CHAPTER

18

Balance and Falls

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INTRODUCTION

Falls are common throughout the life span, but the consequences of a fall event vary depending on the person's age. Young children fall frequently but rarely suffer consequences of a fall other than bumps and bruises. The incidence of falling increases with age. One study reported that approximately 18% of individuals younger than age 45 years fall each year compared to 25% of those between ages 45 and 65 years, and 35% of those older than age 65 years.[1] As people increase in age beyond 65 years, falling increases in frequency and can result in catastrophic loss of function.[2] Another study indicated that 30% of adults older than age 65 years and 40% older than age 75 years fall each year.[3,4]

We define a fall as "an unintentional loss of balance that leads to failure of postural stability"[5] or "a sudden and unexpected change in position which usually results in landing on the floor."[6] Recurrent fallers are those who have fallen two or more times in either 6 or 12 months.[7,8] The fall does not need to be accompanied by an injury to be categorized as a fall, that is, a fall without injury is still a fall. A challenge in examining studies focused on falls is the wide variety of operational definitions used to categorize someone as having "fallen" or, more commonly, the lack of any operational definition of a fall. Hauer et al,[9] in a recent systematic review of falls, reported that falls were not defined in 44 of 90 studies reviewed.

There are a variety of ways of classifying, and thus approaching the discussion of, fall incidents. Falls can be classified as accidental versus nonaccidental, syncopal versus nonsyncopal, intrinsically versus extrinsically driven, falls with injury versus falls without injury, and a single fall incident versus recurrent falling.

HOW SERIOUS IS THE PROBLEM OF FALLING

Falls represent the most common mechanism of injury,[10] and the leading cause of death from injury, in people older than age 65 years.[1] Approximately 30% of community-living older adults in developed countries fall per year, with 10% to 20% falling more than once.[11] The Centers for Disease Control and Prevention reported that in 2004, nearly 15,800 people aged 65 years and older died from injuries related to unintentional falls, and another 1.8 million were treated in emergency departments for nonfatal injuries from falls.[12] Of those who fall, 10% have a serious injury (fracture, dislocation, or head injury).[11,13,14] In 2000, medical treatment for falls among people older than age 65 years cost the United States more than $19 billion, and the number is projected to increase to $43.8 billion by 2020. Shumway-Cook et al[15] recently reported increased costs to Medicare for individuals who fell in the previous year, with a greater cost increase associated with more reported falls.

In addition to the medical costs, there are also enormous societal and personal costs. Falls are associated with pain, loss of confidence, functional decline, and institutionalization.[13,14,16] Falls pose a health hazard and can seriously threaten the functional activities, participation, and well-being of older adults. The United States Congress has recently even enacted H.R. 3710, Safety of Seniors Act (2008), that focuses research efforts on methods to prevent falls in older adults.[17]

FALL RISK FACTORS

Identifying specific risk factors for falls in older adults and using these risk factors to predict who will fall is a very complex undertaking. Although the underlying "causes" of falls are typically divided into extrinsic (environmental) and intrinsic (postural control mechanisms),[18] falls often represent a complex interaction of environmental challenges (tripping, slipping, etc.) and compromises across multiple components of the postural control system (somatosensory inputs, central processing, musculoskeletal effectors) in responding to a postural challenge.[19-21] Intrinsic factors that place one at risk of falling could stem from an accumulation of multiple age-related changes in postural control structures, particularly in those older than age 80 or 85 years, or, more commonly, a combination of health/medical conditions that compromise the postural control system superimposed on age-related changes.

Identifying those at risk for falling, and the particular factors placing them at risk, can guide an intervention program to ameliorate or accommodate risk. In order to provide a more precise assessment of fall risk, most studies choose a relatively narrow category of older adult, chosen either by their current health status (community-dwelling, nursing home, acutely ill, frail, active, etc.) or because they have a specific disease (diabetes, stroke, hip fracture, etc.) likely to affect one or more specific components of the postural control system. Specific risk factors can vary widely across these groups. Similar themes do emerge, however. These include common age-related changes that when combined with health-related conditions across several body systems, serve as intrinsic factors contributing to falls. Figure 18-1 provides a summary of the many intrinsic factors that are commonly associated with falls in older adults.

The American Academy of Neurology (2008) fall guidelines suggested that people with the diagnoses of stroke, dementia, walking, and balance problems or a history of recent falls, plus people who use walking aids such as a cane or a walker, are at the highest risk of falling.[22] This group also identifies Parkinson's disease, peripheral neuropathy, lower extremity weakness or sensory loss, and substantial loss of vision as probable predictors of fall risk.[22]

Polypharmacy, and issues of drug interactions and drug adverse effects, can add substantially to impaired balance and risk of falls. Antidepressants, antianxiety drugs, sedatives, tranquilizers, diuretics, and sleep medications are all related to increasing the risk of falling in older adults.[23] Chapter 4 provides a detailed discussion of this issue. Environmental hazards such as a slippery walking surface, loose rug, poor lighting, and obstacles in the walking path can each increase risk of falling, particularly in individuals with already compromised balance. Chapter 7 provides an in-depth discussion of this topic.

Overall, the take-home message is that, as the number of risk factors increase, there is an associated increase in the chance of falling. Decreasing the number of risk factors can decrease the person's risk of falling, particularly for individuals at high risk. Yokoya et al[24] reported that, after participating in a weekly exercise class, the number of falls decreased in high-risk persons living in the community. There were no differences noted in the low- to moderate-risk groups.

BALANCE AND POSTURAL CONTROL

Postural control is achieved by continually positioning the body's center of gravity (COG) over the base of support (BOS) during both static and dynamic situations.[25] Physiologically, postural control depends on the integration and coordination of three body systems: sensory, central nervous (CNS), and neuromuscular. The sensory system gathers essential information about the position and orientation of body segments in space; the CNS integrates, coordinates, and interprets the sensory inputs and then directs the execution of movements; and the neuromuscular system responds to the orders provided by the CNS. All postural control components undergo changes with aging. Deficits within any single component are not typically sufficient to cause postural instability, because compensatory mechanisms from other components prevent that from happening. However, accumulation of deficits across multiple components may lead to instability and eventually falls.

Sensory System

Sensory information plays a significant role in updating the CNS about the body's position and motion in space. Sensory inputs are gathered through the somatosensory, visual, and vestibular systems. Advancing age is accompanied by diverse structural and functional changes in most of the sensory components of postural control.

Somatosensory Input. Somatosensory information, gathered from receptors located in joints, muscles, and tendons, provide the CNS with crucial information regarding body segment position and movement in space relative to each other, as well as the amount of force generated for the movement. There are age-related declines in two-point discrimination, muscle spindle activity, proprioception, and cutaneous receptors in the lower extremities, plus changes in vibration sense. Vibration sense is decreased or diminished in 10% of people older than age 60 years and 50% of people older than age 75 years.[26] Kristinsdottir et al[27] compared postural control of younger adults (mean age of 37.5 years) and older adults (mean age of 74.6 years), some with intact and others with impaired vibration perception in their lower extremities. Vibration perception in lower extremities was found to be the main determinant for postural control in these older individuals. Older adults with intact vibration perception were found very similar to that of the younger adults, whereas older individuals with impaired vibration perception had increased high-frequency sway. Proprioceptive and cutaneous inputs have been identified as the primary sensory information used to maintain balance.[28-30] Judge et al[31] compared the contribution of proprioception and vision on balance in older adults by using the Equitest sensory organization test (SOT) (discussed in the examination and evaluation section of this chapter) of the computerized dynamic posturography (CDP). Reduction in vision with reduced proprioceptive inputs increased the odds ratio of a fall during testing by 5.7-fold.[31] Therefore, somatosensory sensation including vibration, proprioception, and cutaneous inputs are important to consider in the evaluation and intervention processes in older adults who have postural instability.

INTRINSIC FALL RISK FACTORS

	AGE-RELATED CHANGES	HEALTH CONDITION RELATED*
Somatosensory	• Decreased light touch • Decreased proprioception • Decreased two-point discrimination • Decreased vibration sense • Decreased muscle spindle activity	• Diabetic/Idiopathic neuropathy • Spinal stenosis • Stroke • Mutiple sclerosis
Visual	• Decreased visual acuity • Decreased contrast sensitivity • Decreased depth perception	• Cataracts • Macular degeneration • Glaucoma • Diabetic retinopathy • Stroke • Use of progressive, bifocal, or trifocal corrective lenses
Vestibular	• Decreased vestibular hair cells • Decreased vestibular nerve fibers • Changes in VOR**	• Benign paroxysmal positional vertigo • Unilateral vestibular hypofunction • Meniere disease • Bilateral vestibular hypofunction
CNS	• Decreased coordination	• Parkinson's disease • Stroke • Cerebellar atrophy
Neuromuscular	• Slowing of muscle timing/sequencing • Decreased ROM/flexibility • Decreased muscle endurance • Decreased lower extremity muscle strength, torque, and power • Delayed distal muscle latency • Increased cocontraction • Impaired postural alignment (such as kyphosis)	• Impaired postural alignment • Osteoporosis with vertebral fracture and kyphosis • Diabetes with distal motor neuropathy • Lower limb joint diseases (such as arthritis) • Spinal stenosis
Cardiovascular		• Conditions association with syncope or lightheadedness (arrhythmia, orthostatic hypotension, etc.)
Psychosocial	• Fear of falling • Cognitive impairment	• Depression
Other		• Incontinence • Alcohol abuse

*Selected health conditions commonly associated with fall risk in older adults and responses to medications used to manage the condition
**Vestibular ocular reflex

FIGURE 18-1 Commonly identified factors associated with increased fall risk, organized by postural-control–related body systems.

Visual Input. Visual input provides the CNS with upright postural control information important in maintaining the body in a vertical position with the surrounding environment.[32] Visual acuity, contrast sensitivity, depth perception, and peripheral vision are all essential visual components that provide the CNS with the required information about objects in the surrounding environment. Visual acuity, contrast sensitivity, and depth perception diminish with advanced age.[33] Impairments of visual acuity and contrast sensitivity have been associated with a higher number of falls in older adults.[30] Therefore, examining visual capabilities and the use of the appropriate glasses can be very helpful for older adults who use their vision as a compensatory mechanism to control their balance when their other sensory modalities decline.

Vestibular. The vestibular system provides the CNS with information about angular acceleration of the head via the semicircular canals and linear acceleration via the otoliths. This information is considered key sensory data for postural control. The vestibular system regulates the head and neck position and movement through two outputs: the vestibular ocular reflex (VOR) and vestibular spinal reflex (VSR). The VOR is important for stabilizing visual images on the retina during head movements. The VSR allows for reflex control of the neck and lower extremity postural muscles so that the position of the head and trunk can be maintained accurately and correlated with eye movements. Information from sensory receptors in the vestibular apparatus interacts with visual and somatosensory information to produce proper body alignment and postural control.

Anatomic and physiological changes occur in the vestibular system of older adults. Anatomically, progressive loss of peripheral hair cells[34] and vestibular nerve fibers[35] have been reported in people older than 55 years of age. Physiologically, changes in the VOR and the VSR were attributed to the anatomic changes in the vestibular system. However, these changes do not cause vestibular disorders unless another insult happens to older individuals. For people with unilateral vestibular hypofunction, Norré et al[36] found that their central adaptive mechanisms become less effective with advancing age. Thus, the VSR becomes "dysregulated" and, as a result, postural sway disturbances and imbalance take place with any balance perturbation.[36] Older adults produce significantly more sway in SOT (2 to 6) conditions than younger adults, which contributes to loss of balance.[37-39]

Central Processing

Central processing is an important physiological component of the postural control system. The CNS receives sensory inputs, interprets and integrates these inputs, then coordinates and executes the orders for the neuromuscular system to provide corrective motor output. Multiple centers within the CNS are involved in the postural control processes including the cortex, thalamus, basal ganglia, vestibular nucleus, and cerebellum.

In real-life circumstances, postural responses are elicited in both feedback and feed-forward situations. However, researchers have primarily examined the automatic postural responses in feedback paradigms. Four main conditions have been studied to examine postural control: standing without any perturbations, standing with sudden perturbation using movable platforms, postural control during execution of voluntary movement, and sudden perturbation during voluntary movement execution.[40]

Movable platforms have been used to create perturbations in forward, backward, and rotational directions. Muscle responses then have been recorded using electromyography to determine muscle sequencing and timing. The latency and the sequence of muscle responses have been identified to define strategies of postural control in such perturbations.[41]

Response Strategies to Postural Perturbations. Five basic strategies, depicted in Figure 18-2, have been identified as responses to unexpected postural perturbations. The strategy elicited depends upon the amount of force created and the size of the BOS during the perturbation:

- An *ankle strategy* is the activation of muscles around the ankle joint after a small disturbance of BOS when standing on a "normal" support surface. The latency

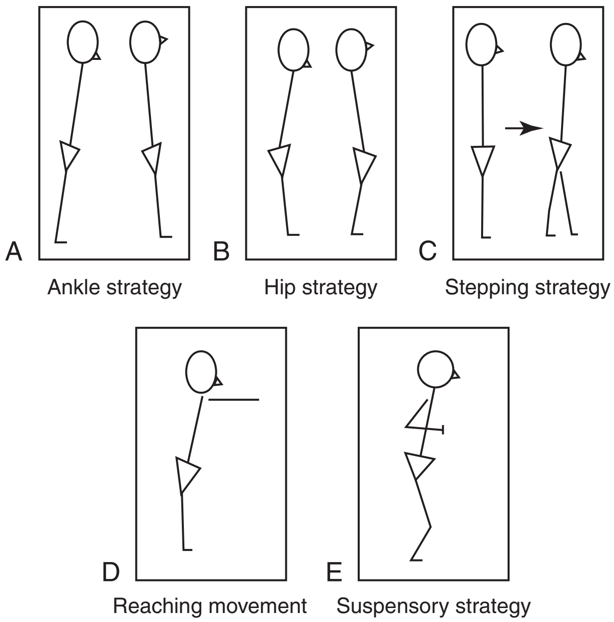

FIGURE 18-2 Five basic postural strategies used in response to postural perturbations. **A,** Ankle strategy: Activation of muscles around the ankle joint after a small disturbance of BOS when standing on a "normal" support surface. **B,** Hip strategy: Activation of muscles around the hip joint as a result of a sudden and forceful disturbance of BOS while standing in a narrow support surface. **C,** Stepping strategy: Taking a forward or backward step rapidly to regain equilibrium when the COG is displaced beyond the limits of the BOS. **D,** Reaching strategy: Moving the arm to grasp or touch an object for support. **E,** Suspensory strategy: Bending the knees during standing or ambulation to enhance stability.

is approximately 73 to 110 ms with a distal-to-proximal muscle sequence.[41] Horak and Nashner have suggested that one may be able to "train" people to execute an ankle or hip strategy based on training paradigms.[41]

A significant amount of ankle strength and mobility is a requisite for successful execution of an ankle strategy. One might use an ankle strategy in order to maintain balance with a slight perturbation of the trunk or center of mass such as reaching for objects in front of you off of a shelf without taking a step.

- A *hip strategy* is the activation of muscles around the hip joint as a result of a sudden and forceful disturbance of BOS while standing in a narrow support surface. The latency is the same as in the ankle strategy; however, the muscle sequence follows a proximal-to-distal pattern.[41] It has been suggested that older adults often utilize the hip strategy rather than an ankle strategy.

A combination of both ankle and hip strategies was reported while standing in an intermediate support surface.[41] In both ankle and hip strategies, muscle activity is generated to keep the COG within the BOS. However, if the disturbances are more forceful to put us at the edge of a fall, other movements must occur that change the BOS to prevent falling.[42]

- The *stepping strategy* has been defined as taking a forward or backward step rapidly to regain equilibrium when the COG is displaced beyond the limits of the BOS.[42] This can be observed clinically by resisting the patient enough at the hips to cause a significant loss of balance requiring one or more steps to maintain postural control.[43] It is very important to recognize when and if a patient can utilize a balance control strategy to optimize their postural control.
- The *reaching strategy* includes moving the arm to grasp or touch an object for support.[42] Arm movements play a significant role in maintaining stability by altering the COG or protecting against injury.

Stepping and reaching strategies are the only compensatory reactions to large perturbations; thus, they have a significant role in preventing falls.[42] In unexpected disturbances of balance, older adults tend to take multiple steps to recover, with the later steps usually directed toward recovering lateral stability.[42,44]

- The *suspensory strategy* includes bending knees during standing or ambulation for the purpose of maintaining a stable position during a perturbation. Bending of the knees usually lowers the COG to be closer to the BOS, thereby enhancing postural stability.

The sequencing and timing of muscle contraction appears to undergo changes with advanced age including delay in distal muscle latency and increases in the incidence of co-contraction in antagonist muscle groups.[45] Older adults with a history of falls demonstrate greater delay in muscle latency when compared to age-matched nonfallers.[46] In a recent study, older adults showed slower reaction times to change the direction of the whole body in response to an auditory stimulus compared to young individuals, and moved in more rigid patterns indicating altered postural coordination.[47] These changes make it harder for an older adult to respond quickly enough to "catch" themselves when challenged with a large unexpected perturbation.

Neuromuscular System

The neuromuscular system represents the biomechanical apparatus through which the CNS executes postural actions. Muscle strength, endurance, latency, torque and power, flexibility, range of motion (ROM), and postural alignment all affect the ability of a person to respond to balance perturbations effectively. Most of those factors change with advanced age in a way that decreases the capacity of the older adult to respond effectively to balance disturbances.

Muscle strength, especially for lower extremity muscles, plays a significant role in maintaining a balanced posture.[48] There is an average reduction of muscle strength of 30% to 40% over a lifetime,[49] which might be due to the loss of type I and type II muscle fibers. Marked reduction in muscle strength of the lower extremities has been noted among older adult fallers.[46,50] Muscle endurance is maintained with aging much more effectively than muscle strength.[51] Prolonged latency in lower extremity muscles, especially those around the ankle joint, was found to be related to frequent falling among older adults.[46] Studenski et al determined that older adult fallers produce significantly less distal lower extremity torque than healthy older adults.[46] Similarly, Whipple et al found that nursing home residents with a history of recurrent falls demonstrated diminished torque production of both the ankle and knee.[50]

Reduction of joint flexibility and ROM are the main consequences of joint diseases that affect postural stability and may contribute to falls. Stooped posture or kyphosis is one of the impaired postural alignment problems in older adults that interfere with balance and stability.[6]

EXAMINATION AND EVALUATION OF BALANCE AND RISK OF FALLS

Figure 18-3 provides an evidence-based, expert panel–approved conceptual framework for best-practice steps to reduce falls in vulnerable older adults. The framework is built around 12 quality indicators for fall risk reduction listed in Box 18-1. The conceptual framework is grounded in the work of Rubenstein et al[52] with a more recent update by Chang and Ganz.[53] The authors

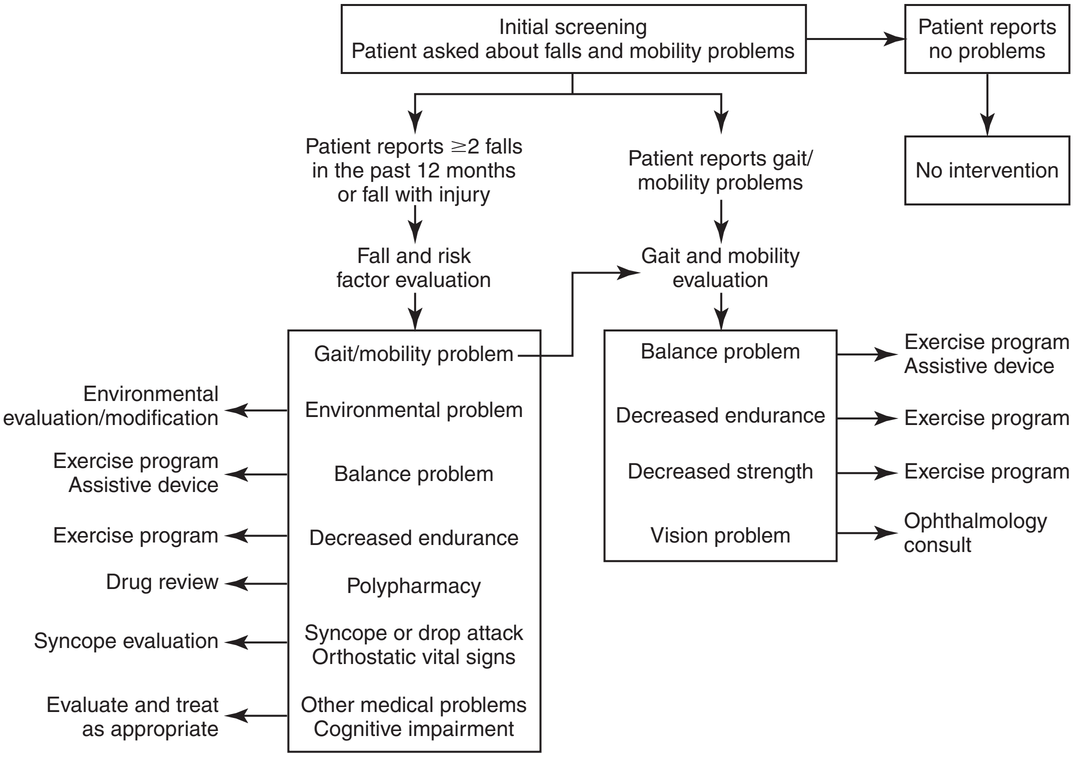

FIGURE 18-3 Conceptual framework for "best practice" steps to reducing falls in vulnerable older adults. *(From Rubenstein LZ, Powers CM, MacLean CH: Quality indicators for the management and prevention of falls and mobility problems in vulnerable elders. Ann Intern Med Oct 16;135(8 Pt 2):686-693,2001.*

intend the framework to be applicable across a variety of health profession fields. The basic framework can be expanded to provide additional specificity. For example, a physical therapist should perform the Dix-Hallpike test for any person whose balance problem appears to be associated with dizziness, with the canalith repositioning maneuver applied if a positive Dix-Hallpike test was obtained.

Determining the underlying cause of balance deficits and related fall risk is a complex undertaking. Most typically, balance dysfunctions gradually emerge from the accumulation of multiple impairments and limitations across many components of postural control, some associated with normal age-associated changes and others with acute and chronic health conditions. The redundancies built into the postural control system often

BOX 18-1 12 Evidence-Based Quality Indicators for Best Practice in Managing Older Adults at Risk for Falling[53]

For All Vulnerable Older Adults Regardless of History of Falls There Should be Documentation of:

1. Inquiry about falls within the past 12 months
2. Basic gait, balance, and muscle strength assessment for anyone expressing new or worsening gait difficulties
3. Assessment for possible assistive device prescription IF demonstrating poor balance, impairments of proprioception, or excessive postural sway
4. Participation in a structured or supervised exercise program IF found to have a problem with gait, balance, strength, or endurance

In Addition to the Above, All Older Adults Who Have Fallen Two Times or More in the Past Year, or Who Have Fallen Once With an Injury, There Should be Documentation That:

5. A basic fall history has been obtained
6. An assessment for orthostatic hypotension has been done
7. Visual acuity has been examined
8. Basic gait, balance, and muscle strength have been assessed
9. Home hazard assessment has been completed
10. Medication side effects have been assessed with special note if the person is taking a benzodiazepine
11. The appropriateness of the device has been assessed
12. Cognitive status has been assessed

(*Adapted from Chang JT, Ganz DA: Quality indicators for falls and mobility problems in vulnerable elders. J Am Geriatr Soc 55 (Suppl 2):S327-S334, 2007.*)

allow one system to compensate for deficiencies in another system, thus masking developing deficits. Once the extent of the deficits reaches a critical point or an acute illness incident exceeds the "deficit" threshold, the patient can no longer consistently manage challenges to their balance and begins to fall.

Ideally, the physical therapist would intervene at an early point in the process to remediate, compensate, or accommodate the impairment. Frequently, however, the physical therapist is only called upon following one or multiple falls, often for individuals at risk of frailty. A hypothetical functional progression along the "slippery slope" of aging, including critical thresholds for functional ability, is graphically depicted in Chapter 1. This slippery slope is partially modifiable: the physically fit and healthy older adult has less downward slope in the curve; the unfit or unhealthy individual has a sharper downward slope. Interventions to improve physiological factors contributing to functional ability can move the entire curve upward (and perhaps above key critical thresholds); illness and deconditioning can move the entire curve downward. Although the trajectory can be modified at all levels of the curve, it is much easier to modify the curve upward when the person is starting from the "fun" or "functional" levels than when they have reached the frailty level.

Although it is important to assess all physiological and anatomic factors likely to contribute to a given patient's fall risk, the physical therapist must develop strategies to narrow down the factors considered so as not to overwhelm the patient with tests and measures. Each test and measure should have a reasonable likelihood of revealing significant contributors underlying the balance dysfunction and to be of assistance in guiding a balance intervention program.

The examination and evaluation process includes taking the medical history and performing a review of systems. The data gathered from this preliminary step help guide our choice of tests and measures deemed important to understanding the postural control and functional performance issues of this patient as well as the impact of environmental factors and current health conditions on psychosocial status and participation.

There is no "one" best way to structure examination activities. For extremely frail individuals or individuals with marked balance deficits, the examiner may start with the simplest static postural tasks and move to more dynamic tasks as deemed appropriate. For the person who walks into your clinic independently with less obvious signs of balance deficits, beginning the examination by having the person complete one or two functional movement tests (TUG, BBS, DGI, etc.) allows you to observe movement under various postural challenge conditions while identifying a baseline score for fall risk based on norms for the tests. The physical therapist's observation of the quality of the individual's performance of specific items within these functional tests can provide invaluable clues about possible impairments to guide subsequent examination activities.

Tools assessing functional balance typically aim to examine balance challenges across many conditions and situations. Functional balance tests can also examine activity across each of the multiple systems contributing to postural control. Horak et al have recently proposed a model that has promise as a treatment classification system to identify specific structures contributing to postural deficits, each of which suggests a specific direction for more specific examination, and likely leading to differential intervention approaches. More of these types of integrated frameworks are likely to emerge in the future. As described later, the wide variety of characteristics of patients to be assessed for falls requires a substantial "toolbox" on the part of the physical therapist, with functional assessment tools carefully linked to a given patient with consideration of floor and ceiling effects as well as amount of new information to be gleaned and the ability of the test findings to contribute to the decision about plan of care.

The physical therapist is uniquely qualified to assess the components of gait, mobility, and balance that contribute to fall risk, and then, in conjunction with information about environmental and personal factors, guide an intervention program to improve or accommodate many of these risk factors. The physical therapist will also screen for balance and fall risk conditions that may be outside the scope of physical therapy and refer to, or consult with, the appropriate practitioner (e.g., vision consult when significant undiagnosed visual issues are uncovered, medical consult when orthostatic hypotension is identified).

History

During the initial interview the physical therapist gathers medical history data and listens carefully to the patient's self-report of any gait and balance deficits or fall incidents. It is critical that the patient and the therapist have the same definition of a fall. Patients who have slid down to the floor or who have fallen onto their knees often incorrectly fail to define these incidents as a "fall." Other patients fail to perceive an incident as a fall unless they were injured.

Interview data can provide critical information about the etiology and the likely problems contributing to falling incidents and to the person's risk for future falls. A thorough exploration of the circumstances surrounding previous falls should be conducted in order to help guide the patient examination and inform the evaluation and diagnosis. One can much better manage and develop a plan of care for a patient when all of the facts about falling or near-falling episodes are available.

This exploration should start with open-ended questions. Then, the questions can become progressively narrowed. It is important to ask about the onset of falls, activities at the time of falls, symptoms at or prior to falls, direction of falls, medications, and environmental conditions at the time of the fall. Box 18-2 summarizes the key questions that should be addressed with every patient who has fallen. The causes of a fall can be as varied as syncope associated with an acute medical problem or inability to recover from a simple balance challenge as a consequence of gradual decline in postural control mechanisms. In general, a history of a recent fall (within 3 months to 2 years) is an important indicator for future falls, and recurrent fallers are at particularly high risk for additional fall events.[22] Determining an individual's activities at the time of a fall and symptoms prior to a fall event provide valuable clues toward identifying factors contributing to the fall. For example, symptoms of dizziness or vertigo at or prior to the fall can signal a circulatory or vestibular problem. Gathering information about the direction of a fall (forward, backward, or to the side) provides the therapist with ideas for additional patient education. Falling to the side is much more likely to result in a hip fracture than a fall forward or backward.[54]

The risk of falling increases with taking multiple medications and with use of specific medications such as antidepressants, tranquilizers, and benzodiazepines (see Chapter 4). Thus, the past and current medication history should be noted for possible contribution to unsteadiness. Lastly, it is important to examine any extrinsic or environmental factors likely to contribute to fall risk. Chapter 7 provides a detailed discussion of environmental risk factors and home modification strategies and summarizes some of the key environmental risk factors for falls. In general, it is useful to ask about the height of the bed, lighting, loose carpet, cords or other material on the floor, railings on steps, and the presence or absence of any supportive bars in the bathroom, any impediments in the entranceways (rough, uneven surfaces), and the lighting outside the home.

BOX 18-2 Key Questions to Ask Someone about Falling

1. Have you fallen?
    - If yes, in the past month how many times have you fallen?
    - How many times have you fallen in the past 6 months?
2. Can you tell me what happened to cause you to fall?
    - If the person cannot tell you why they fell, this clearly deserves more questions and is a "red flag" to question them more thoroughly. (Consider cardiovascular or neurologic causes carefully if they are cognitively intact and cannot tell you why they fell.)
3. Did someone see you fall? If yes, did you have a loss of consciousness (LOC)?
    - If they had an LOC, make sure that their primary care physician is aware of this finding.
    - Often with a hit to the head with an LOC, persons may develop benign paroxysmal positional vertigo (BPPV)
    - The Dix-Hallpike test is indicated to rule out BPPV after an LOC with a hit to the head.
4. Did you go to the doctor as a result of your fall or did you have to go to the emergency room?
5. Did you get hurt?
    - No injury
    - Bruises
    - Stitches
    - Fracture
    - Head injury
6. Which direction did you fall?
    - To the side
    - Backwards
    - Forwards
7. Did you recently change any of your medicines?
    - If yes, what was changed?

Cardiovascular changes with advanced age can increase risk of losing balance and falling.[6] Sudden blood pressure alterations can cause syncopal falls. Lower standing systolic blood pressure (128 vs. 137 systolic in standing) was found to predict falling among older adults.[55] Ooi et al found that if the subjects had falls in the past 6 months, those with orthostatic hypotension had an increased risk of a subsequent fall, especially if the orthostatic hypotension was seen two or more times.[56]

Cognitive changes complicate the taking of a fall history, as the patient may not be a reliable source of information about fall history or the conditions surrounding the given falling incident. Family members are a valuable resource while taking a history of a person with significant cognitive impairment. In addition, careful examination of the skin can help the therapist identify recent or new injuries from falls. Particular attention should be paid to the knees, elbows, back of the head, and hands.

SYSTEMS REVIEW AND TESTS AND MEASURES

The next step after history taking is to examine the components of postural control to determine the etiology of the imbalance problem. Systems review should always include an assessment of vital signs. Blood pressure should be assessed for signs of orthostatic hypotension with positional changes in older adults who have fallen, particularly those who complained of lightheadedness at the time of the fall or who are taking medication to control their blood pressure.

Sensory

Sensory changes may play an integral role in determining the etiology of falls. We know that abnormal or insufficient sensory input due to injury or disease in one of the sensory systems (vision, vestibular, or somatosensory) may predispose a person to falling.[57] Therefore, it is important to examine each of these sensory components contributing to postural control.[58]

Vision. Vision is an important sensory component of intrinsic postural control as well as an important mechanism for avoiding balance challenges from environmental hazards. Significantly impaired visual acuity as well as impaired contrast sensitivity and depth perception have been associated with falls, as well as health conditions resulting in central or peripheral visual field cuts.[59]

Visual Acuity. Visual acuity can be estimated clinically by having the patient read a Snellen chart with both eyes and then, as deemed appropriate, with each eye separately, both with and without the glasses the patient typically wears while walking. An extreme loss of visual acuity is associated with gait instability in older adults.[33] Bifocals, trifocals, and progressive lenses often used by older adults can increase the likelihood of a fall event, especially on steps.[60]

Contrast Sensitivity. Contrast sensitivity is the ability to detect subtle differences in shading and patterns. Contrast sensitivity is important in detecting objects without clear outlines and discriminating objects or details from their background, such as the ability to discriminate steps covered with a patterned carpet. Contrast sensitivity declines with increased age and with health conditions such as cataracts and diabetic retinopathy. Brannan et al[61] found that falls decreased from 37% prior to cataract surgery to 19% by 6 months following cataract surgery.[33] Contrast sensitivity can be measured clinically by using a contrast sensitivity chart such as the Hamilton-Veale contrast test chart[1] depicted in Figure 18-4. Persons are asked to read all of the letters they can see on the special visual chart.

The letters at the top of the chart are dark with a greater number of pixels and then gradually become lighter until they are almost impossible to visualize. The chart has eight lines of letters. Each line of letters has corresponding line numbers associated with the person's performance. Scoring is based on the ability to see the letters. Persons fail when they have guessed incorrectly two of the three letters out of a combination of three letters. The score is based on when the person has last guessed two of three correctly. Poor performance has been associated with persons requiring a low vision assessment and disease, that is, Parkinson's disease, glaucoma, and others.

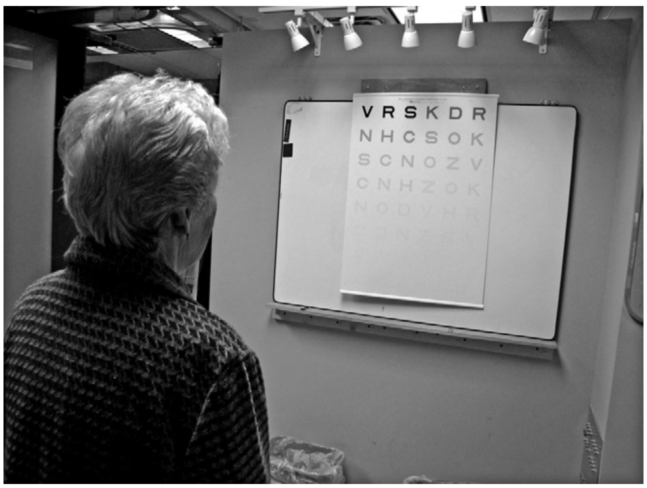

FIGURE 18-4 An older adult reading letters from a contrast sensitivity chart.

Depth Perception. Depth perception is the ability to distinguish distances between objects. There are different ways to screen depth perception. One simple clinical test, depicted in Figure 18-5, is to hold your index fingers point upward in front of the patient at eye level, one finger closer to the patient than the other. Gradually move the index fingers toward each other (one forward, one back), until the patient identifies when the fingers are parallel or lined up. If the patient's perception of parallel is off by 3 in. or more, then depth perception may be a problem and referral to an ophthalmologist for additional investigation is warranted.

Visual Field Restrictions. Peripheral vision is the ability to see from the side while looking straight ahead. To test peripheral vision, the examiner brings his or her fingers from behind the patient's head at eye level while the patient looks straight ahead. The patient identifies when he or she first notices the examiner's finger in his or her side view. A significant field cut unilaterally or bilaterally would be important to notice. Loss of central vision, most typically seen with macular degeneration, has also been related to falling.

Vestibular. It has been suggested that persons with impaired vestibular function may be more likely to fall.[62] In adults older than age 40 years, those who reported vestibular symptoms had a 12-fold increase in the odds of falling.[63] Vestibular evaluation may be necessary if the patient is complaining of dizziness or significant postural instability. Vestibular assessment ranges from simple tests and measures to highly sophisticated examination tools. Visual impairments may reflect vestibular dysfunction as a result of the complex central connections between the vestibular system and eye movements.

For smooth pursuit, the examiner asks the patient to follow a moving target (18 in. from nose) across the full range of horizontal and vertical eye movements (30 degrees all directions) while keeping the head stationary. Abnormality in smooth pursuit is reported as a corrective saccade and indicates central (brain) abnormality. To examine saccadic eye movement, patients are asked to keep their head stationary while switching their gaze back and forth quickly between two targets, each positioned at a distance of 18 in. from the patient's nose and slightly (15 degrees) to the side of the nose horizontally, and then repeated with the targets similarly positioned but in a vertical midline position. Saccadic eye movements are very quick eye movements. It is important to note if the patient over- or undershoots the target and in what direction. Over- or undershooting the target may indicate a brain abnormality. A magnetic resonance image (MRI), computed tomographic (CT) scan, or other imaging may be needed to identify the central origin of the disorder.

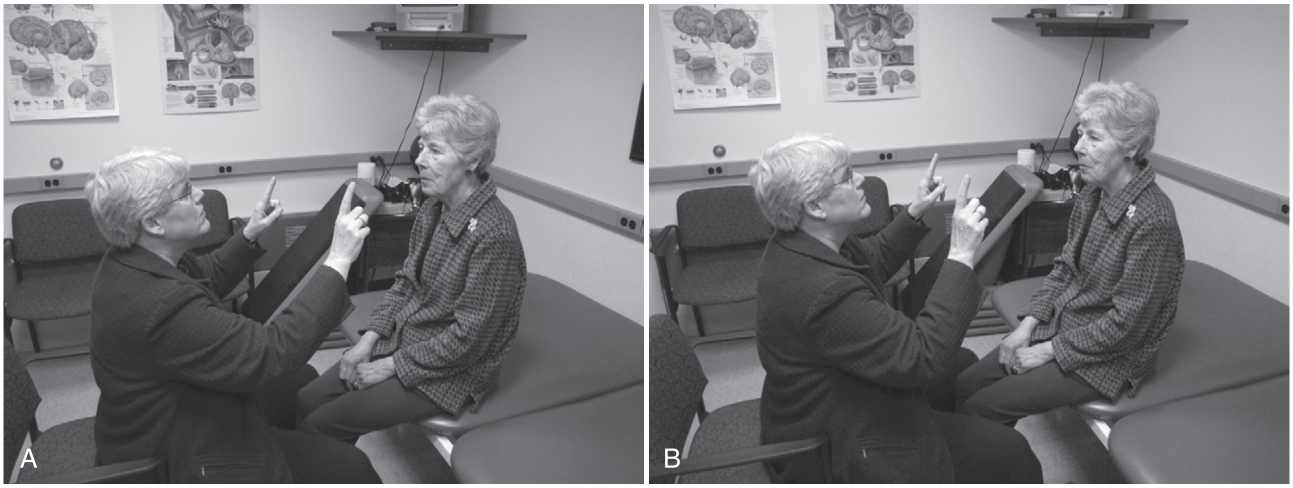

FIGURE 18-5 Assessing depth perception. **A,** The right hand is closer and is slowly moved away from the patient until the fingers align an equal distance from the patient's face. **B,** The patient reports that the fingers are of equal distance from their face.

Three clinical tests to assess VOR function, which controls gaze stability, are briefly described here. VOR can be tested clinically by asking the patient to focus on a fixed target and move the head to the right and left (horizontally) and then up and down (vertically) with various speeds. Normally, a person should be able to maintain gaze without blurring of the target. Inability to maintain gaze fixation on the target indicates abnormal VOR function as a result of peripheral or central vestibular lesion.[64] VOR function can also be tested clinically by assessing the patient's response to rapid head thrusts, with the patient seated.[65] Ask the patient to relax and allow you to move his or her head and check his or her cervical ROM. Then ask the patient to focus on a fixed target directly in front of him or her (usually your nose) while you move the patient's head rapidly over a small amplitude. Observe the patient's ability to sustain visual fixation on the target and look for corrective saccades plus note the head thrust direction if a saccade occurs. A positive head thrust test indicates an impaired VOR due to a peripheral lesion.

A third clinical test of VOR function is the assessment of static/dynamic visual acuity. This test is performed by asking the patient to read a visual acuity chart to the lowest possible line (until he or she cannot identify all the letters on a line) with the head held stationary. Then, the patient reads the chart again while the examiner moves the patient's head side to side at 2 Hz. A drop in visual acuity of three or more lines indicates an impaired VOR as a result of either peripheral or central lesion.[66]

Patients with an acute peripheral vestibular disorder will have positive test results with the head thrust test, have abnormalities with the VOR, and will have impairments of static and dynamic visual acuity. With a central vestibular disorder, one would expect to see impairments of saccades or smooth pursuit. Therefore, if the therapist is expecting a peripheral vestibular disorder then testing the head thrust, the VOR, and the static and dynamic visual acuity will be a priority to perform. While inspecting abnormalities with saccadic eye movement or smooth pursuit, the therapist's attention should be directed to a central vestibular disorder.

The assessment of the VSR requires examination of gait, locomotion, and balance. Some examples of clinical tests that can examine VSR include walking with head rotation, the Dynamic Gait Index (DGI),[67] the Timed Up and Go (TUG),[68] and functional reach.[69]

Somatosensory

A somatosensory examination includes proprioception, vibration, and cutaneous sensation. Proprioception (sense of position and sense of movement) can be tested clinically by a joint position matching test beginning distally with a "toe up/down" test with eyes closed, and moving more proximally to the ankle and knee if impairments are noted in the toes. A patient with normal proprioception should be able to detect very subtle movements of the big toe. Vibratory sense can be tested by placing a tuning fork at the first metatarsal head. Proprioception testing, vibration testing, cutaneous pressure sensation, and two-point discrimination were together found to have reliable results in assessing sensory changes that affect balance.[70]

Sensory Integration Testing

The interaction between all sensory modalities (vision, vestibular, somatosensory) can be tested in different ways. The Clinical Test of Sensory Interaction and Balance (CTSIB) is a commonly used measure to examine the interaction between the vision, vestibular, and somatosensory systems.[71] Traditionally, the CTSIB has been performed by assessing a person's balance under six different standing conditions. The person stands on a solid surface with eyes open, eyes closed, and with altered visual feedback by wearing a visual conflict dome and then repeats each visual condition while standing on a foam surface. The magnitude of the sway (minimal, mild, or moderate) and fall occurrence are then reported or the performance can be timed with a stopwatch. The CTSIB was able to classify 63% of people at risk for falling.[72] More recently, based on studies finding little difference between the eyes closed and the visual conflict dome conditions, the visual conflict dome condition has been omitted in many tests.[73,74]

The sensory organization test (SOT) of computerized dynamic posturography, depicted in Figure 18-6, is a quantitative test that objectively identifies abnormalities in the sensory components that contribute to postural control during standing balance. The subject stands on a movable force plate with a movable surrounding wall. Visual and somatosensory elements are manipulated in various combinations to provide six different sensory conditions, described in Box 18-3. Functional responses of subjects and occurrence of falls are reported.

Patients who fall under conditions 5 and 6 are often assumed to have vestibular dysfunction, whereas patients who fall under conditions 4, 5, and 6 are considered to be surface dependent. The SOT is a very helpful tool in determining how to treat patients. Older adults have lower (less effective) SOT scores compared to younger individuals.[75] In young adults, a 10-point score or better on the composite SOT has been noted to have optimal sensitivity and specificity for improvement in postconcussed athletes,[76] and composite SOT has also been noted to change over time in older adults who have undergone rehabilitation.[77]

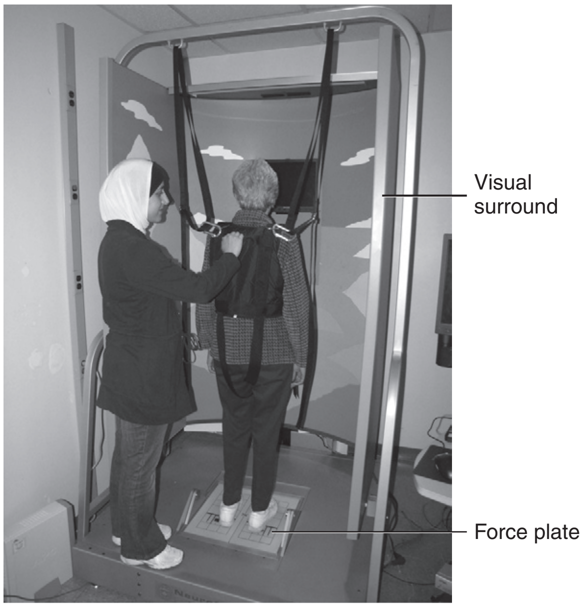

FIGURE 18-6 The sensory organization test (SOT) of computerized dynamic posturography. The physical therapist is guarding the patient but *not* touching them during the testing.

Neuromuscular Testing

Muscle strength, range of motion, and endurance should be assessed in all older adults. The neuromuscular system changes that occur with aging affect the ability of individuals to react quickly to postural perturbations and, thus, can become important risk factors of falling. A loss of muscle mass, strength, and endurance especially in the lower extremities has been found to increase the risk of falling by 4 to 5 times.[78] Small changes within multiple systems may reduce physiological reserve, resulting in challenges in the postural control system.

Strength. Muscle strength is known to be reduced in older adults and should be addressed when there is a history of falling. Testing strength in older adults provides essential information regarding the ability to generate enough muscle force to recover from balance disturbances. Manual muscle testing (MMT) is the traditional way of testing muscle strength. However, MMT is a subjective measure and may not provide the most useful information regarding balance control. Isokinetic testing of lower extremity (LE) muscles at both slow and moderate speeds provides a more accurate picture of patient's torque-generation capacity under different conditions. A patient who can produce sufficient torque at very slow speeds but has difficulty generating torque at faster speeds may have difficulty generating torque quickly enough to produce an effective postural response.[79] Toe flexor strength, ankle range of motion, and severe hallux valgus have all been related to increased risk of falling for seniors living in the community.[80]

The five times sit to stand test (FTSST)[81] and the 30-second chair rise time[82] are both functional performance tests that assess multiple components of neuromuscular effectors of balance, with both requiring good lower extremity muscle strength to complete at age-appropriate norms. For the FTSST, patients are asked to cross their arms on their chest and start by sitting at the back of the chair. Subjects then are asked to stand and sit five times as quickly as possible. The time is measured by a stopwatch from the word "go" until the subject sits completely in the chair after the fifth repetition.[81] Poor performance in rising from a chair is a strong predictor of fall risk in community-dwelling older adults when combined with other fall risk factors such as medications, comorbid disease, or at least one other fall risk factor.[83] A score of 13 seconds or higher on the FTSST demonstrates a modest ability to predict those at risk of falls, particularly for multiple fallers.[84] The FTSST has good test–retest reliability (intraclass correlation [ICC] was 0.89).[81] Normative data suggest that FTSST scores higher than 15 seconds are abnormal in healthy older adults.[81,85]

For the 30-second chair rise time,[82] patients are asked to cross their arms on their chest and start by sitting at the back of the chair. Subjects then move from

BOX 18-3 Six Testing Conditions of Sensory Organization Testing Using Posturography

Condition 1	Person stands on the force plate with eyes open, feet together. There is no movement of the force plate or the visual surround.
Condition 2	Person stands on the force plate with eyes closed, feet together. There is no movement of the force plate or the visual surround.
Condition 3	Person stands on the force plate with eyes open and the platform surface is sway referenced to visual surround (the floor moves commensurate with the person's sway).
Condition 4	Person stands on the force plate with eyes open while the force plate is sway referenced, and fixed visual surround
Condition 5	Person stands on the force plate with eyes closed while the force plate is sway referenced.
Condition 6	Person stands on the force plate with his or her eyes open while both the force plate and the visual surround are sway referenced

sit to stand for 30 seconds. The number of full standing positions in 30 seconds is recorded.

ROM and Flexibility. Assessing the ROM of the ankle, knee, hip, trunk, and cervical spine is particularly important in uncovering ROM impairments that can negatively affect balance. Assessment of ROM can be accomplished by using standard goniometric methods. Reduced ROM of the ankle or hip joints may affect the ability to use ankle or hip strategies, respectively, in recovering from external perturbations.

Aerobic Endurance

Endurance is another important factor that should be carefully determined. Assessing general endurance provides an idea about an older adults' ability to generate adequate force during tasks that require continued effort, such as walking for a long distance. The 6-minute walk test (described in Chapter 17) is a commonly used quantitative test to assess endurance. The 6-minute walk test can assess endurance in frail older adults.[86] In this test, the patient walks up and down a premeasured walkway, for example, a hospital corridor, at his or her normal pace for 6 minutes, resting as needed. The distance covered after 6 minutes is recorded as well as perceived exertion. Fatigue in older adults has been related to increased mortality rates.[87]

Functional Balance and Gait

Balance and gait are closely intertwined. Assessment of balance requires a variety of tests. Some tests emphasize one specific postural control system such as the ability to maintain balance during a static standing or sitting posture. Other tests assess balance across multiple systems during a variety of complex activities. Typically, these latter tests contribute to the assessment of overall upright functional ability, including gait and mobility under a variety of conditions and activities of daily living (ADLs).

The choice of the most appropriate functional balance and postural control measures to use to assess a specific older adult depends on many factors, including the main goal of the assessment, the mobility level of the person, history of falls, availability of required equipment, and time. Table 18-1 provides insights to help differentiate many of the commonly used balance tools discussed later.

Functional performance tests provide insights into balance capabilities that are critical to the management of balance deficits. It is during this part of the evaluation that the therapist must determine how specific deficits in the system affect the patient's overall function. In targeting tests and measures for balance capabilities, one often starts with simple static tests assessing one physiological system and progresses to more dynamic tests assessing across multiple systems.

The first static measure that the therapist can begin with is the Romberg test. Functionally, the Romberg test helps to determine if the patient can stand with feet together without falling and is purported to assess proprioception. Older adults less able to maintain the Romberg position were more likely to have had a previous fracture.[106] A "positive" Romberg occurs if the person demonstrates substantially more sway or loses balance when comparing standing in Romberg position with eyes open for 20 to 30 seconds to standing in Romberg with eyes closed. A positive Romberg test should make one suspect sensory loss distally and lead to testing distal lower limb sensation. The tandem (sharpened) Romberg test is very difficult for older adults and can separate those who are more capable from those who have minimal to significant balance impairment. It is performed by asking the subject to put one foot directly in front of the other and remain still.

Single-Leg Stance. Single-leg stance (SLS) is another difficult static test for older adults.[91] It requires good strength in the lower extremities. Single-leg stance provides the therapist with useful information about the strength of each leg individually and guides the intervention. Often it is timed for 30-second intervals. The SLS test has demonstrated a sensitivity of 95% and specificity of 58% in separating older adults who fell from those who did not.[92] This suggests that individuals who can stand on one leg for at least 30 seconds are at low risk of falling (high sensitivity). However, being unable to stand on one leg for at least 30 seconds does not provide much information about an individual's risk of falling (fairly low specificity).

Functional Reach. The functional reach test assesses a person's ability to reach forward with the right arm and recover without altering the BOS.[69] The excursion of the arm from the beginning to the end of reaching is

TABLE 18-1 Functional Balance Measures

Balance Measure	Type of Balance Assessed (Sitting, Standing, Dynamic Standing, Gait)	Items Included	Equipment Required	Interpretation of Scores	Administration	The Main Uses of the Measure in Older Adult Population
The Romberg test [88]	Examines standing balance with feet together	Standing with feet together with eyes closed and hands crossed and touching the opposite shoulders for 30 seconds	Stopwatch	Substantial increase in sway or loss of balance (positive Romberg) indicates sensory loss distally, so clinician should test distal sensation	Easy to administer, simple, and safe	Used to detect distal sensory loss in older adults[88]
The Tandem (sharpened) Romberg test[89]	Examines standing with one foot in front of the other	Standing with one foot in front of the other with eyes closed and hands crossed and touching the opposite shoulders for 60 seconds[90]	Stopwatch	Difficult to perform for older adults	Easy to administer, simple, and safe	Used to detect distal sensory loss in older adults[89]
Single-leg stance (SLS)[91]	Examines standing balance on one leg	Standing on one leg with eyes open and hands crossed and touching the opposite shoulders for 30 seconds	Stopwatch	Sensitivity of 95% and specificity of 58% in separating older adults who fell from those who did not[92]	Easy to administer, simple, and safe	Used to examine lower extremity musculature strength
Functional reach[69]	Examines dynamic standing while reaching	Standing and reaching forward	Yardstick fixed on the wall	A reach $<$6 in. predicted the risk of falling within the next 6 months[93]	Easy to administer, simple, and safe	Used to assess the maximum forward reach to the edge of the base of support
The Multi-directional Reach Test (MDRT)[94]	Examines dynamic standing while reaching in four directions	Standing and reaching forward, backward, and laterally	Yardstick fixed to a telescoping tripod at the level of the acromion[94]	Fear of falling may prevent people from reaching further	Easy to administer, simple, and safe	Used to determine maximal reach in multiple directions, which provides insights into risk of falling.[94] It is a dynamic standing test with no gait included
Five times sit to stand test (FTSST)[81]	Examines dynamic sit to stand	The time required for an older adult to perform sit to stand five times as quickly as possible	Chair and stopwatch	Scores $>$15 seconds: abnormal in healthy older adults.[81] A score of $>$12 seconds had a sensitivity of 0.66 and a specificity of 0.55 and a likelihood ratio of 1.47 in the tool's ability to discriminate between nonmultiple fallers and multiple fallers[84]	Easy to administer, simple, and safe	Poor performance in rising from a chair was found to be a strong predictor of fall risk in community-dwelling older adults[83]

Continued

TABLE 18-1 Functional Balance Measures—cont'd

Balance Measure	Type of Balance Assessed (Sitting, Standing, Dynamic Standing, Gait)	Items Included	Equipment Required	Interpretation of Scores	Administration	The Main Uses of the Measure in Older Adult Population
The four-square step test (FSST)[95]	Examines dynamic standing balance through measuring the ability to perform multidirectional movements	Stepping over canes forward, backward, and sideways	Four canes and a stopwatch	The cutoff score is $>$15 seconds.[95] Sensitivity score of 89%, and for nonmultiple fallers a specificity of 85% with a positive prediction value of 86%[95]	Easy to administer, takes approximately 5 minutes or less to complete	Used as a screening tool for older persons.[95] It can assist with helping the clinician to determine if the patient can change directions quickly. Backward stepping is particularly difficult
The Berg Balance Scale (BBS)[96]	Examines standing and dynamic standing	14 total items: sitting to standing, standing unsupported, sitting with back unsupported but feet supported on floor or on a stool, standing to sitting, transfers, standing unsupported with eyes closed, standing unsupported with feet together, reaching forward with outstretched arm while standing, pick up object from the floor from a standing position, turning to look behind over left and right shoulders while standing, turn 360 degrees, place alternate foot on step or stool while standing unsupported, standing unsupported one foot in front, standing on one leg	Chair, stool, yardstick, stopwatch	Score $<$ 45: high risk for falls[97] Scores $\leq$ 36: 100% chance of falling in the next 6 months in older adults[98] However, it has been suggested that the BBS is best used as a score with no cutoff value ascribed to fall risk, as fall risk increases significantly as the score on the test decreases[99]	A skilled evaluator can complete the test in less than 15-20 minutes	Used for patients who exhibit a decline in function, self-report a loss of balance, or have unexplained falls Can predict fall risk of older adults. Good to use for persons of lower functional ability also because the tests incorporate sitting and standing but no locomotion. A person cannot use an assistive device

The Physical Performance Test (PPT)[100]	Examines dynamic balance such as turning 360 degrees and picking up a penny from the floor	Nine total items: sentence writing, simulated eating, turning 360°, putting on and removing a jacket, lifting and then placing a book on a shelf, picking up a penny from the floor, a 50-foot walk test, and two measures of stair climbing (time to ascend one flight; number of flights climbed up and down) [100]	Pencil and paper, a jacket, a book, a penny, stopwatch, and stairs	Detect risk of falling	Easy to perform within 10 minutes	Used as a follow-up tool to monitor changes in physical frailty, quality of life, and increasing function following exercise training programs including strength training and treadmill walking[101]
The Short Physical Performance Battery (SPPB)[102]	Examines standing, dynamic standing, and gait	Three types of physical maneuvers: the balance tests (Romberg, semi-tandem Romberg, tandem Romberg), the gait speed test, and the chair stand test[102]	Chair and stopwatch	Scores $\leq$10: high risk of mobility disability[102]	Easy to administer and safe, takes 10-15 minuets	Used as a predictive measure for morbidity and mortality in older persons[102]
Dynamic Gait Index (DGI)[67]	Examines gait	Eight total items: gait level surface, change in gait speed, gait with horizontal head turns, gait with vertical turns, gait and pivot turn, step over obstacles, step around obstacles, and steps	Boxes, cones, and steps	A score $\leq$19 was found to be predictive of falls in older adults [98]	It takes 10 minutes or less to administer	Used to assess older adults' ability to modify gait and maintain normal pattern and pace in response to changing task demands[67]
Timed Up and Go (TUG)[68]	Examines gait	The therapist measures the time an older adult needs to stand from a chair with armrests, walk for 3 m, turn around, and return back to the chair and sit down at his or her normal, comfortable speed	Chair with armrests and stopwatch	Older adults who took $\geq$13.5 seconds were classified as fallers, with an overall correct prediction rate of 90%.[103] A score $\geq$30 seconds indicates that the patient will have significant difficulties in ADL.[103] It is a very reliable test with high sensitivity (87%) and specificity (87%).[103]	Very easy to administer	Used to measure the functional mobility in older adults that is important for ADL
Gait speed[104]	Examines gait	Timed walking over 3-4 m	Stopwatch	Predict hospitalization and mortality rate[105]; 0.1 m/second change is considered clinically significant[104]	Easy to administer	Used as a measure of functional exercise capacity in older adults

measured via a yardstick affixed to the wall. It is a useful measure for patients complaining of falling. A reach of less than 6 in. has been reported as a risk factor for falling within the next 6 months, with an adjusted odds ratio of 4.0.[93]

The multi-directional reach test (MDRT) was developed by Newton[94] to determine how well older adults could reach forward, to the side, and backward. A yardstick fixed to a telescoping tripod at the level of the acromion was used. Their instructions included "without moving your feet or taking a step, reach as far as you can to the (right, left, forward, or lean backwards)."[94] The test appears to be a reliable and valid measure of the "limits of stability."[94] Forward reach is less when done via Newton's test compared to the functional reach test. This difference is most likely because the tripod is not located next to a wall. Fear of falling may prevent people from reaching further.[94]

Reaching tests can serve as a quick and low-effort mechanism for gathering crucial information regarding the postural stability of older adults. Reaching tests provide an option for examining postural stability in frail older adults who cannot perform other tests that include ambulation and can be used as a quick screen for community testing of seniors.

Four-Square Step Test. The four-square step test (FSST) has also been used in older adults to assess fall risk. The FSST involves stepping over four standard canes at 90 degree angles to each other, whereby the tips all touch each other at the center to create the "four squares."[95] The patient is asked to stand in one square facing forward and then is asked to step clockwise over the canes by moving forward, to the right, backward, to the left, and then reversing the path in a counterclockwise direction. Both feet are to enter each designated spot. The patient is instructed to move as quickly as possible without touching the canes with both feet touching the floor in each square. They are also asked to face forward throughout the testing.[95] Interrater reliability has been reported to be $r = 0.99$.[95] Using a cutoff score of >15 seconds to predict individuals with two or more falls, the test has good sensitivity and specificity (89% and 85%, respectively).[95] The FSST is especially helpful in quantifying how well your patient can change directions and move backward quickly.

Berg Balance Test. The Berg Balance Scale (BBS) was developed by Katherine Berg in 1989 to measure balance ability (static and dynamic) among older adults.[96] The BBS is a qualitative measure that assesses balance via performing functional activities such as reaching, bending, transferring, and standing that incorporates most components of postural control: sitting and transferring safely between chairs; standing with feet apart, feet together, in single-leg stance, and feet in the tandem Romberg position with eyes open or closed; reaching and stooping down to pick something off the floor. Each item is scored along a 5-point scale, ranging from 0 to 4, each grade with well-established criteria. Zero indicates the lowest level of function and 4 the highest level of function. The total score ranges from 0 to 56. The BBS is reliable (both inter- and intratester) and has concurrent and construct validity.[107,108]

Although a cutoff score of greater than 45 has been traditionally identified as a useful cutoff to predict falls in those who scored below the cutoff score,[97] recent work by Muir and Berg[99] suggests an alternative scoring system as well as suggesting that the BBS is more effective in identifying those who will fall more than once than those who have fallen one time only. They suggest a cutoff score of 40 to predict those who will experience multiple falls (positive likelihood ratio of 5.19 with 95% confidence interval [CI] of 2.29 to 11.75) and injurious falls (positive likelihood ratio of 3.3 with 95% CI of 1.40 to 7.76). In the Shumway-Cook et al model for using the BBS to predict the likelihood of falling, a score of 36 or less indicated a nearly 100% chance of falling in the next 6 months in older adults.[98] The BBS is less useful in confirming someone is at low risk of falling. Even subjects who achieve a very high score (53 or 54 of 56) only have a moderate assurance that they are not at risk for a fall in the next few months. The BBS is particularly helpful in determining sitting and standing balance. No measures of gait are directly recorded within the scale.

Physical Performance Test. The physical performance test (PPT) was developed to assess function in community-dwelling older adults[100] and is a useful measure of early physical decline in older persons.[109] The PPT's relationship with recurrent reported falls demonstrated a sensitivity of 79% and a specificity of 71% in older men.[110] The PPT tool assesses multiple domains while observing the patient performing various tasks. The PPT includes nine items such as eating, putting on a sweater, writing, picking up a penny from the floor, turning while standing, walking, and stair climbing, with three degrees of difficulty. An ordinal scale is used based on the time that it takes the subject to complete the tasks, except for the last item, stair climbing, which is based on the number of flights that the person can ascend and descend.[100]

The Short Physical Performance Battery (SPPB) was developed to assess risk of falling in older adults.[102] The SPPB has three components: (1) the Romberg, semitandem Romberg, and tandem Romberg; (2) repeated sit to stand; and (3) gait speed. Scores range from 0 to 12, which has been norm-based on more than 10,000 older adults (higher scores indicate better function).[111]

Dynamic Gait Index. The Dynamic Gait Index (DGI) is particularly useful for individuals with suspected vestibular disorders because the test incorporates various head rotation actions that challenge vestibular responses to gait activities.[112] The DGI is an eight-item test with each item graded (0 to 3) as severely impaired, moderately impaired, mildly impaired, or normal, for a maximal score of 24.[67] Scores on the DGI provide only a modest contribution to falls risk prediction, with both sensitivity and specificity generally ranging between 55% and 65% when the "best" cutoff score of 19 or less is defined as a "positive" risk factor.[98] However, the ability to observe the interaction of visual and vestibular input when head movement is superimposed on forward walking may provide insights into specific impairments that can help direct decision making about interventions. Obviously, people must be able to ambulate with or without an assistive device and need to have the endurance to complete the eight gait tasks.

Timed Up and Go. The TUG (described in Chapter 17) is a gait-based functional mobility test that is easy to administer, reliable, and has high sensitivity (87%) and specificity (87%) for predicting falls.[103] Individuals taking 13.5 seconds or longer to perform the TUG were classified as fallers with an overall correct prediction rate of 90%. The TUG is advantageous because it includes people who use an assistive device, is not overly time burdensome, only requires that individuals be able to walk 6 m (20 feet) to be included, and provides opportunities to assess more complex balance activities such as moving sit to stand and turning around at the halfway point of the walk to return to the chair.

Gait. Gait speed is an essential component to include in the test battery for older adults with a history of falls. A change of 0.1 m/sec is considered clinically significant in older adults. During assessment of gait, the physical therapist should vary the conditions under which the patient performs the task.[113] For example, it is useful to see how the patient responds to changes in gait speed and direction, negotiates obstacles, manages with various competing attentional tasks,[114] and handles changing surfaces and other environmental distractions and conditions.

Environmental Assessment

Environmental factors can either facilitate or hinder the abilities to function within one's surroundings. The International Classification of Functioning, Disability and Health (ICF) recognizes the role of the environment, providing it a prominent role in the ICF model of disability.[115] The level of disability experienced by an individual depends not only on body functions and structures but also on the environmental support and personal factors.

Patients or their family members may complete a home safety checklist that assesses the home environment and highlights extrinsic factors that serve as fall hazards. These data are then incorporated into patient education interventions. An "in-home" safety check should be a routine part of the home-care physical therapist's role and is occasionally incorporated into discharge activities of a rehabilitation patient. A safety check examines things like lighting in the house, types of flooring, availability of grab bars in the tub or shower, and handrails for stairways. The physical therapist may need to watch the patient's performance during routine activities within his or her home. The therapist may observe the patient getting in and out of bed and in and out of the shower or bath tub. In addition, it is important to assess the patient's access to light switches. Obstacles, cords, and clutter become particularly relevant to the patient with serious visual deficits or gait abnormality but need to be addressed only to the extent that they pose a threat to the patient's safe function. Environmental evaluation allows the physical therapist to determine the degree of environmental hazard and suggest modifications that aid in preventing falls.[116,117] Chapter 7 provides further details about environmental assessment.

Psychosocial Assessment

Social support and behavioral/cognitive function should be addressed in the comprehensive evaluation of patients experiencing recurrent falls. Impaired cognition has a strong relationship with falls[118-127] as it is often difficult for the cognitively impaired person to recognize "risky" situations and make prudent choices that would prevent a fall. Strong social support can help minimize fall risk by providing a safe and supportive environment that allows the cognitively impaired person to function maximally within their environment. Memory deficits, dementia, and depression are health conditions seen with greater prevalence in older adults and that have been associated with increased fall risk.[128]

Fear of Falling

Fear of falling is a potential behavioral outcome of previous falls that may limit older adult activities. One third of older adults who experience a fall develop a fear of falling.[129] Fear of falling may lead to more sedentary lifestyle with subsequent deconditioning that creates an ongoing downward spiral leading to frailty[130] and increased risk of future falls.[131] Fear of falling has been associated with the use of a walking device, balance impairment, depression, trait anxiety, female gender, and a previous history of a fall or falls.[132,133]

The Falls Efficacy Scale International (FES-I) is a short tool that records fear of falling and is growing in acceptance in Europe, with a recently developed short version. The FES-I consists of either seven[134] or sixteen[135] items that are very similar to the 16-item Activities-specific Balance Confidence Scale (ABC).[131,135] Box 18-4 displays the short-form FES-I. The additional factors on the 16-item version include cleaning the house, preparing simple meals, going shopping, walking outside, answering the telephone, walking on a slippery surface, visiting a friend or relative, walking in crowds, and walking on an uneven surface.

The ABC was developed for use with older adults to attempt to quantify fear of falling.[136] The test items,

BOX 18-4 The Short-Form Fall Efficacy Scale–International (FES-I): Patient Directions, Seven Items That Make Up the Scale, and Response Options

Introduction

Now we would like to ask some questions about how concerned you are about the possibility of falling. Please reply thinking about how you usually do the activity. If you currently do not do the activity, please answer to show whether you think you would be concerned about falling IF you did the activity. For each of the following activities, please put the number in the box which is closest to your own opinion to show how concerned you are that you might fall if you did this activity.

☐ 1. Getting dressed or undressed
☐ 2. Taking a bath or shower
☐ 3. Getting in or out of a chair
☐ 4. Going up or down stairs
☐ 5. Reaching for something above your head or on the ground
☐ 6. Walking up or down a slope
☐ 7. Going out to a social event (e.g., religious service, family gathering, or club meeting)

Answer options:

1 Not at all concerned
2 Somewhat concerned
3 Fairly concerned
4 Very concerned

Handling Short FES-I sum scores:

To obtain a total score for the Short FES-I, simply add the scores on all the items together, to give a total that will range from 7 (*no concern of falling*) to 28 (*severe concern about falling*).

Handling Short FES-I missing data:

If data are missing on more than one item then that questionnaire cannot be used. If data are missing on no more than one of the seven items, then calculate the sum score of the six items that have been completed (i.e., add together the response to each item on the scale), divide by six, and multiply by seven. The new sum score should be rounded up to the nearest whole number to give the score for an individual.

(From Kempen GI, Yardley L, van Haastregt JC, et al: The Short FES-I: a shortened version of the Falls Efficacy Scale-International to assess fear of falling. Age Ageing 37:45-50, 2008.)

with varying degrees of difficulty, were generated by clinicians and older adults. Each item is rated from 0% to 100% related to how confident the person is that he or she can perform the activity. Lower scores indicate greater fear of falling and higher scores greater confidence (less fear) of falling. ABC scores can help categorize the functional level across a wide range of capabilities: Scores less than 50 indicate low physical functioning; scores above 50 and below 80 indicate moderate levels of physical functioning; and scores above 80 indicate high-functioning older adults.[137] Lajoie et al[138] determined that scores on the ABC and the BBS were highly correlated, suggesting that fear of falling is related to falls in older persons.

The Falls Efficacy Scale (FES) is a ten-item test rated on a 10-point scale from not confident at all to completely confident.[139] It is correlated with difficulty getting up from a fall and level of anxiety. The test–retest reliability was 0.71.[139] The FES and fear of falling were correlated.[140]

Participation

The evaluation of participation in older adults at the societal level is another essential area to address. More than 50% of older adults (50 years and more) reported participation restriction in a population survey.[141] The International Classification of Functioning, Disability and Health emphasizes the term *participation* and defines it as “involvement in a life situation.”[142] Assessing participation in older adults provides information about the level of concern an older adult has about his or her specific functional activities, regardless of actual observable impairment.[143] Activities and participation can be assessed by asking about difficulties in performing daily living activities (eating, dressing, bathing, reading, and sleeping) and outdoor activities (driving and working). In addition, the difficulty in performing recreation and leisure activities and relationship with family members should also be addressed.

The life habits (LIFE-H) questionnaire can be used to assess participation.[144] The LIFE-H was developed to assess the handicapping situations in people with disability based on the International Classification of Impairment, Disability and Handicap (ICIDH). The intrarater reliability of using the LIFE-H in the older adult population with disabilities was greater than 0.75 for seven of the ten life habits studied, and overall the interrater reliability (ICC) was 0.89 or higher.[145]

INTERVENTION

Comprehensive, and frequently multidisciplinary, examination and evaluation should guide the management of the older adult with substantial postural instability.[146,147]

The main goal of management is to maximize independence in mobility and function and prevent further falls. Physical therapists are the health professionals most uniquely prepared to analyze movement dysfunctions and provide interventions to address the physical functional impairments and limitations contributing to the movement dysfunctions.

The physical therapist may be working in an environment that allows them to be part of an existing interdisciplinary geriatric assessment or management team or may refer to and collaborate with other health professionals to achieve a team approach as needed. Other team members may include a physician, social worker, nutritionist, occupational therapist, nurse, and psychologist or counselor. Existing fall risk factors should be addressed and prevented first. Several preventive strategies have been used to reduce the rate of falling by eliminating factors contributing to falls and improving balance and gait. Table 18-2 provides a listing of the common fall risk factors and strategies used by physical therapists to decrease or eliminate these risk factors. Overall prevention and intervention management can be categorized into medical, rehabilitative, or environmental strategies.

Medical strategies include careful review and modification of medications used by older adults.[2,146] Four or more medications, or any psychotropic medications (neuroleptics, benzodiazepines, antidepressants), should be reviewed to see if all are needed.[146,148] In addition, any combination or interaction between drugs should be

TABLE 18-2 Fall Risk Factors, and Strategies a Physical Therapist Should Consider to Ameliorate the Risk Factor and Improve Patient Function

Fall Risk Factor	Strategies to Ameliorate the Fall Risk Factor
Weakness	• Individualized muscle strengthening program followed by • Community exercise program for continued participation in strength training
Loss of flexibility and range of motion	• Stretching program • Modifications if range of motion cannot be achieved
Low/high body mass index	• Refer patient for consultation with a physician • Refer patient for consultation with a nutritionist • Assess for depression
Impaired vision	• Determine when the patient received their most recent glasses • Refer patient for consultation with an ophthalmologist if any undiagnosed or changing visual impairments • Patient education on environmental strategies to minimize risk in the presence of impaired vision • (Be sure physical therapist's environment adequately accommodates low vision needs.)
Impaired recreation	• Careful listening to the patient's interests and desires for specific recreational activities, and strategize options to achieve participation (in typical or adaptive form) • Building a rehabilitative program to address the specific skills required to participate in the activities • Recommendations for local programs that provide recreational opportunities consistent with the individual's capabilities.

Impaired sensation	• Exercises to maintain or improve distal muscle strength
	• Tai Chi has been demonstrated to be successful at enhancing distal sensation
	• Patient education in skin checks to prevent injury to feet:
	  • Daily check of skin on feet
	  • Wearing cotton socks
	  • Checking shoe wear and condition frequently
	• Patient education in use of alternative balance systems (visual and vestibular) to maximize balance function.
	• Future direction could be subthreshold vibration in the shoe

Cognitive impairment	• Review of medication, with particular emphasis on medications with a sedative effect • Attempt to keep the environment consistent • Evaluate the environment for safety hazards • Family education on safety and monitoring in the home setting • Participation in exercise and physical activity programs appropriate to individuals with cognitive impairment • Referral to primary physician if cognitive impairment is new or has demonstrated substantial change recently

Continued

TABLE 18-2 Fall Risk Factors, and Strategies a Physical Therapist Should Consider to Ameliorate the Risk Factor and Improve Patient Function—cont'd

Fall Risk Factor	Strategies to Ameliorate the Fall Risk Factor
Incontinence	• Patient and caretaker education in establishing a regular toileting program • Patient and caretaker education about effects of caffeine and particular risks of excessive fluids late in the day requiring trips to the bathroom at night • Consultation with physician, as indicated, for medication management

Environmental hazards	• Provide an environmental assessment:
	  • Stability of furniture likely to be used to assist with ambulation in the home
	  • Need for grab bar, tub floor mat installation in the bathroom
	  • Recommend handrails on steps
	  • Adequacy of lighting and accessibility of light switches
	• Assess clothing and footwear

Postural hypotension	• Consult with the physician about a medication review or need for a cardiovascular referral
	• Patient assessment for, and education in, physiological maneuvers beneficial in decreasing an orthostatic event:
	  • Active movements of the lower extremities prior to moving from sit to stand
	  • Use of elastic pressure stockings or an abdominal binder
	  • Slowly move from supine to sit
	  • Ankle pumps or upper extremity movement prior to changing position

Osteoporosis	• Standing exercises/weight-bearing exercise • Consider hip pads • Patient education in the benefits of medications and vitamin D supplementation
Polypharmacy	• Review of medications: Consult with physician if signs that an adverse medication response may be affecting balance, particularly those causing postural hypotension or confusion • Attempt, with the help of the team, to determine if benzodiazepines are necessary
Impaired gait	• Determine factors contributing to the gait disturbance • Balance exercises • Establish a walking program • Assistive device use or modification
Impaired balance	• Exercises performed in standing • Attempts to increase the person's limits of stability in all directions
Joint pain	• Strengthening program • Physical agents as an adjunct

monitored carefully, especially drugs that contribute to fall risk, such as sedatives and hypnotics.[146,147]

Another medical strategy is to address visual problems that might be corrected simply by changing eyewear. Glasses with prisms can compensate for peripheral-field deficits, tinted glasses can increase contrast sensitivity, and different glasses for near and far vision can reduce problems caused by bifocals. Lord et al suggest that multifocal lenses impair both edge-contrast sensitivity and depth perception.[60] Significant visual restrictions from cataracts may require cataract surgery to improve vision and decrease fall risk. Maximizing vision in both eyes appears to be critical.[33] For macular degeneration in older adults, medication and careful observation by the ophthalmologist can slow the progression of macular degeneration. The physical therapist should determine if an older adult with a balance complaint has had an eye examination within the last year and, if not, to be even more vigilant to the possibility of an undetected eye impairment as a possible contributor to the balance deficits, with recommendations to the patient for obtaining an eye examination.

The use of vitamin D plus calcium in persons in long-term-care facilities has been found to decrease the number of falls over the intervention period.[149,150] Vitamin D and calcium together reduced the risk of falling by 49% compared to calcium alone.[150] There were associated improvements in musculoskeletal function by vitamin D and calcium intake. Vitamin D may be more useful in frail older adults than in healthy persons. A recent Cochrane review suggests that vitamin D reduced the rate of falls but not fall risk in 4512 subjects living in long-term-care environments.[151]

Physical therapy interventions may play a restorative, compensatory, or accommodating role in minimizing balance instability and decreasing risk of falls. Therapeutic exercise is a primary restorative approach[116,118,124]; footwear[6] that provides increased sensory cues in the presence of decreased position sense serves as a compensatory approach; and wearing hip protectors[152] or using an assistive device[148] serves an accommodating role. The physical therapist has a leading role in providing safe mobility training and in referral and collaboration with other health care providers to address all salient patient issues. Muscle strengthening, gait training, balance training, and flexibility or range of motion exercises are all key ingredients for a successful physical therapy program to address balance deficits.

Individuals who are frail are at high risk for falling and can often benefit greatly from a comprehensive fall risk assessment and subsequent targeted interventions that include physical therapy. Frail individuals have low physiological reserve and impairments across multiple physiological systems, thus making them particularly vulnerable to stressors.[153] Figure 18-7 provides examples of the many therapeutic interventions that should be considered for "frail" and "very frail" older adults.

The examination data regarding fear of falling needs to be considered when developing and implementing the plan of care. The exercise environment and exercise activities should be structured to minimize fear while ensuring adequate challenge to lead to improvements. Particular attention should be paid to home exercise programs, as exercises that are perceived as too challenging are less likely to be carried out because of fear of falling. For all except the extremely frail, it is essential that balance exercises be performed in upright stance in order to adequately challenge balance responses. Seated balance exercises do little to affect standing balance responses, and very few people fall from the seated position. It is also important to move the older adult beyond low-level elastic resistance exercise in order to use overload principles to increase muscle strength.[154] Often frail older adults will need more supervision to perform their exercise program and move about the physical therapy gym. Those older adults who are very frail in outpatient settings may initially need to be seen more frequently so that they can be closely supervised during their exercise program.

Balance Training

One aspect of balance training focuses on exercises that improve the speed and accuracy with which the patient responds to unexpected perturbations via ankle, hip, stepping, or reaching strategies. Simple weight shifts in a safe environment with the hips and knees straight while leaning forward and back may enable the person to more effectively choose an ankle strategy. Performing active leaning forward or back with resistance at the shoulders and then "letting go"[43] (done carefully to protect the patient from falling) may be used as an intervention aimed at having patients practice executing an optimal postural control strategy when required. An option to train hip strategy response is to ask the patient to practice leaning forward at the hips while maintaining foot position (touch their nose to the mat table), or pulling the patient off balance at the hip enough that they must lean at the trunk to control their balance.

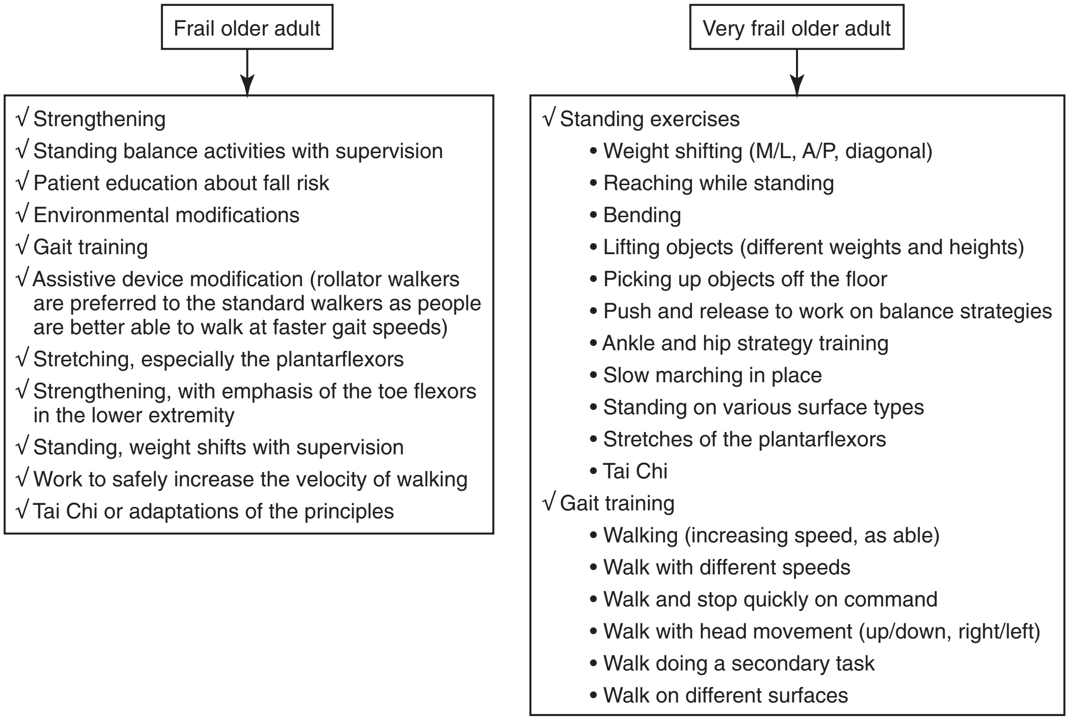

FIGURE 18-7 Illustrative ideas for physical therapy intervention based on the degree of frailty.

Standing, standing with fast and slow weight shifts in all directions, standing and reaching, standing with small pushes and then reaching for an object with a slight push would be an example of how to progress the patient's standing balance. During any weight shift, it is important to teach the patient to better recognize where their weight is under their feet. Activating distal sensation has been reported to be one of the possible reasons that Tai Chi may be successful in reducing falls in older persons.[155] Success is key when working with individuals with balance deficits. One can always incorporate the more difficult part of the exercise program in the middle, ending the session with exercises that are a little less challenging, thus boosting the patient's confidence and sense of success.

Any individual with a balance deficit can fall while performing a balance activity, so each patient must be carefully assessed while performing each new activity in order to determine the level of supervision necessary for adequate patient safety.

Tai Chi. Tai Chi (TC) is considered a balance training program because it contains slow movements that stress postural control.[156] TC can be performed in groups and requires the person to move body parts gently and slowly while breathing deeply. TC has a positive effect on balance in older adults. Wolf et al demonstrated that the TC group had a reduction in fear of falling, a decrease in risk of falls by 47.5%, and lower blood pressure.[156] Hakim et al found that greater balance ability was achieved in both the TC group and structured exercise group in a randomized control trial.[157] However, the multi-directional reach test (MDRT) scores from sitting position were significantly better in the TC group. Richerson and Rosendale recorded distal sensation after TC exercise in older adults with diabetes and healthy older persons and found that both groups demonstrated improvements in their distal sensation.[158]

Vestibular Training. Dizziness is never normal in older adults. Persons with vestibular deficits (dizziness, lightheadedness, or vertigo complaints) benefit from exercise and balance programs. Often older adults do not complain of spinning but may only report lightheadedness during movement. Other conditions that cause dizziness must be ruled out to ensure that you are treating a vestibular condition. Not all persons with vestibular disorders have both dizziness and balance problems. The exercise program should specifically address the impairments and functional deficits noted.

The most common intervention for older adults is the use of the canalith repositioning maneuver (Epley maneuver) for benign paroxysmal positional vertigo (BPPV).[159] Benign paroxysmal positional vertigo is extremely common in older persons and reports of dizziness in people older than age 40 years are related to reported falls.[63] The canalith repositioning maneuver is highly effective in resolving dizziness that is associated with a change of head position relative to gravity.[160]

Eye/head movements are often used with visual fixation in order to attempt to normalize the gain of the VOR in persons with vestibular dysfunction.[161-163] It is thought that retinal slip drives the adaptation of the VOR.[162]

Standing balance and gait exercises that are progressed in difficulty are provided to patients, including the following key concepts: (1) starting in more static and advancing toward more dynamic movements[164]; (2) considering subject learning style and key motor learning concepts such as knowledge of results and performance[165]; (3) increasing the difficulty of the environment (closed to open skills, quiet vs. busy environment)[165]; (4) varying from no head movement to complex head movement during standing and gait[165]; (5) adding secondary tasks to the balance or gait task (talking, holding/carrying, calculating)[67]; and (6) manipulation of the support surface (flat/stable surface progressing to a dynamic surface [towel, foam pad, gravel, grass]).[164]

Exercise Interventions: Strength, ROM, and Endurance

To the extent that muscle strength, ROM, and aerobic endurance contribute to a patient's instability, each needs to be addressed in the intervention program. Research indicates that lower extremity weakness is significantly associated with recurrent falls in older adults,[46,50] and that improved lower extremity strength is associated with improvements in static and dynamic balance.[166] Therefore, exercise therapy may be an effective strategy to increase lower extremity strength and endurance, improve functional balance, and reduce fall risk. A multidimensional training program that included stretching, flexibility, balance, coordination, and mild strengthening exercise has demonstrated improvements in physical functioning and oxygen uptake in community-dwelling older adults.[167] Similarly, a strength and balance training program improved muscle strength, functional performance, and balance in older adults with a history of recurrent or injurious falls.[168] Although it is clear that exercise is important to balance training, the optimal type, duration, and intensity of exercise programs are unclear.[2,148] In general, exercise programs should address static and dynamic balance, coordination, strength, endurance, and ROM. Most exercise/balance programs that have demonstrated effectiveness lasted for greater than 10 weeks.[2,148] Chapter 5 provides a detailed discussion of general exercise principles for the older adult.

Assistive and Accommodative Devices

Ambulation devices, such as different types of canes and walkers, may provide older fallers with greater stability and reduce risk of falling. These devices increase the BOS in standing and walking by increasing the ground contact. Ambulation devices may also help in reducing fear of falling by providing physical support and by adding tactile cues to enhance somatosensory contributions to postural control and sense of where the person is in space.[6,169] The proper ambulatory device can be prescribed according to older adults' needs based on a comprehensive balance assessment.

Hip pads are most commonly used with patients in nursing homes who are at very high risk for injury from a fall. Hip pads have been shown to reduce the fracture rate marginally in older adults.[6,152] Compliance is a concern as the hip pads are somewhat cumbersome and unattractive worn under clothing. However, wearing hip protectors may provide psychological support for some older adults who are fearful of falling.[6]

Properly fitting footwear with a low heel and high sole/surface contact area also decreases the risk of falling. Because decline in distal somatosensory function with advanced age can lead to instability and increased risk of falling, special insoles have been designed to enhance somatosensory input. A facilitatory insole, as depicted in Figure 18-8, was recently shown to improve lateral stability during gait and decrease the risk of falling in older adults.[170] Vibrating insoles have also been used to enhance sensory and motor function in older adults.[171,172] The use of vibrating insoles demonstrated a large reduction in older adults' sway during standing trials. Therefore, vibrating shoe insoles might contribute to enhancing the stability of older adults during dynamic balance activities.[173] Gait variability in the laboratory was reduced for older adults plus older fallers while wearing the subthreshold vibratory device during gait.[174]

Environmental Modifications

Environmental modifications may prevent falls and reduce the risk of falling significantly. They also can serve as important adaptive strategies to promote mobility. Environmental modifications at home may include changes in lighting, floor surfaces, handrails, bed, and the bathroom.[6] Certain locations at the home or in the hospital need extra lighting, especially at night such as the bedside area, the path to the bathroom, and in the bathroom. Lack of slip-resistant surfaces contributes to high fall rates.[128] Therefore, it is helpful to identify risky floors and to modify surfaces that can make them safer. In the bathroom, for example, a slip-resistant surface or nonslip bathmat can be used to reduce the risk of falling. Removal of rugs in the home is recommended to avoid tripping and falling.[175] The absence of grab bars in the tub/shower of older adults was found to be a dangerous influence on the risk of falling.[176] Therefore, adding grab bars in the tub/shower may have a beneficial effect on reducing the number of falls. Handrails are also important to install to provide support for older adults. It is very important to consider the angle and the diameter of the bar so that the installation of the grab bar is customized for the person.

Other modifications can be added to the bed and its surrounding area to provide support and prevent falls. These modifications may include adjusting the height of the bed to be appropriate for the older adult, adding a slip-resistant footboard, and installing bedside rails.[6] The other area in the home that requires modifications for older adults with balance and mobility problems is the bathroom. Toilet seat modifications may include raising the seat or adding grab bars to help the older adult get on and off the seat safely.[6]

SUMMARY

Falls in older adults are a major concern and are a major cause of morbidity and mortality. Falls are multifaceted and a heterogeneous problem. A comprehensive evaluation of pathophysiological, functional, and environmental factors of falls is important for effective management. The goal of intervention should always be to maximize functional independence in a manner that moves the person up higher on the "slippery slope," away from the line that indicates frailty and closer to the line that indicates "fun," and to do this safely so that older persons can participate in their community.

REFERENCES

To enhance this text and add value for the reader, all references are included on the companion Evolve site that accompanies this text book. The reader can view the reference source and access it online whenever possible. There are a total of 176 cited references and other general references for this chapter.

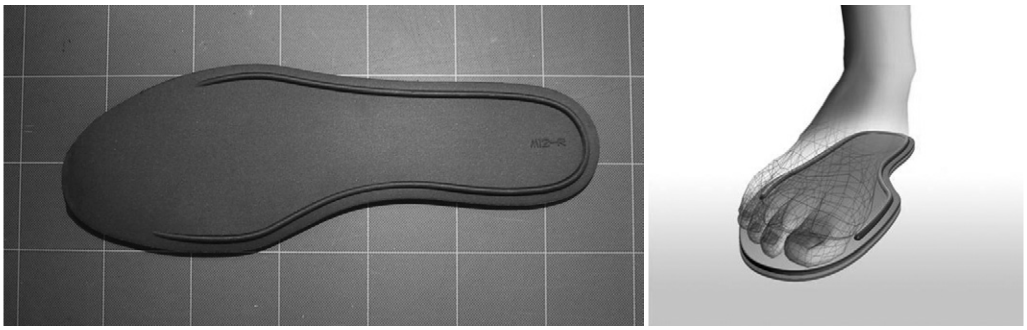

Figure 18-8 An insole that provides increased lateral cues to older adults when they move close to their limits of medial/lateral stability. *(From Perry S, Radtke A, McIlroy W, et al: Efficacy and effectiveness of a balance-enhancing insole. J Gerontol 63A:595-602, 2008.)*

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