feels tired and wishes to stop, or until four flights, four ups and four downs total, have been completed.

Record the number of flights (maximum of four) climbed (up and down is one flight). A handrail and/or an assistive device may be used.

Instructions to Patient:

"Now, the next task is to climb, up and down, as many times as you are comfortable, up to four times. You can determine how many flights you feel comfortable doing. Are you willing to try? How many flights do you think you can do?" Ready? Go!

Helpful Hints

- Typically, a demonstration is not needed and only one trial is given.
- Prior to beginning the stair tasks, it is helpful to ask the patient how many flights he or she thinks can be completed to give some idea of the anticipated level of performance.
- Patients should be gently encouraged, but not coerced or forced, to do more than they feel they can safely and comfortably do.
- Taking vital signs pre and post stair climbing or asking the patient to identify the level of exertion via the Borg Scale of Exertion may provide additional information to help inform the therapist's clinical decision making.

The stair tasks complete the nine-item PPT. See Fig. 8.18 for the PPT scoring form. To complete the M-PPT, ask the patient to perform the next two tasks.

Physical Performance Test Scoring Sheet

				Physical Performance Test	
			Time	**Scoring**	**Score**
1	Writing task: (Write the sentence "Whales live in a blue ocean.")	Sec*		≤10 sec = 4 10.5–15 sec = 3 15.5–20 sec = 2 >20 sec = 1 unable = 0	
2	Eating task (simulated eating)	Sec		≤10 sec = 4 10.5–15 sec = 3 15.5–20 sec = 2 >20 sec = 1 unable = 0	
3	Lift a book and put it on a shelf Book: approximately 5.5 lbs Bed height: 23 in Shelf height: 46 in	Sec		≤2 sec = 4 2.5–4 sec = 3 4.5–6 sec = 2 >6 sec = 1 unable = 0	
4	Put on and remove a garment 1. Standing 2. Use of bathrobe, button-down shirt, or hospital gown	Sec		≤10 sec = 4 10.5–15 sec = 3 15.5–20 sec = 2 >20 sec = 1 unable = 0	
5	Pick up a coin from the floor	Sec		≤2 sec = 4 2.5–4 sec = 3 4.5–6 sec = 2 >6 sec = 1 unable = 0	
6	Turn 360°		Discontinuous steps = 0 Continuous steps = 2 Unsteady (grabs, staggers) = 0 Steady = 2		
7	50-foot walk test (15.24 meters) <15 sec = 3.33 feet/sec or 1.0 m/sec	Sec		≤15 sec = 4 15.5–20 sec = 3 20.5–25 sec = 2 >25 sec = 1 unable = 0	
8	Climb one flight of stairs	Sec		≤5 sec = 4 5.5–10 sec = 3 10.5–15 sec = 2 >15 sec = 1 unable = 0	
9	Climb four flights of stairs		Number of flights of stairs up and down (maximum of 4)		
	TOTAL SCORE (maxium 36 for nine-item; 28 for seven-item)				
	*For time measurements, round to nearest 0.5 seconds			Total score	

Data from: Reuben DB, Siu AL. An objective measure of physical function of elderly outpatients (the Physical Performance Test). *Journal of the American Geriatric Society* 1990; 38(10): 1105-1112.

FIGURE 8.18 Physical performance test (PPT) scoring form.

Modified Physical Performance Test

The modified physical performance test does not include the PPT tasks 1 (writing) and 2 (simulating eating). Instead, the following balance test is done first, followed by the chair stand test. Then tasks 3 to 9 from the physical performance test are performed.

1 Testing Procedures for Standing Static Balance Tasks

These balance tasks examine the patient's ability to stand in three positions: side-by-side, semi-tandem, and full tandem. The three positions should be tested in order because they increase in difficulty. The duration of the three balance positions is timed. If the patient cannot perform one position, then the next position is not performed but rather is scored as “unable.” These positions are designed to maximally challenge balance, so the therapist should be alert for balance difficulties and maintain the patient's safety at all times.

Each balance position is timed for a maximum of 10 seconds. The semi-scoring tandem and tandem positions are tested with each foot forward. No out-toeing is permitted. Foot positioning should be strictly observed. If the patient cannot attain the proper position, the score is zero for that stance task. Only one trial is allowed for each position.

Each position is demonstrated before testing. If desired, ask the patient to practice the position. The patient may be assisted to assume the positions, but when timing starts, no support is given. Once the patient appears to be steady, the therapist begins timing, relinquishing support if it was initially needed to assume the correct position. The timing is continued until the patient moves a foot, uses a hand for support, or 10 seconds have elapsed. Record any time less than 10 seconds to the nearest hundredth of a second on the test form.

a Feet Together Stance

Testing Procedure:

The first balance task is feet together stance. In this position, the patient is asked to stand for 10 seconds with the feet together in a side-by-side stance position (Fig. 8.19).

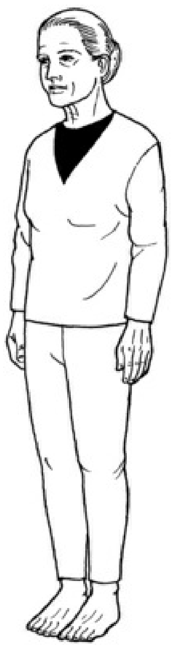

FIGURE 8.19

Instructions to Patient:

“These three balancing tasks require you to stand in three different positions for up to 10 seconds. First we'll start with the feet together stance position. You can use me to get into the position but then you have to stand by yourself. I will be timing you when you are ready.

“First, I want you to place your feet completely together, like this. Then hold the position as long as you can. Ready? Begin.”

If the patient was able to hold the position for 10 seconds, proceed to the next balance position. If the position was held less than 10 seconds, record the seconds and proceed to the chair stand test.

b Semi-tandem Stance

Testing Procedure:

The second balance task is the semi-tandem stance position. Demonstrate the position. The patient stands with the heel of one foot placed to the side of and touching the big toe of the other foot. Either foot can be placed in the forward position. The position should be timed (Fig. 8.20). (Note: This task should be performed only in patients who were able to perform the previous feet together stance task for 10 seconds.) Score the worst performance.

FIGURE 8.20

Instructions to Patient:

"Move one foot in front of the other so that the heel of the front foot is against the side of the big toe of the other foot, like this. Make sure you do not turn your foot out. You can choose whichever foot you like. Begin!"

If able to complete 10 seconds, proceed to the third balance test. If unable to hold the semi-tandem position for 10 seconds, record the time held and proceed to the chair stand test.

c Full Tandem Stance

Testing Procedure:

The third and final position is the tandem stance position. Demonstrate the position. Ask the patient to place the heel of one foot directly in front of the toes of the other foot. Either foot can be placed in the forward position (Fig. 8.21). (Note: This task should be performed only in patients who were able to perform the semi-tandem stance for 10 seconds.)

FIGURE 8.21

Instructions to Patient:

"Place the heel of one foot directly in front of the toes of the other foot, like this." "Either foot can be placed in the forward position. Are you ready? Begin."

Helpful Hint

- Allowing the patient to choose which foot to place forward in the semi-tandem or full tandem stance may indicate which foot the patient feels is stronger. Only one foot forward position is tested.
- The original instructions, stated here, were for research purposes. In the clinical situation, patients may not be able to assume the ideal position because of severe valgus, for example. Therefore, some latitude may be required.

2 Chair Stand (Five-Repetition)

Testing Procedure:

The chair stand task is a test of leg strength and mobility. The patient is asked to stand from the chair with the arms folded across the chest while the therapist observes. If the patient is able to rise from the chair once, the patient is then asked to stand up and sit down five times as quickly as possible. Timing begins as soon as the command to stand is given and continues until the patient is fully upright at the end of the fifth stand.

Position of Patient:

Seated, with arms crossed over the chest. Feet are planted on the floor in a comfortable position (Fig. 8.22).

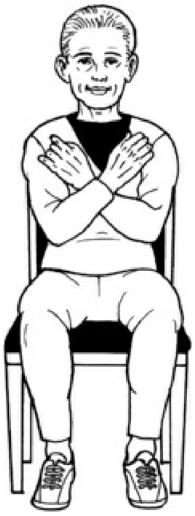

FIGURE 8.22

Instructions to Patient:

"Fold your arms across your chest and sit so that your feet are on the floor. Then, stand up, keeping your arms folded across your chest." (After it is observed that the patient can safely stand independently without the use of the arms, proceed to the timed five-repetition part of the chair stand task.) "Now stand up straight, as quickly as you can, five times, without stopping in between. Keep your arms folded across your chest. I'll be timing you with a stopwatch."

Helpful Hints

- Place the chair against a wall, to avoid any movement.
- Observe the quality of the movement such as the position of the hips, reflected in valgus.
- Refer to the chair stand test on page 334.

Scoring

Each task's performance is recorded on the PPT scoring form (see Fig. 8.18) or M-PPT scoring form (Fig. 8.23) using a scale of 0 to 4. Total possible scores for the seven-item version of the PPT is 28, whereas the nine-item version PPT is 36. The M-PPT total possible score is 36. Reuben and Siu established percentile norms for the PPT based on the performance of a 79-year-old male who is independent in all ADLs.[27]

Modified Physical Performance Test

1.	Standing Static Balance	Feet Together: ____sec	Semi-tandem: ____sec	Tandem: ____sec	Score
		❑ 10 sec	❑ 10 sec	❑ 10 sec	❑ 4
		❑ 10 sec	❑ 10 sec	❑ 3–9.9 sec	❑ 3
		❑ 10 sec	❑ 10 sec	❑ 0–2.9 sec	❑ 2
		❑ 10 sec	❑ 0–9 sec	Unable	❑ 1
		❑ 0–9 sec	Unable	Unable	❑ 0
			Time	**Scoring values**	Score
2.	Chair stand (5 × without arms)			≤11 sec = 4 11.1–14 sec = 3 14.1–17 sec = 2 >17 sec = 1 unable = 0	
3.	Lift a book and put it on a shelf			≤2 sec = 4 2.1–4 sec = 3 4.1–6 sec = 2 >6 sec = 1 unable = 0	
4.	Put on and remove a garment			≤10 sec = 4 10.1–15 sec = 3 15.1–20 sec = 2 >20 sec = 1 unable = 0	
5.	Pick up a coin from the floor			≤2 sec = 4 2.1–4 sec = 3 4.1–6 sec = 2 >6 sec = 1 unable = 0	
6.	Turn 360°		Discontinuous steps = 0 Continuous steps = 2		
			Unsteady (grabs, staggers) = 0 Steady = 2		
7.	50-foot walk			≤15 sec = 4 15.1–20 sec = 3 20.1–25 sec = 2 >25 sec = 1 unable = 0	
8.	Climb one flight of stairs			≤5 sec = 4 5.1–10 sec = 3 10.1–15 sec = 2 >15 sec = 1 unable = 0	
9.	Climb four flights of stairs		Number of flights of stairs up and down (maximum 4)		
TOTAL SCORE				9-item score	/36

FIGURE 8.23 Scoring form for modified physical performance test (M-PPT).

25th percentile … 21 (9-item), 15 (7-item)
75th percentile … 29 (9-item), 22 (7-item)
90th percentile … 31 (9-item), 24 (7-item)

See Table 8.10 for mean scores for men and women aged 60 to 101 for the PPT.[33] Reuben determined that the following scores indicated a degree of frailty.[27]

Table 8.10

7-ITEM PHYSICAL PERFORMANCE TEST SCORES*

Age	Male	Female
60–69	26	26.4 (0.9)
70–79	24.6 (1.7)	25.1 (0.9)
80–89	20.4 (4.8)	19.5 (3.8)
90–101	16.5 (6.4)	16.2 (6.0)

*Subjects were able to use an assistive device.

Data from Lusardi MM, Pellecchia GL, Schulman M. Functional performance in community living older adults. *J Geriatr Phys Ther*. 2003;26:14–22

32 to 36 = not frail
25 to 32 = mild frailty
17 to 24 = moderate frailty
<17 = unlikely to be able to function in the community.

The minimal important difference in older adults is 2.4 points.[26]

Helpful Hint

- Timing a patient during task performance should be done with the utmost awareness of the influence of timing. Many patients may move faster than is safe, because of a competitive nature. In some cases, it may not be best practice to tell the patient the task is timed, especially in cases where balance is significantly impaired.
- It is recommended to use the lowest score because of the need to accurately record the patient's performance in the clinical setting. Although performance may improve with repeated trials, the most genuine real-life performance may be the lowest timed or poorest performance.

Timed Up and Go

Purpose:

The timed up and go test (TUG) is a test of general mobility that involves standing from a standard-height chair, walking, turning, and sitting down.[34] The test can be performed with an assistive device.[35] Typically, the use of an assistive device indicates slower performance.

The TUG takes only seconds to perform and can be used in all health-care settings because of the minimal equipment and space required. The test can be used to identify impairments related to mobility.

Essential Muscle Movements for Task Performance:

Hip extension, hip abduction from a flexed position, hip external rotation, knee extension, ankle plantar flexion, ankle dorsiflexion and inversion,[3] and trunk extension and flexion. Hip flexion also contributes to walking velocity.[16] The reader is referred to the gait section of this chapter for a more specific list of muscles that are imperative for smooth and normal gait.

Reliability:

ICC = 0.99; test-retest reliability, ICC = 0.99.[36] In individuals with Alzheimer disease, ICC = 0.97.[37]

Validity:

Construct validity is for independence in mobility (the time taken is strongly correlated to the level of functional mobility). Similar to gait speed, it can predict global health and new ADL difficulty. Those who required more than 20 seconds to perform the TUG had a 50% chance of having difficulty performing household chores.[38] It has limited ability to predict falls in community-dwelling older adults and should not be used in isolation to identify individuals at risk for falls.[39]

Equipment:

Standard 17-in.-high chair with arms, stopwatch, and 3 m measured on the floor.

Testing Procedure:

A chair with arms is placed against a wall to prevent the chair from moving. Measure a distance of 3 m from the front legs of the chair. A line or other object should indicate the 3-m mark (Fig. 8.24). Demonstrate the task for the patient, using an assistive device if the patient will be using one. Ask the patient to walk at a usual and comfortable speed 3 m to a specified mark on the floor, turn around and walk back to the chair, sitting all the way back in the chair. Timing starts on "Go!" rather than when the patient starts to rise. Be clear so that the patient knows you are about to start the test. Stop timing when the patient is fully seated with his or her back against the chair. A practice trial is given before the two test trials are performed.

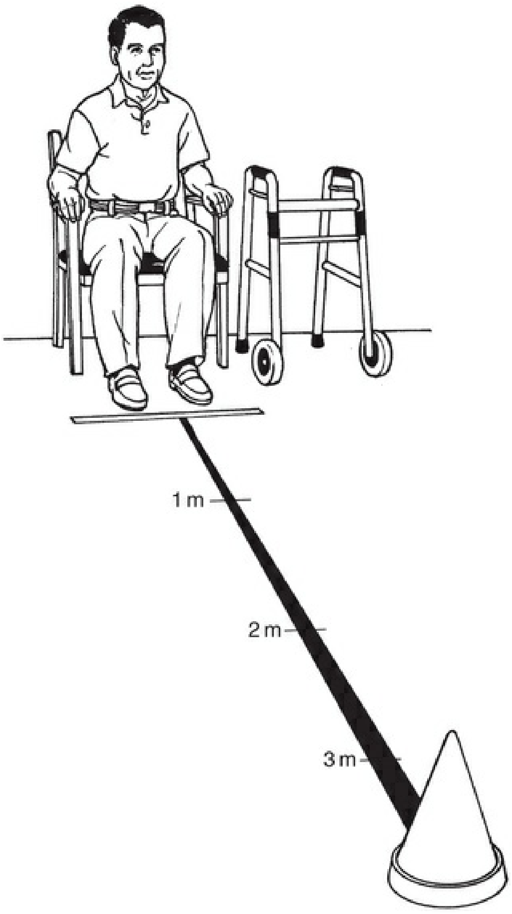

FIGURE 8.24

Position of Patient:

Seated in a chair with arms, feet on the floor, and back against the back of the chair.

Position of Therapist:

Stand to the side of the patient. The therapist may choose to walk with the patient if safety is a concern (Fig. 8.25).

FIGURE 8.25

Instructions to Patient:

"On 'Go!' I want you to stand up and walk as quickly but as safely as you can to the mark on the floor, turn, and return to the chair, sitting down with your back against the back of the chair. I'll be timing you, OK? Go!"

Scoring

The fastest trial time taken to perform the TUG is the score.
10 seconds or faster indicates the patient is freely mobile.
30 seconds or slower indicates the patient is dependent in mobility.[40]
A score greater than 9 seconds is predictive of developing disability within 2 years.[41]

Norms

A total of 92% of community-dwelling older adults had TUG times of less than 12 seconds, whereas only 9% of institutionalized patients performed the TUG in that time. Community-dwelling women between 65 and 85 years of age should be able to perform the TUG in 12 seconds or less.[42]

TUG times are worse than average if they exceed 9.0 seconds for 60- to 69-year-olds, 10.2 seconds for 70- to 79-year-olds, and 12.7 seconds for 80- to 89-year-olds.[43] Table 8.11 lists normative values for the TUG test.

Table 8.11

NORMATIVE REFERENCE VALUES FOR THE TIMED UP AND GO TEST

Age Group (Years)	Time in Seconds (95% Confidence Interval)
60–69	8.1 (7.1–9.0)
70–79	9.2 (8.2–10.2)
80–89	11.3 (10.0–12.7)

Data from Bohannon RW. Reference values for the timed up and go test: a descriptive meta-analysis. *J Geriatr Phys Ther*. 2006;29(2):64–68.

Helpful Hints

- Make sure the patient can hear you and waits for your "Go!"
- If using an object to mark the farthest point of the 3-m distance, make sure it is moved forward of the 3-m mark to avoid lengthening the course as the patient walks around the object (see Fig. 8.25).
- Always retest using the same assistive device as used in the original test.
- Avoid overcoaching. Valuable information that will inform clinical decision making can be obtained from observing how the patient chooses to perform the test.
- Using the general procedure for the TUG, a timed performance can be obtained from any surface, such as a couch or car seat, to assist in clinical decision making and objective documentation.
- Scoring may be either the fastest, the slowest, or an average of the trials. Each repeat test should reflect the same choice.

Stair Climb

Purpose:

The stair climb test assesses the ability to climb a flight of stairs. Qualitative and quantitative assessment can be made to determine the amount of assistance a patient needs, identify impairments that may contribute to stair climbing, and indicate how quickly and/or safely the patient can accomplish the task. The stair climb test is also used as a functional test of power.[44,45]

Essential Muscle Movements for Task Performance:

Ascent: hip extension, knee flexion and extension, ankle plantar flexion, ankle dorsiflexion, spine extension, and core stability. Descent: eccentric knee extension, hip flexion, and core muscles. For a test that requires stability and balance, however, any lower extremity muscle or group will be used at some point during the task.

Reliability:

ICC = 0.99[46]

Validity:

Moderate validity as a functional measure with correlations to other functional measures such as TUG, gait speed, and sit-to-stand movement.[47] Also correlates with balance tests and lower extremity strength and power.

Equipment:

Any flight of stairs with a railing can be used. The pediatric version (timed up and down stairs [TUDS]) requires 11 stairs to compare the score with normative data.

Testing Procedure:

Timing starts when the patient's first foot is lifted from the floor and is stopped when both feet are on the top stair. Because descent is typically more difficult, the therapist should time ascent and descent separately. The therapist should document the use of handrails, assistive devices, gait belts, and the number of stairs.

Position of Therapist:

Safety of the patient should be the therapist's primary concern. Therefore the therapist may need to closely guard the patient, ascending and descending the stairs with the patient (Fig. 8.26). If the therapist is confident of the safety of the patient, the therapist can choose to remain at the bottom of the flight of stairs during the test.

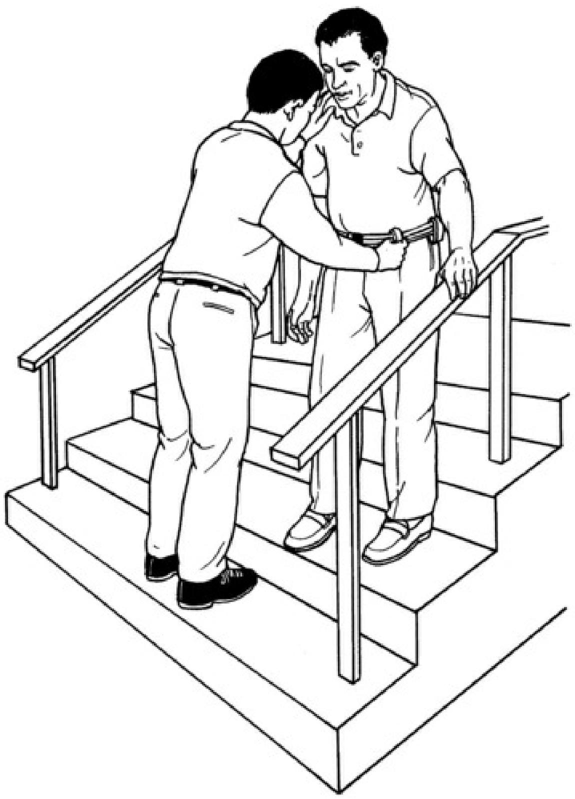

FIGURE 8.26

Instructions to Patient:

"I want to see how safely and how quickly you can climb this flight of stairs. Do you feel safe to climb these stairs? You may hold onto the railing if you want to. Please stop at the top of the stairs before coming down so I can time how long it takes you to descend. Ready? Go!"

Scoring

Scoring the time it takes the patient to ascend and descend stairs must include the number of stairs. Time is calculated by dividing the number of stairs in the flight by the time taken to go up and down.

In nondisabled adult individuals, 0.5 second per stair (up and down) is typical (Table 8.12).[47] Stair ascent and descent (combined) decreases with age from 2.5 stairs per second in 20- to 39-year-olds to 1.2 stairs per second in 90+ year olds.[48] In children ages 8 to 14, 8.1 seconds for 14 steps (0.58 second per step) was determined to be normal for combined ascent and descent (Table 8.13).[49]

Table 8.12

GROUP DATA FOR STAIR CLIMB TIME FROM SYSTEMATIC REVIEW

Age	Ascent	Descent
18–49	0.48 ± 0.14	0.50 ± 0.14
50–65	0.46 ± 0.17	0.54 ± 0.29
>65	0.65 ± 0.41	1.4 ± 0.55
>65 with decreased mobility	0.95 ± 0.44	1.11 ± 0.47
Neurological	1.01 ± 0.57	0.9 ± 0.47
Medical	0.6 ± 0.15	0.81 ± 0.15
Musculoskeletal	0.82 ± 0.33	0.96 ± 0.41

Data from Nightengale EJ, Pourkazemi F, Hiller CE. Systemic review of timed stair tests. *J Rehabil Res Dev*. 2014;51(3):335–350.

Table 8.13

TIME OF COMBINED ASCENT AND DESCENT ON FLIGHT OF 11 STAIRS (SEC/STAIR)

	3–9 Years	10–19 Years	20–59 Years	60+ Years

	M	F	M	F	M	F	M	F
95th percentile	2.32	2.31	0.73	0.84	0.78	0.97	1.5	2.0

F, Female; *M*, male.

Data from McKay MJ, Baldwin JN, Ferreira P, Simic M, Vanicek N, Burns J. 1000 Norms Project Consortium. Normative reference values for strength and flexibility of 1,000 children and adults. *Neurology*. 2017;88(1):36–43.

Helpful Hints

- Carefully observe the patient's use of the handrail. The patient may use the handrail for balance or may use the handrail for weight bearing to off-load a painful joint or compensate for weakness. Watch for the patient pulling on the handrail. This observation can inform clinical decision making.
- Note the position of the feet during stair descent, which may indicate compensation for muscle weakness or pain.
- Stair climbing without a handrail typically increases ground reaction forces by seven times the body weight.[50,51]
- If a patient with eyeglasses has difficulty descending stairs, don't encourage him or her to move faster. Glasses sometimes cause the patient to see a step where it isn't and increased speed may result in a fall.
- It typically takes longer to ascend than descend stairs, in the healthy population. Stair ascent and descent time increase with age, with stair descent time increasing to a greater extent.[47]
- Single-leg squats can identify independent stair negotiation ability in older adults.[52]
- Standardization recommendations include a flight of at least 10 stairs timing ascent and descent times separately, and asking the patient to perform as quickly as possible with the handrail to be used for balance only.[47]

Floor Rise

Purpose:

Floor rise ability is necessary for a patient's safety and confidence. Anyone who falls should be able to rescue themselves from the floor (unless they have become seriously injured). The floor rise test assesses the patient's ability to rise from the floor, thereby identifying impairments, functional ability, and informing clinical decision making.

Essential Muscle Movements for Task Performance:

Knee extension, ankle plantar flexion, hip extension, core stability, and trunk rotation. If arms are needed to assist, scapular adduction and downward rotation, scapular depression and adduction, elbow extension, and shoulder horizontal adduction.

Reliability:

Excellent reliability

Validity:

An inability to rise from the floor is associated with older age, increased mortality, and lower functional abilities and risk for serious injury.[53]

Equipment:

Stopwatch, chair with arms, and an unobstructed floor surface that allows the patient to lie flat.

Testing Procedure:

The therapist should demonstrate the lowering of the body to the floor, lying supine, and rising again. During the test, the patient should lie supine so that 75% of the body is in contact with the floor. The patient may choose to place the head and trunk flat on the floor, bending the knees or lying flat with only the head and shoulders raised (Fig. 8.27). Either position is acceptable. A chair should be nearby to be used by the patient if needed. Timing begins on "Go!" and ends when the patient is fully standing again and steady. Document the type of assistance needed to rise, as appropriate.

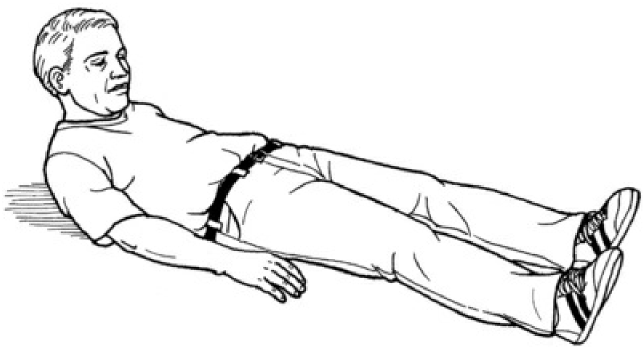

FIGURE 8.27

Instructions to Patient:

"I want you to get onto the floor, without assistance if possible, lying flat so that most of your body is flat on the floor, then get up again. You may get up in any way you choose and if you need to, you may use this chair. I can help you if you can't get up by yourself. I will demonstrate. I will be timing you and will stop timing when you are fully standing and steady. Are you ready? Good. Go!"

Scoring

The score is the time it takes to complete the floor transfer. There are no norms for this test, but in the author's experience, more than 10 seconds often involves the need for assistance with the transfer. The therapist may score only the time it takes to rise from the floor, rather than the combined floor descent and rise.

Helpful Hints

- When an individual has difficulty getting up from the floor, it often involves an inability to shift weight at the hips and roll onto the side as in side-sitting to the knees.
- The therapist should note the “cause” of any difficulty in rising—such as pain, weakness, or an inability to motor plan. These causes may form the basis of a treatment plan.
- Because there are several ways to rise from the floor, the method used by the patient should be noted in the documentation. The position requiring the most strength is rising without assistance (Fig. 8.28); using one knee to rise requires less strength (Fig. 8.29); and using assistance such as a chair requires the least amount of strength (Fig. 8.30).

FIGURE 8.28

FIGURE 8.29

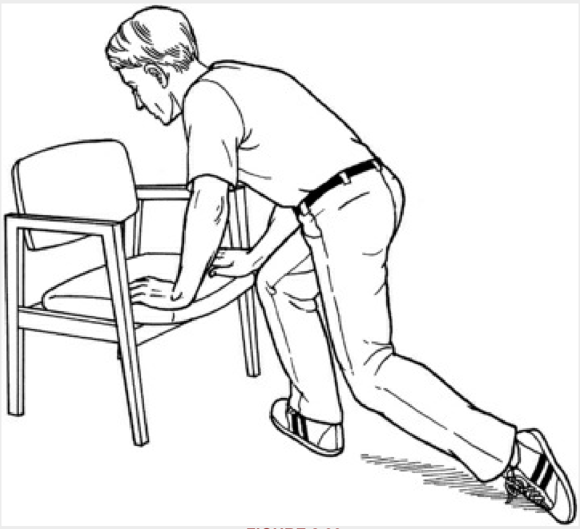

FIGURE 8.30

Gait

Human gait is a remarkable feat. Each step is a complex integration of muscular and neural events, all of which have to occur in proper sequence and magnitude to prevent loss of balance and maintain a smooth and integrated forward progression with the least expenditure of energy.[54,55] Loss of muscle strength has a devastating effect on gait, particularly velocity, safety, and energy cost.[56,57] An entire issue of the journal *Physical Therapy* was devoted to this and related topics in 2010.[58]

This chapter segment is focused only on five events in the gait cycle that occur smoothly and successfully if the muscles involved are sufficiently strong. Weakness in the gluteus medius, tibialis anterior, quadriceps, gluteus maximus, or gastroc-soleus will significantly blunt gait velocity and interrupt the integration of gait events and the limb segments involved.

Because locomotion is so important to humans, rehabilitation is often focused on its restoration. The key to successful rehabilitation, however, is the identification of the muscles or muscle groups that are weak. What follows are some common deviations in the gait cycle that are directly linked to specific muscle weakness. These deviations are easily observed, and once observed, the therapist can perform specific muscle testing for confirmation.

Gluteus Medius Weakness

During the loading phase of the gait cycle, as the stance limb is accepting the entire weight of the body (single limb support), the gluteus medius contracts vigorously to keep the pelvis from dropping to the opposite side. When electromyographic output during gait is measured and compared to the electromyographic output generated during a maximal isometric contraction, the demand on the gluteus medius appears to be approximately 25% of its maximum force capacity. Thus, in general, strength must be at least Grade 3 to prevent the pelvis from dropping.[59] If pelvic drop is observed, strength must be restored because gait velocity slows and the energy required to walk increases in the presence of gluteus medius weakness.[56]

Inman calculated the demand on the gluteus medius during single limb stance (most of the gait cycle) as 2.5 times the weight of the head, arms, and trunk.[60] Thus, for a 150-lb individual, the gluteus medius must generate approximately 100 lb of torque with each step. If the therapist is strength testing with a handheld dynamometer, a minimum of 100 lb should be the expected value in a 150-lb person.

Tibialis Anterior Weakness

Immediately following heel strike, the tibialis anterior (TA) decelerates the foot to the floor.[56,59] This eccentric contraction is a rapid event that places high demand on the muscle, estimated at between 45% and 75% of its maximum strength.[59,61] A demand this high requires a manual muscle grade of at least 4. Weakness of the TA immediately eliminates the foot-lowering portion of the normal gait cycle. With moderate weakness (approximately Grade 3) the therapist will observe a foot flat gait.[59] Stride length is shortened to permit the foot flat landing. A shorter stride results in slower gait velocity. Thus, if the therapist observes a patient who fails to execute heel strike and approaches each step with a foot flat approach, muscle test the TA to confirm its strength loss. If there is severe weakness, the therapist will observe (and hear) a foot slap gait.

Quadriceps Weakness

Another key event in the stance phase of gait is shock absorption at the knee shortly after heel strike.[59] During this instant in the gait cycle, the knee (in a normal person) rapidly goes from full extension to 15° of flexion and the quadriceps absorb a high amount of force, estimated to be 75% of maximum.[59] With shock absorption, the quadriceps permit a smooth transition to mid-stance. If the quadriceps are weak the entire shock absorption process disappears, which is another observable event. Instead of a brisk knee flexion following heel strike, the patient with weak quadriceps will shorten the stride and approach the entire first half of the stance phase with a nearly extended knee. No shock absorption takes place. Strength estimates vary, but the quadriceps must be at least a Grade 3 to absorb the shock of knee flexion immediately after heel strike.[59] If the therapist observes a failure of knee flexion during the initial phase of stance, quadriceps strength should be evaluated.

Gluteus Maximus Weakness

The highest strength demand on the gluteus maximus occurs during loading response and is complete by the mid-stance phase of gait.[62] Once total body weight is transferred onto the stance leg, the gluteus maximus must assume responsibility for the upright trunk (muscle acting on its origin). If muscle weakness is present, the patient will exhibit a forward trunk lean. Forward trunk lean may occur during the entire stance phase or occur suddenly, a “pitching forward,” suggesting a sudden failure of the muscles to hold the trunk upright. Gluteus maximus strength should be sufficient to hold the weight of the head, arms, and trunk, or about 60% of body mass.[59] If suspected gluteus maximus weakness exists, as evidenced by a forward trunk lean during stance, with subsequent slowing of gait, further muscle testing is indicated for confirmation.

Gastrocnemius-Soleus Weakness

When the gastrocnemius and soleus act on their insertion, they produce plantar flexion and stabilize the ankle during roll-off.[61,63,64] The soleus is one of the most important muscles of the leg because it works not just to control the foot and ankle complex but has a critical role in stabilizing the knee.[65] Equally important is the role of the soleus to prevent forward translation of the tibia toward the end of the stance phase. If the soleus is functioning adequately, the ankle is stable and heel rise occurs.[59] The demand on the gastrocnemius and soleus is extremely high, measured at 75% of maximum for the gastrocnemius and at more than 80% for the soleus. When gastrocnemius-soleus muscle strength is at least Grade 4, the ankle will lock and heel rise will occur, which is another key event in the gait cycle that markedly influences velocity.[66] If heel rise is noticeably diminished or nonexistent, further muscle testing is indicated.

Each of the five gait events described has been identified as one of the “critical determinants of gait.”[65-67] Without these five critical determinants, gait velocity is markedly diminished, and as noted, if gait speed slows enough, community ambulation is no longer feasible and/or independence may be lost. Indeed, loss of gait function is a major reason for nursing home placement in a person's later years.[68]

Hicks and colleagues reported that the collective strength of 24% of normal is required to walk.[69] If strength is below 24% of normal, profound changes in gait speed have already occurred, and a person with this much weakness is on the threshold of frailty, loss of independence, and in need of an assistive device.[70] Physical therapists can recognize subtle but highly observable gait deviations long before strength losses become catastrophic. Muscle testing techniques as presented in this book permit identification of strength losses in the early phase of loss, when rehabilitation is more feasible and successful.

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[*] The stair climbing tasks (climbing one flight of stairs and climbing four flights of stairs) may be performed together, but they are scored separately. Generally, only one trial is given.