Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Lesson One: Course Introduction

When observing an older adult walking, it is not surprising to see a slumped-forward posture along with short, slow, shuffling steps. Many seniors who exhibit this type of impaired posture and gait are at an increased risk for losing their balance and falling. The significant health complications and substantial costs associated with falls in the elderly are two reasons why several health and community organizations are increasing their efforts to find preventive solutions to this growing public health concern.

Is deterioration of locomotion inevitable, or are there preventive actions all individuals can take to decrease the risk of suffering the limited mobility commonly associated with aging? In general, research on physical activity as a successful strategy for fall prevention in older adults looks promising. Research suggests that an exercise program that significantly increases strength, assists in the maintenance of a body weight and composition that are efficient for locomotion, and improves balance is a useful countermeasure against falls in older adults (Meyers et al. 1991; Morey et al. 1989; Era & Heikkinen 1985; Manchester et al. 1989; Fansler et al. 1985; Gossmann et al. 1989).

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Lesson Two: U.S. Fall Statistics

It is estimated that one third to one half of the American population over age 65 will fall at least one time each year. Considering that the fastest growing segment of the United States' population consists of individuals age 65 and older, the importance of developing and implementing fall-prevention programs cannot be overstated. Due to the increasing prevalence of osteoporosis in our society, the tragic consequence of an older person falling is often a fracture—specifically a fracture of the hip, spine, and/or wrist. Falls are one of the most common problems that threaten the independence of older individuals, and approximately 10 to 15% of falls in the elderly result in fracture. Fractures are extremely costly in terms of health, quality of life, and finances.

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Hip Fractures

Hip fractures are the most devastating type of fall-related fractures, accounting for approximately 300,000 hospitalizations annually. Falls cause 90% of hip fractures, and almost all hip-fracture patients are hospitalized. Because the typical hip-fracture patient is about 80 years old, the trauma and surgical procedures associated with this type of fracture are not trivial. Hospitalization rates are increasing by approximately 9% each year, and hip fracture patients represent nearly half of all hospitalizations for osteoporotic fractures in the United States. Fractures of the hip commonly lead to disability, as more than one in four (26%) individuals suffering a hip fracture becomes disabled the year following the fracture. Nearly one out of five hip-fracture sufferers requires long-term nursing home care, and approximately 20% of all hip-fracture patients die within a year. Approximately one half of those who break their hips never regain a fully functional status. Taking into account the monetary, physical, and emotional costs associated with a hip fracture, the overall lifetime expense can be quite exorbitant.

Spinal Fractures

Americans experience approximately 700,000 vertebral fractures related to osteoporosis annually, one-fourth of which are the result of falling. The other 75% of clinically diagnosed spine fractures are primarily the result of excess stress on the spine caused by everyday activities. Spine fractures are typically observed in individuals 60 to 80 years old. Many spine fractures go undiagnosed because they produce no obvious symptoms to the patient. These “silent” fractures may involve compression of the vertebrae, can result in kyphosis and chronic back pain, and may be associated with an increase in morbidity. Although the majority of osteoporotic spine fractures are not the result of falling, they contribute to poor posture and therefore put individuals at risk for losing their balance and falling. Spine fractures rarely cause institutionalization, but their adverse affects influence most activities of daily living. This loss in functional status is mainly due to the pain caused by the fractures.

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Wrist Fractures

The rate of fracture of the wrist in the United States is approximately 250,000 per year. At least 90% of wrist fractures are caused by falling and they most often occur when a person attempts to break a fall by throwing the hands forward. They are the least devastating of the three common fracture types mentioned. Fractures of the wrist mainly occur in women in their mid-50s and usually have only a short-term impact. Although the overall impact of a wrist fracture is much less than that associated with a hip or spine fracture, it is nonetheless painful and requires repositioning of the bones and stabilization in a cast for four to six weeks. Wrist fractures may cause a number of short-term problems, including persistent pain, loss of function, nerve impairments, bone deformities, and arthritis.

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Lesson Three: Balance

As adults mature and advance into old age, the constant pull of gravity on their upright postures begins to take its toll. Balance becomes more difficult, the chances of falling increase, and the quick, youthful actions of jogging, running, and jumping are replaced with walking. Maintaining an adequate sense of balance into old age is crucial for preventing trips and falls in the last decades of life. Balance is the ability to maintain the body's position over its base of support within stability limits, both statically and dynamically. Stability limits are boundaries of an area of space in which the body can maintain its position without changing the base of support (i.e., without taking a step). Efficient standing balance requires that the body's center of mass (COM) be kept within stability limits, as defined by the length of the feet and the distance between them. The extent to which an older adult is willing or able to lean in any direction without having to change the base of support by taking a step illustrates his or her stability limits.

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Static Balance

Good posture is critical for ensuring adequate balance. Posture refers to the biomechanical alignment of the individual body parts and the orientation of the body to the environment. Standing efficiently requires the vertical alignment of each of the body's parts to expend the least amount of muscular energy. Although standing in one place requires no visible movement, a number of muscles are active in maintaining an upright posture and resisting the force of gravity. These muscles include the soleus, gastrocnemius, tibialis anterior, gluteus medius, tensor fasciae latae, iliopsoas, erector spinae, and abdominals.

Static balance refers to an individual's ability to control postural sway during quiet standing. Even when a young, fit individual who has excellent balance capabilities attempts to stand quietly on both feet, the body sways over its base of support. Given that it is impossible for someone to stand absolutely motionless, postural sway is the path of the body's movement in the anterior/posterior (i.e., sagittal) and lateral (i.e., frontal) planes while standing still. Postural sway is functionally significant because it is related to the risk of falling—specifically for those elderly who fall without warning and without a loss of consciousness, as opposed to those who trip and fall. This aspect of static balance is of interest because it may identify older people at a higher risk for falling, and for whom behavioral and physiological strategies can be developed and implemented to help prevent falls.

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Static Balance (Continued)

When older people stand quietly, the amount of postural sway is greater than in younger individuals, and greater in women than in men. When standing quietly with the eyes closed, postural sway is exaggerated in all individuals, but especially in the elderly. Additionally, maintaining static balance on one foot is much more difficult than maintaining stability over two feet because the base of support is smaller and the available neuromuscular response is much more limited. Not surprisingly, postural sway in elderly subjects is much more pronounced when balancing on one foot than in younger subjects. In fact, one of the most sensitive measures of aging is the ability to stand on one leg with the eyes closed. Explanations for the reduced stability limits seen in older adults include weakness in the muscles of the ankle joint, reduced range of motion about the ankles, neurological trauma (e.g., stroke, Parkinson’s disease), and a fear of falling. A significant reduction in an older adult’s stability limits, especially in the lateral and backward directions, increases his or her risk for falling.

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Dynamic Balance

During physical activity, an individual must maintain control of the body's COM while moving over the base of support. The act of maintaining postural control while moving is called dynamic balance. It is required when upper-body movements shift the COM (e.g., reaching for objects, opening doors), or when the position of the body changes from one location to another, as in locomotion.

Results from tests used to determine age-related differences in dynamic balance have revealed that elderly subjects' area of stability over the base of support is smaller than the area found in younger subjects. In other words, any small disruption to standing balance (e.g., a support surface on which an individual is standing moves unexpectedly) will quickly move older adult subjects beyond their limits of stability and require that they reach for something nearby or take a step to prevent a fall. When the support surface of the subjects unexpectedly moves forward, the response of younger individuals is to sequentially contract the tibialis anterior, quadriceps, and abdominals. A sequential contraction of the gastrocnemius, biceps femoris, and erector spinae takes place in young people when an unexpected backward movement of the support surface occurs.

Compared to the muscle sequences exhibited by young people, older individuals show significant differences in the order of muscle contraction and timing when their base of support moves unexpectedly. Older people exhibit a delay in contracting the balance support muscles, and sometimes the optimal sequence of muscle contractions is impaired in the aged. In addition, the balance of the elderly is more affected compared to younger individuals when a source of information about the balance process is lost (e.g., vision impairment).

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Balance Control Strategies

In humans, the attempt to control postural sway is accomplished by three distinct processes—the ankle, step, and hip strategies. In the ankle strategy, the upper- and lower body move in the same direction and the COM is restored to a position of stability through body movement centered primarily around the ankles. Due to the relatively weak force that can be generated by the muscles of the ankle, individuals normally use this strategy to control sway when they are standing in an upright position or swaying through a very small range of motion. Use of the ankle strategy requires intact range of motion and strength in the ankles. A firm, broad surface below the feet and an adequate level of sensation in the feet and ankles are also required for effective use of the ankle strategy.

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Balance Control Strategies (Continued)

The hip strategy involves activation of the larger hip muscles and is used when the COM must be moved more quickly back over the base of support to restore stability. An individual who uses the hip strategy moves the upper- and lower-body in opposite directions. Situations that require this strategy include responses to faster balance disturbances, standing on a compliant, or relatively unstable, support surface, and standing on a support surface that is smaller than the feet (e.g., balance beam). When standing on these surface conditions, the ankle strategy is no longer useful because there is not enough surface to push against to generate sufficient force to restore balance using the smaller ankle muscles. Effective use of the hip strategy requires an adequate amount of muscle strength and range of motion in the hip region. Additionally, sway in the lateral direction is controlled by the adductor and abductor muscles of the hip. Therefore, any weakness in these muscles will adversely affect lateral stability, a key element in efficient walking.

The final postural control strategy used to control balance is the step strategy. When the COM is displaced beyond stability limits or when the speed of sway is so fast that a hip strategy is no longer effective in maintaining the COM within stability limits, the step strategy is utilized. To prevent a fall during these conditions, an individual must take one or more steps in the direction of the loss of balance to establish a new base of support. Lower-limb strength and the speed with which it can be generated are two important characteristics of an effective step strategy. In other words, the ability of an individual to use the power of the legs, hips, and thighs to move rapidly during step initiation determines the success of this strategy. Furthermore, normal lower-body range of motion and adequate nervous system reaction speed are required for an effective step strategy. The three postural control strategies exist along a distinct movement pattern continuum, but it is important to realize that various combinations of these strategies can occur. In fact, many permutations of these strategies are used to manage balance.

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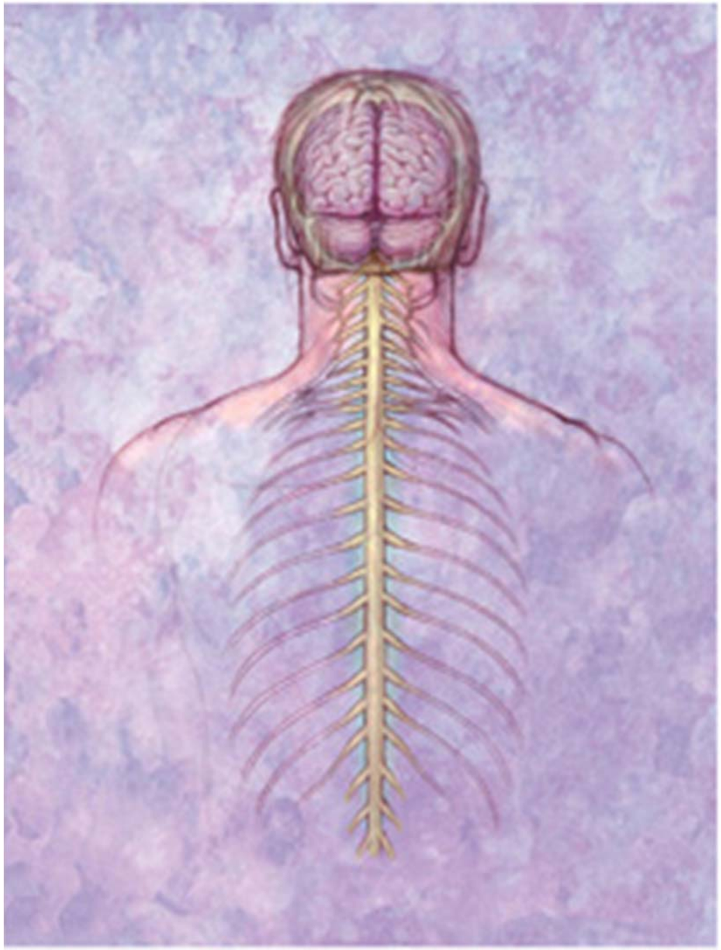
Lesson Four: Balance-related Sensory Systems

The central nervous system (CNS) holds the key to successful balance. The CNS must have an accurate picture of where the body is in space and whether it is stationary or moving. Peripheral inputs from three sensory systems—the visual, somatosensory, and vestibular systems—provide the CNS with information related to the body's position in space with respect to gravity and the environment. The visual system provides information related to where the body is in space, how fast it is moving, and what obstacles are likely to be encountered. The somatosensory system relays information from the skin, joints, and vibratory sensors, all of which help to detect body position. The vestibular system, located in the inner ear, provides information related to movements of the head. Although no separate system provides the CNS with all of the sensory information necessary to determine the body's position in space, each of the three systems contributes its own specific information about body movement and position. The sensory and motor systems are the key components of every balance-related effort, as they are inextricably combined to provide kinesthetic input and then select appropriate movements based on this input. In addition, the cognitive system is crucial for interpreting incoming sensations and planning motor responses related to balance. The cognitive system, which is composed of the processes of attention, memory, and intelligence, presents the ability to anticipate or adapt the body's actions in response to changing task demands and the environment.



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Vision

Humans rely heavily on visual inputs for balance. Visual information gives a reference for verticality, as many things in the environment, like doors and windows, are aligned vertically. The visual system also relays information regarding head motion, because as the head moves forward, surrounding objects move in the opposite direction. Furthermore, studies have suggested that peripheral vision is the most significant component of vision with regard to maintaining balance because it makes a very important contribution to the control of anterior-posterior sway. In fact, it has been suggested that older adults rely more on peripheral vision than young adults do and that the absence of peripheral vision leads to a greater frequency of falls.

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Vision (Continued)

Although vision is a significant component used by the CNS to maintain balance, it is not absolutely necessary. Most people can keep their balance with their eyes closed or when standing in a dark room. In addition, visual inputs are not always accurate sources of spatial information. For example, when an individual sits at a stoplight in a car, and the car next to him moves slightly, a likely response is for him to apply even more pressure on the brake. In this situation, visual inputs signal motion, which the brain initially interprets as self-motion; in other words, he thinks his car is rolling. The brain signals the motor neurons of the leg and foot to apply the brake to stop motion, even though the car is sitting still. Thus, visual input may be misinterpreted by the brain because it has a difficult time distinguishing between object-motion (i.e., exocentric motion) and self-motion (i.e., egocentric motion).

Throughout the aging process, vision becomes degraded and provides decreased or distorted information. As a result, poor visual acuity is associated with an increased number of falls in the elderly. With aging, most individuals lose their ability to detect the spatial information that is important for balance. For example, older adults need three times more contrast to see some stimuli at slow frequencies, and their depth perception and peripheral vision decline. These changes impair the quality of visual input received and will result in slower processing of the incoming sensory feedback, poor integration of sensory inputs, and an altered kinesthetic awareness. Consequently, an older adult's ability to avoid obstacles, negotiate terrain, and efficiently move about in low-light conditions will be negatively affected. Although age-related vision impairments make it difficult for the elderly to use visual inputs for balance control, information from the somatosensory and vestibular systems can be called upon to compensate for the declining visual system in most cases.

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The Somatosensory System

The CNS receives information from the somatosensory system regarding body position in space with reference to supporting surfaces as well as the relationship of body segments to one another. Somatosensory receptors include cutaneous and pressure receptors, and joint and muscle proprioceptors. In the absence of vision, the somatosensory system becomes the primary source of sensory information for maintaining upright balance and moving about in dark environments.

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The Somatosensory System (Continued)

When any mechanical stimulus is applied to the body's surface, cutaneous receptors in the skin relay this information to the CNS. Therefore, when the skin is contacted and changes in pressure on the skin occur, neural impulses are directed to the CNS. To exemplify the importance of this system as it relates to balance, think of the difficulty of standing up and walking after sitting in one position for a long time, restricting the blood supply to the lower limbs. This causes a temporary loss of function of the cutaneous receptors. Consequently, the feet and lower legs feel numb and the sensation of contact of the skin with the shoes and the changes in pressure that occur as the body weight rolls through the foot during walking are no longer available and balance becomes threatened. The process of aging brings about a decline in an individual's ability to sense cutaneous inputs. This results in a reduced ability to feel the quality of contact between the feet and the supporting surface. To measure the decline in cutaneous receptor activity due to aging, researchers test how accurately individuals can detect vibration of the skin, as vibration sense in the legs is used to control postural sway. The ability to detect vibratory stimuli has been shown to decrease significantly with age as the speed with which vibration information reaches the CNS and the amplitude of this information decreases. Additionally, older adults lose some sensitivity to touch as they age.

Muscle and joint proprioceptors provide information about the mechanical displacements of muscles and joints. Stretch receptors (i.e., muscle spindles) in the muscle signal a change in length when the muscle is stretched. Reflexively, the muscle contracts so that the desired muscle length and tension are obtained. For example, when the body leans forward, the calf muscles are stretched. This brings about a reflex contraction of the soleus and gastrocnemius to return the body to a more upright position and maintain balance within stability limits. Similarly, when a joint angle is changed, this information is relayed to the CNS via joint receptors. Muscle spindle activity and, to a lesser degree, joint receptor inputs are impaired with aging.

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The Vestibular System

The system of receptors located in the inner ear that is responsible for providing directional information as it relates to the position of the head is called the vestibular system. When the head moves, fluid rushes over hair cells within this system causing them to bend, which signals the head's position with respect to gravity (i.e., upside down, sideways, or tilted) and turning of the head. The vestibular system has a powerful influence over the motor neurons in the spinal cord that activate postural muscles (especially extensors) and thus contributes substantially to balance.

As early as age 30, hair cells within the vestibular system begin to decline in density, resulting in a reduced sensitivity to head movements. Individuals over age 70 may have lost 40% of the sensory cells within the vestibular system. Consequently, an increase in sway and risk of falling, especially when the visual and the somatosensory systems are impaired, are likely. Decreases in vestibular function also have been associated with visual problems and dizziness in older adults.

When individuals are moving around in a very dark environment and on an unstable surface, they primarily call on the vestibular system for balance. Additionally, the vestibular system helps to resolve conflicts that arise between the other sensory systems while in complex visual environments (e.g., crowded public places, traffic). Sensory conflict occurs when information provided by one or more sensory systems is not in agreement with one or both of the other sensory systems. Many older adults have reported that they dislike venturing into crowded malls or grocery stores because they feel unsteady due to people constantly moving in and out of their visual field. To compensate for this unsteadiness, they may push shopping carts for increased stabilization or simply avoid these types of sensory situations altogether. Undoubtedly, they are unable to resolve the conflict among the three sensory systems because they have lost their ability to identify and then quickly ignore the conflicting input from the visual and somatosensory systems.

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The Dynamic Equilibrium Model

The dynamic equilibrium model describes each of the processes that occur in the peripheral and central components of the sensory and motor systems that make up the perception-action cycle. The peripheral and central components play a part in first receiving and organizing sensory information and then using that input to generate the appropriate action. The peripheral component of the sensory system encompasses the visual, somatosensory, and vestibular systems, and the central component includes the transmission pathways and specialized areas within the CNS. The central component receives information from the visual, somatosensory, and vestibular receptors and compares, selects, and combines it so that the body's position in space can be determined accurately.

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The Dynamic Equilibrium Model (Continued)

The motor system, on the other hand, begins the process of determining what action, if any, is required based on the data from the sensory system. The central component of the motor system selects various muscle groups to carry out the action along with specific muscle contractile patterns necessary to accomplish the intended movement. Finally, the peripheral component of the motor system consists of the muscles throughout the body that are ultimately responsible for generating the required force to initiate the desired movement.

Because the transmission of these neural responses occurs so rapidly--in less than a quarter of a second--the CNS must have programs, much like computer programs, that organize balance information subconsciously and then automatically activate the appropriate correction mechanisms. These corrective balance programs are called motor response synergies and utilize characteristic muscular patterns of activation to counteract movements of the body's COM. These can be classified as both response synergies related to a loss of balance and preparation strategies for changes in balance.

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The Dynamic Equilibrium Model (Continued)

When the support surface on which one is standing is suddenly and unexpectedly perturbed forward, a normal counterbalance response is to sequentially contract the tibialis anterior, quadriceps, and abdominals to prevent falling backward. Conversely, an unexpected perturbation of the support surface backward results in sequential contractions of the gastrocnemius, biceps femoris, and erector spinae to prevent falling forward. Studies have shown that these two motor response synergies are altered in older subjects in four distinct ways [Woollacott, M.H., Inglin, B., & Manchester, D. (1988)]

- The tibialis anterior in older subjects contracts more slowly than in younger subjects when trying to counteract a postural sway backward.
- The activation sequence of older subjects' muscles is occasionally disrupted. This could result from inadequate muscular force during foot flexion and extension or because neurological deficits reduce the amount of information provided by the ankle joint receptors.
- The amplitudes of muscle activation in the synergistic response of older adults are more variable than those of younger individuals.
- The co-contraction of antagonistic muscles is greater in older subjects when compared to younger adults. Older adults are able to stiffen their joints by simultaneously contracting muscles that oppose each other, which reduces their ability to control the amount of movement required to maintain balance. This increased activation of co-contractors may be a result of a lack of confidence in balance ability experienced by many older adults. Furthermore, lack of confidence at any age has been associated with the contraction of muscles that do not contribute to balance. This act of contracting muscles that are nonspecific to the intended task is also commonly seen when people are learning a new skill and when they begin to fatigue in a well-learned skill.

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The Dynamic Equilibrium Model (Continued)

Motor response synergies that are activated prior to voluntary movements are called anticipatory postural adjustments and are specific to the movements to be made. For example, when planning to open a door, the body makes postural adjustments before extending the arm toward the door to counter the forces that will occur when the hand is applied to the door handle. Research on the anticipatory postural response patterns of older adults reveals that it is similar to that displayed in younger adults, but it may be delayed with faster movements. When a fast movement is necessary, the slower anticipatory postural response of older individuals delays the onset of the voluntary movement, the synergy is disrupted, and the quality of the movement is decreased. An example of this age-associated change can be observed when an older adult is asked to start or stop quickly, transition between different support surfaces, or negotiate obstacles in an environment. A decline in anticipatory postural adjustment ability will cause the elderly individual to decrease gait speed as an obstacle is approached and wait for a brief pause before the stepping action is initiated.

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The Cognitive System

Age-associated changes in the cognitive system also play an important part in maintaining balance in older adults. Adverse changes in the processes of attention, memory, and the ability to solve problems affect at least 10% of all individuals over the age of 65 and 50% of those older than 80. These declines in cognitive function, ranging from mild deficits to dementia, affect older adults' abilities to anticipate and adapt to changes occurring in the environment. Both the speed and accuracy of responses to incoming sensory data are influenced by the memory of a given situation and the ability to focus on more than one task at a time. Older adults' abilities to divide attention between different tasks, especially when one of those tasks involves balance, are more tenuous than for their younger counterparts. Consequently, several research studies have demonstrated that older adults must allocate more attention to the task of balancing. Finally, the decline in cognitive function that commonly occurs as a result of aging may affect older adults' abilities to quickly find solutions to movement challenges that they may not have encountered before or that are presented in a different way.

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Lesson Five: Other Factors that Affect Balance

In addition to the sensory and motor systems that regulate the body's posture and stability, muscular strength and self-confidence also contribute to the maintenance of balance.

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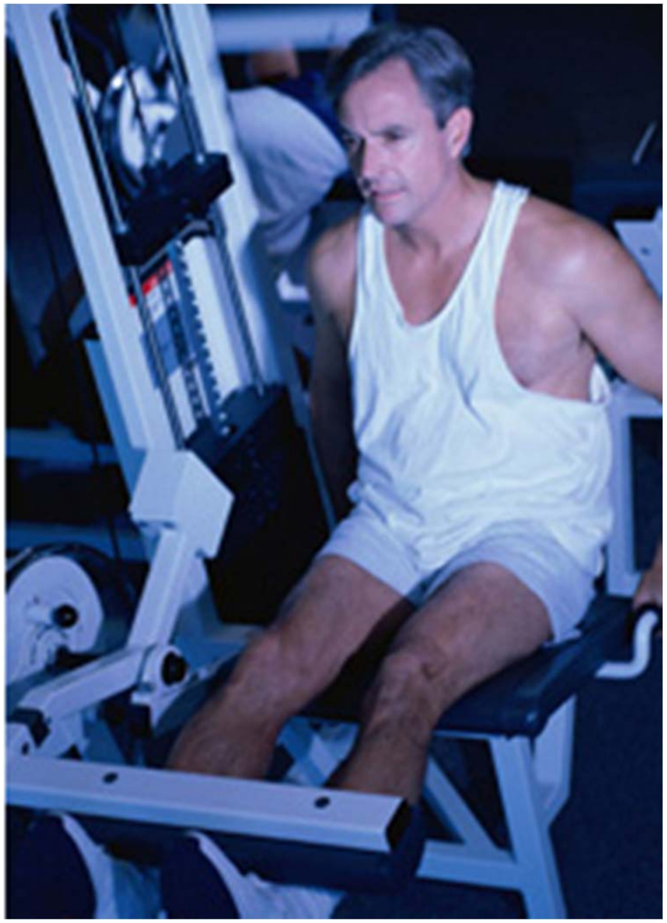
Leg Strength

Age-related decreases in muscular strength, particularly in the lower body, are associated with a degraded ability to maintain dynamic balance, walk, prevent falls, and move quickly. Muscle strength has been shown to decrease by as much as 30% between the ages of 50 and 70, most likely due to decreases in both the size and number of muscle fibers. This loss of strength directly affects an individual's ability to maintain balance and, therefore, prevent a fall. Research studies have shown that the muscles that exert force against the ground during walking and provide stabilization around the ankle joint are considerably weakened with aging (Vandervoot & Hayes 1989; Whipple et al. 1987). In addition, a decline in strength of the musculature that supports the knees has been associated with a greater risk for falling. Furthermore, older adults tend to use the hip or step strategy instead of the ankle strategy more often than younger adults when their balance is disrupted, which may be a result of weak lower-leg muscles. Adequate leg strength also plays an important role in walking for the older adult. Age-related declines in strength result in failure to lift the foot high enough during the swing phase of gait and, as a result, tripping is more likely. A loss of walking speed, which is common for seniors, is directly related to leg strength. Specifically, adequate calf muscle strength has been shown to significantly influence gait speed in older adults.



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Leg Strength (Continued)

It has been widely reported that physical inactivity is a primary contributor to the loss of muscle strength in older adults, and the causes of declining strength as a result of the aging process have been studied extensively. As noted earlier, a decrease in muscle fiber size and number plays a part in this decline. Although controversial, many researchers contend that aging brings about a selective loss of fast-twitch muscle fibers. One hypothesis contends that more fast-twitch than slow-twitch muscle fibers are lost because of a progressive and selective death of the large motor neurons that activate fast-twitch motor units (Engel 1970; Larsson 1978). Another theory claims that fast-twitch motor units transform, mainly through disuse, into slow-twitch units, altering the slow- to fast-twitch ratio and making it appear that fast-twitch fibers have been lost (Grimby & Saltin 1983). Despite the controversy surrounding the causative mechanisms of strength loss in the elderly, it is relatively well accepted among biogerontologists that muscle fibers, and therefore strength and function, are lost with aging.

Other skeletal muscle characteristics of the aging human body have been described. Results from laboratory testing and clinical observations reveal that muscle strength of the lower body declines more quickly with age than does muscle strength of the upper body (Asmussen & Heebol-Neilsen 1961; Larsson et al. 1979; Murray et al. 1985; Murray et al. 1980). This is a concern because studies of physical function of the frail elderly have shown that losses of lower-body strength are more problematic than losses of upper-body strength. Additionally, it has been reported that isometric strength is maintained better than dynamic strength, and that strength during eccentric, lengthening contractions is better maintained in the elderly than strength during concentric, shortening contractions. As a result, many older adults find it easier to lower themselves into a chair, which requires a lengthening contraction of the quadriceps, than to rise from a chair which requires a shortening contraction of these same muscles.

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Leg Strength (Continued)

In addition to bringing about a deterioration in strength, aging also negatively affects muscle endurance and power. A decrease in muscular endurance results in an earlier onset of fatigue during activity and places an older adult at an increased risk for loss of balance or a fall. A decrease in muscular power contributes to an older adult's inability to respond quickly and effectively to an unexpected loss of balance or the need to move rapidly in day-to-day situations.

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Confidence

Unlike the other characteristics that contribute to an individual's balance ability that are physical in nature, the fear of falling is a mindset that has been shown to increase an older adult's risk for suffering a fall. Many older adults lack confidence in their mobility and, as a result, are constantly afraid of falling. In fact, studies have shown that some older adults will avoid certain activities to prevent falling and rate their fear of falling to be greater than their fear of robbery, forgetting appointments, or financial difficulties.

The fear of falling manifests itself physically in older adults when they habitually stiffen their joints, causing unnecessary contraction of muscles and a flexed-forward posture. Many elderly people have an exaggerated fear of falling backward and hitting their heads or breaking their backs and hips. Consequently, the flexed-forward posture puts them at a more advantageous position to fall forward if a disruption in balance occurs, thereby resulting in potential fractures to the wrists and arms, but protecting their backs and hips. A flexed posture does place the body in a more stable position, but because it requires more muscular force to maintain, there is an increased reliance on muscular strength and endurance.

Impaired mobility contributes to a fear of falling, which in turn can contribute to further decrements in mobility. If an individual is haunted by a fear of falling, he or she is likely to avoid walking and being physically active, which minimizes the use of the musculoskeletal system, thereby weakening the muscles that play such an important role in maintaining balance. This reluctance to be active leads to more immobility and heightens an elderly person's lack of self-confidence in ambulation. Ironically, family and friends of older adults who fall, often compound the problem by discouraging walking after a fall. Ultimately, a perceived sense of insecurity related to balance may actually increase the likelihood of a traumatic fall.

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Lesson Six: Locomotion

The act of moving from place to place is called locomotion. Humans rely on walking as their primary physical form of locomotion, and to those who are ambulatory, walking may seem like a thoughtless, simple task. However, the act of walking is a complicated process that involves many physiological systems. Vision is required to monitor the direction and speed of movement, the vestibular system maintains equilibrium and provides information about acceleration, and the muscles, joints, and skin relay proprioceptive information that help the brain determine muscular forces and the angles produced at the joints. Walking is a complex process of transferring the COM from one foot to the other in a series of successive losses of balance. In other words, when people walk they are continuously disrupting their balance and forming a new base of support with each step forward.

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Gait

Walking is cyclical in nature and can be described via the gait cycle--the time between the first contact of the heel of one foot with the ground and the next heel-ground contact with the same foot. Human gait is subdivided into support and swing phases. The support (or stance) phase of the gait cycle starts when the foot strikes the ground, and the swing phase begins when that same foot leaves the ground. When walking at a comfortable speed, most adults spend 60% of the gait cycle in the stance phase and 40% in the swing phase. Approximately the first and last 10% of the stance phase is spent in double support (i.e., when both feet are in contact with the ground). The single-support phase is the period when only one foot is in contact with the ground, and the opposite limb is in the swing phase.

Successful, efficient walking requires the achievement of three main tasks: weight acceptance, single-limb support, and limb advancement. Of the three tasks, weight acceptance (initial contact and loading) is the most demanding. It requires sufficient knee flexion (approximately 15 degrees) to help absorb the shock associated with accepting the body's full weight on impact, adequate limb stability as the foot makes contact with the ground, and the ability to keep the body's COM moving forward in preparation for the swing phase of gait. The muscle groups involved in completing this task are the hip extensors (to provide limb stability), quadriceps (to limit knee flexion), and dorsiflexors (which are engaged during heel strike and foot contact with the ground, and in preparation for limb loading).

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Gait (Continued)

Single-limb support includes two important components--supporting the total body weight on one leg while simultaneously moving the body forward in preparation for the swing phase. The key muscle groups engaged during this task include the hip abductors (to stabilize the hip), trunk muscles (to maintain an upright position), quadriceps (to assist forward progression of the COM), and plantar flexors (to regulate the anterior movement of the tibia during the middle and final portions of the stance phase).

Finally, limb advancement involves lifting the limb off the floor and advancing it forward in front of the body. Knee flexion of approximately 35 degrees initiates this task as the body prepares to lift the foot off the floor. The knee will continue to flex to approximately 60 degrees to allow for toe clearance prior to reaching full extension in preparation for heel contact. Stride length is determined by how far the limb is advanced during this phase. The muscle groups required for limb advancement are the hip flexors (to bring the thigh forward and assist in clearing the foot from the floor), knee flexors (for limb clearance), and quadriceps, dorsiflexors, and hamstrings (for preparation of heel contact).

Clearly, all of the muscle groups described in these three major tasks must remain strong to maintain the quality of the gait pattern and minimize the risk of falls. Additionally, adequate joint range of motion, appropriate sequencing of muscle activation during the gait cycle, and accurate sensory input from the visual, somatosensory, and vestibular systems are essential for the maintenance of a normal gait pattern throughout life.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Age-associated Changes in Gait

Aging adversely affects an individual's gait pattern. The most obvious change is the variance in gait speed among older and younger adults. Even healthy older adults with no history of falling walk at a preferred speed that is approximately 20% slower than the walking speed of younger adults. In addition, when asked to walk at a fast speed, older adults are approximately 17% slower than younger adults who are asked to do the same. Interestingly, the slower gait speed that accompanies aging is not due to a decreased cadence, but is the result of a decrease in stride length. This decrease in stride length has negative consequences for other aspects of the gait cycle, including reduced arm swing and rotation of the hips, knees, and ankles; increased double-support time; and a more flat-footed contact with the ground during the stance phase prior to toe-off. Thus, older adults take more steps to cover the same distance, and the time when both feet are on the ground is longer.

One explanation for the decreased function related to gait in the elderly is the theory of motion economy. Locomotion requires the expenditure of energy. Researchers theorize that in both humans and animals gait speeds are chosen that are most economical in terms of energy consumption [Larish, D.D., Martin, P.E., & Mungiole, M. (1988)]. Humans, presumably, prefer certain speeds of walking because those speeds are the most economical for them based on their body structure, weight, muscular strength, and flexibility. Therefore, older walkers may use the strategy of increasing stride frequency instead of stride length because it maximizes their motion economy. Furthermore, endurance of weaker lower-body muscles is maximized with shorter strides, and the energy cost of walking is minimized.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Age-associated Changes in Gait (Continued)

Another possible explanation is that slower gait speeds allow older adults to spend more time monitoring the progress and result of walking and to respond to changes in the environment. Additionally, limited ranges of motion in the ankles and knees are responsible for a shortened stride length. Finally, a decreased ability to balance encourages older individuals to spend less time in the single-support phase of gait, thereby increasing time spent in double-support and ultimately slowing gait speed.

Common adaptations in the gait cycle seen in the elderly are the tendency to load the limb more cautiously during weight acceptance, a flatter foot-to-floor contact pattern, less forward advancement of the limb during single-limb support, and reduced flexion during the pre-swing and swing phases of gait. Furthermore, older adults approach obstacles more cautiously, reducing their gait speed and clearing the obstacle using slower, shorter steps. In addition, they cross the obstacle so that it is 10% farther in front of them in their crossing step when compared to younger adults' stepping strategies. This reduction in step length does actually decrease the risk for tripping, but it may also cause the heel of the foot to contact the object before it returns to the ground on the other side. Thus, because older adults make more obstacle contact, their risk of tripping and falling while negotiating an obstacle is higher.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Lesson Seven: Factors That Contribute to Falling

The causes of falls in older adults can be divided into two categories: a stimulus that results in the loss of balance (e.g., dizziness, fainting, uneven terrain), and an inability to correct for an unexpected loss of balance (i.e., decreased reaction time, diminished CNS integration, decreased strength, and limited joint range of motion). Therefore, the condition of the skeletal and neuromuscular systems, cognition, use of medication, and the status of the surrounding environment all influence the causes of falls.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Neurological Conditions

Gait patterns are adversely affected by certain neurological conditions, including stroke, Parkinson's disease, peripheral neuropathy, cerebellar ataxia, and Alzheimer's disease. Although each neurological disorder causes its own specific gait pathology, the type and severity of the problems will vary depending on the medical condition and among the individuals diagnosed with the same disorder.

The one-sided muscle weakness and increases in muscle tone (spasticity) that often accompany a stroke result in a gait pattern that is asymmetrical. Individuals who suffer a stroke and are left with impaired gait typically exhibit a "step-to" pattern wherein the impaired limb steps forward and the unimpaired limb catches up to it on the next swing phase but does not pass it, as would be observed in a normal gait pattern.

In contrast, an older individual with Parkinson's disease exhibits a shuffling gait pattern in which the foot is flat upon initial contact, the muscles are rigid, trunk rotation is limited, and the posture is stooped forward. Parkinson's disease degrades an individual's ability to initiate locomotion and control the degree of movement during the gait pattern. As a result of the characteristic shuffling movement, older adults suffering from this condition are not able to adequately clear the floor with the foot during walking and are more likely to trip during the swing phase of gait.

Peripheral neuropathy, often associated with the damaging effects of uncontrolled diabetes, impairs the continuous flow of somatosensory information from the lower body that is crucial for a normal gait pattern. Abnormalities that are observed with this condition include walking with a wider base of support, a slower velocity, and a decreased ability to clear the foot from the floor during the swing phase of gait. Because individuals suffering from peripheral neuropathy lose sensation in the feet and lower limbs, their ability to adapt their gait patterns to different surfaces is compromised, especially when vision is impaired.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Neurological Conditions (Continued)

The cerebellum plays a vital role in balance by providing continuous error detection and correction information. Thus, any damage to the cerebellum will result in an abnormal gait that is termed ataxia. Walking characteristics of individuals with cerebellar ataxia include a wide base of support and irregular or unpredictable step lengths. In addition, individuals may veer to the right or left when walking and have difficulty stopping, starting, and turning.

Finally, Alzheimer's disease patients exhibit an abnormally slow gait pattern that also includes shuffling. Excessive knee flexion throughout the entire gait cycle and reliance on verbal cueing to maintain the walking pattern are also observed in Alzheimer's patients. Older adults with dementia are at an especially high risk for falling and should be closely observed during physical activities.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Orthopedic Conditions

Older adults who lose passive range of motion and exhibit restricted movement patterns during certain phases of the gait cycle are at a higher risk for falling. Many older individuals have arthritis, which results in pain and articular problems of the toes, ankles, knees, hips, or spine. The discomfort experienced with arthritis causes the elderly to attempt to relieve the mechanical stress that occurs during walking by altering the gait pattern. Furthermore, fractures and total joint replacement surgery also are associated with abnormal gait patterns in older adults.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Cardiovascular Disease

Several cardiovascular conditions result in pathological gait patterns. One very common problem is orthostatic hypotension, wherein individuals experience a fluctuation in blood pressure upon standing that causes dizziness and balance loss during the gait cycle. The reduced amount of blood flow to the brain can cause a temporary loss of consciousness and major disruptions in the flow of postural control information reaching the brain. Many older adults have high blood pressure and are on medication to control it. However, they are more affected by the medications than are younger adults and react less quickly to challenges in homeostasis. Intermittent claudication, which causes chronic pain in the calves, also leads to pathological gait patterns. In addition, gait speed is generally slower in older individuals with cardiovascular disease due to the lack of cardiorespiratory conditioning.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Medication

The use of prescription drugs in the elderly is associated with an increased risk for falls. It has been shown that older adults who are taking four or more prescription medications are four times more likely to experience a fall than their peers who are taking fewer medications. Side effects related to these drugs (e.g., dizziness, reduced alertness, weakness, fatigue, postural hypotension) adversely influence an individual's gait pattern. Furthermore, specific types of medications (i.e., antianxiety, antidepressants, hypnotics/sedatives, diuretics) are more likely to cause a fall.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Environmental Hazards

Hazards experienced in the home environment are one of the most common causes of falls in independent-living elderly. Slippery bathtub floors, absence of grab bars, low toilet seats, torn or loose rugs, inaccessible light switches, wet or waxed floors, shelves that are too high, and unstable tables and chairs have been associated with falls in older adults. In addition, descending or ascending a flight of stairs also has been shown to produce falls in the elderly. Studies researching fall prevention in the home have demonstrated that many falls can be prevented if individuals consistently wear appropriate footwear and prescription corrective lenses. Outside the home, uneven sidewalks, varying curb heights, and sloping driveways also present fall-related risks for older adults.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Intrinsic Characteristics of Fallers

Intrinsic factors associated with an older adult's risk for falling include being over age 80, being female, and having a history of falls. Fallers are most likely individuals who take more steps to turn in a complete circle, cannot stand up from a chair without pushing off, have a high prevalence of antidepressant use, and have impaired kinesthetic awareness. In addition, they also have unusually weak hip adductors, knee extensors, knee flexors, and ankle dorsiflexors. They may experience moderate dementia, episodes of dizziness, have an impaired gait, and have problems with activities of daily living. Finally, people who routinely take several medications may fall more often.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Lesson Eight: Exercise as a Strategy to Prevent Falling

An improved level of physical fitness can be an effective strategy to combat falls in the elderly. An effective exercise program enhances muscular strength and endurance, flexibility, and motor control. Additionally, cardiorespiratory training, which improves an individual's aerobic capacity, can also facilitate positive changes in body composition (i.e., decreased total body weight and fat weight) that contribute to better balance by making the task easier for the neuromuscular system. Studies have shown that older subjects who are physically fit are better at controlling their balance in single-leg balance and functional walking tests than their non-active peers. Additionally, older, physically fit subjects who undergo tests that produce unexpected balance perturbations typically show the same muscle activation patterns as those seen in younger subjects. It is theorized that regular physical activity enhances balance by providing daily challenges and practice opportunities for the body's balance mechanisms. Furthermore, chronic physical activity may also increase the self-confidence of older adults in their abilities, in turn enhancing mobility.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Exercise as a Strategy to Prevent Falling (Continued)

There are several reliable physical function assessments that fitness professionals can use to measure balance and mobility in their older adult clients. These assessments are important because they may facilitate the early identification of older adults who are beginning to experience significant changes in multiple sensory systems resulting in observable changes in postural stability and mobility. After interpreting assessment results, fitness professionals can determine an appropriate exercise plan to target the impaired sensory systems. Furthermore, administering the same balance and mobility tests on a regular basis allows fitness professionals to use the assessment results to guide them in selecting new exercises, progressing existing exercises, or deleting certain exercises from the training program. Two tests used to measure functional limitations associated with the performance of daily activities requiring balance are presented here. They are the Fullerton Advanced Balance Scale (Rose & Lucchese 2003) and the Berg Balance Scale (Berg et al. 1992).

The Berg Balance Scale (BBS) represents an individual's ability to perform a series of functional tasks that require balance. Many of the tasks simulate activities likely to be encountered by older adults in their daily lives such as transfers, object retrieval, and turning. The BBS also may be used for identifying older adults who need intervention in the way of a comprehensive functional balance-training program. The BBS is recommended for assessing lower-functioning older adults. Detailed test administration procedures, a scoring form, a list of the possible underlying sensory impairments associated with poor performance, and a set of recommended exercises to address the identified impairments can be found in Appendix A.

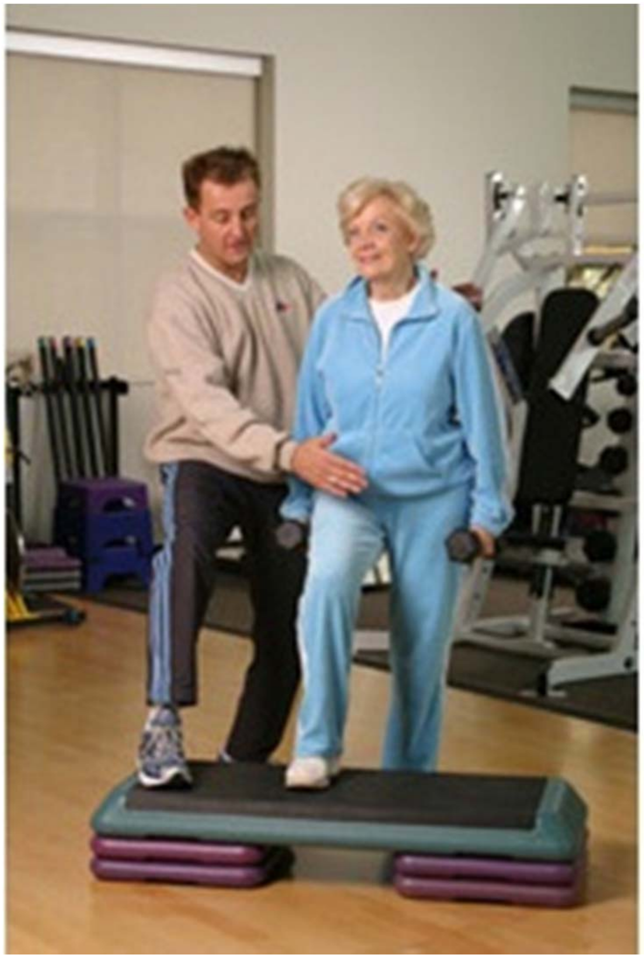
Exercise as a Strategy to Prevent Falling (Continued)

The Fullerton Advanced Balance Scale (FAB) is designed to measure changes in balance occurring in higher-functioning older adults. Therefore, it is appropriate for use with community-dwelling older adults who are most likely to enroll in a community-based program. The FAB Scale consists of 10 items that include a combination of static and dynamic balance activities performed in different sensory environments as well as items that may help identify those at risk for falling as a result of sensory impairments. The FAB Scale was created for use as an alternative to the BBS as the BBS tends to produce a ceiling effect (i.e., very high scores on repeated tests) when administered to higher-functioning older adults with impaired balance. Also, the BBS has been criticized for its lack of sensitivity in identifying various sensory system impairments. An individual's performance on the FAB Scale can be interpreted and the possible underlying balance impairment identified so that exercise progressions that specifically target those impairments can be selected. Detailed test administration procedures, a scoring form, a list of the possible underlying sensory impairments associated with poor performance, and a set of recommended exercises to address the identified impairments can be found in Appendix B.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Balance Training

A comprehensive balance-training program should include activities that increase a participant's awareness of his or her COM, utilize multisensory mechanisms, and enhance the gait pattern. The ultimate goal is to tailor the exercises in the balance-training program to increase the older adult's capacity to perform activities of daily living (e.g., reaching for, picking up, and carrying objects, performing household tasks, reacting to obstacles in the environment). Older adults can incorporate balance-training activities into the beginning of their current exercise sessions or they may choose to perform a series of balance exercises on separate days apart from other types of training. A frequency of two to three nonconsecutive days per week is adequate for enhancing balance through training. However, fundamental balance principles can be applied on a daily basis as individuals transfer what they learn from their balance-training exercises to the functions of daily living.



Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Balance Training (Continued)

When older adults develop an increased awareness of COM, they are able to maintain a better upright position during sitting and standing, lean away from and return to midline with more postural control, and move through space more quickly and confidently. Activities that enhance COM awareness are performed seated, standing, or while moving. Different levels of balance challenge can be added by manipulating the type of support surface used for the exercise and reducing or eliminating visual feedback. These tactics require the participants to use the vestibular system as the primary system for maintaining balance because both the somatosensory and visual systems are compromised.

An introductory seated balance exercise involves having the participant sit in a chair with back support and keep the feet flat on the floor. The participant should practice sitting with the back against the chair and maintaining correct posture (i.e., eyes focused forward on a target, chin gently pulled back, ears directly above the shoulders, shoulders placed slightly back and down, abdominal muscles gently pulled up and in). Have the participant hold the position for 15 seconds, while breathing normally and relaxing the rest of the body. Individuals who are unable to achieve correct sitting posture while seated on a stable surface are not ready to progress to a more difficult seated balance challenge. If the participant successfully completes the introductory seated posture exercise, he or she is ready to try the same exercise in an unsupported sitting position before then performing the exercise while seated on an unstable surface (e.g., Dyna-discTM, balance ball). The individual should attempt to hold correct posture for 30 seconds with the eyes focused on a forward visual target. Next, the exercise can be repeated with the eyes closed. Finally, for added balance challenges, the participant can add arm and leg movements while focusing on maintaining a correct seated posture.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Balance Training (Continued)

Beginning standing-balance activities teach the participant how to maintain correct standing posture while performing various tasks. To begin, participants should check their standing postures (i.e., eyes focused forward on a target, chin gently pulled back, ears directly above the shoulders, shoulders placed slightly back and down, abdominal muscles gently pulled up and in, hips level, kneecaps facing forward, ankles and feet straight, weight evenly distributed on both feet). Have the participant hold the position for 15 seconds, while breathing normally and relaxing the rest of the body. Next, the participant should attempt to close his or her eyes for 15 seconds and concentrate on the feeling of standing correctly. To progress the standing-balance activities, the base of support is altered so that subtle shifts of the COM are required to maintain an upright posture. A typical altered base of support challenge starts with the individual standing with the feet together, holding the position for 15 to 30 seconds. The same exercise is repeated with the eyes closed. Next, the participant moves the feet to a tandem position (front foot ahead of the rear foot with a small space between the feet) and holds for 15 to 30 seconds. The same exercise is repeated with the eyes closed. Finally, the participant adopts a single-leg stance and holds the position for 15 to 30 seconds. The same exercise is repeated with the eyes closed. Other ways to manipulate the balance challenge during standing exercises are to alter the position of the arms or change the support surface beneath the feet (e.g., foam pad, rocker board, Dyna-discTM, half of a foam roller).

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Balance Training (Continued)

Adding movement to standing-balance tasks is the next progression for challenging balance. These activities enhance motor coordination and adaptive postural control by requiring the participant to march in place and turn the head to one side. This will help older adults improve daily activities that might require them to turn their heads during walking, for example, to check oncoming traffic as they cross the street. To begin, the participant marches in place for 30 seconds on a firm surface with emphasis on lifting the knees toward the ceiling. Correct posture should be maintained with the upper body and head erect and the eyes directed forward. Next, the participant continues marching while turning the head one-quarter turn to the right for eight counts. The participant returns the head to the forward position for eight counts before turning the head one-quarter turn to the left for eight more counts. The next progression in this series is to have the participant continue to march while turning the head and body together for each eight-count quarter turn. Any of the above COM awareness training activities can be progressed to a more difficult level by adding any of the following: external timing component (e.g., music, counts), a secondary task (e.g., count backward, reaching, throwing and catching objects), reduced vision (dark sunglasses), eyes closed, or looking at a wall with a busy visual pattern (e.g., checkerboard).

The exercises used to enhance the gait pattern build on the balance activities previously described. They are intended to help older adults achieve a gait pattern that is efficient, flexible, and adaptable to changing task and environmental demands. To begin, participants should practice walking with directional changes and abrupt starts and stops. For example, the participant makes an abrupt start or stop on command (e.g., verbal, whistle, music). Progress the difficulty by having the participant change direction on verbal command as well as complete quarter, half, and full turns on command. The activity can be repeated using various gait patterns (e.g., backward, side step, marching with high knees).

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Balance Training (Continued)

The next level of balance challenge involves walking with an altered base of support to develop a more flexible gait pattern. For this activity, the participants begin by walking forward with a narrow step width (2 inches) and then change to walking with a wide step width (8 to 12 inches). Participants can then combine narrow and wide steps by completing a certain number of narrow steps followed by the same number of wide steps, or by varying the number of each type of step. To progress to the next level, participants walk forward with normal-width steps exclusively on their heels or on the balls of their feet. Heel and toe walking can then be combined by completing a certain number of heel steps followed by the same number of toe steps, or by varying the number of each type of step.

Finally, one of the best ways to challenge the gait pattern is an obstacle course. The level of challenge can be increased by manipulating the task or environmental demands. Examples of increasing the task demands include: increasing the number of obstacle types that must be negotiated along the course, introducing an object to be carried through the course (e.g., laundry basket, grocery bag), introducing a cognitive task while negotiating the course (e.g., counting by twos), and introducing an external timing demand. Environmental demands that can be manipulated to alter the challenge of an obstacle course include wearing dark glasses while walking the course, walking on different support surfaces throughout the course, and multiple participants (i.e., two to four) negotiating the same obstacle course at the same time.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Balance Training (Continued)

The balance-training activities previously described will do much to enhance an older adult's balance and mobility capabilities as they age. However, permanent losses, such as vision impairment related to eye disease (e.g., age-related macular degeneration, glaucoma), are beyond the control of exercise modalities. With regular balance training, older individuals can expect to enhance all three balance systems (visual, somatosensory, and vestibular) so that losses to any one of the systems can be compensated for by the improved functions of the other two systems. The balance activities presented here are by no means a comprehensive listing of available exercises for improving one's balance abilities. The reader is encouraged to review the resources list to find additional information and guidelines on balance training and fall prevention.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Muscular Strength and Power

The loss of muscle mass and declines in strength and power associated with aging has a profound effect on an older adult's ability to maintain balance, walk, and perform activities of daily living. It has been reported that 28% of men and 66% of women over the age of 74 years cannot lift objects that weigh more than 10 pounds, which equates to the weight of a typical bag of groceries. Many daily functional tasks (e.g., stair climbing, rising from a seated position, walking) demand specific levels of lower-body muscle power, and studies have demonstrated that age-related declines in power are much greater than the declines observed for muscle strength. Therefore, activities designed to increase both strength and power should be included in a balance- and mobility-training program.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Muscular Strength and Power (Continued)

A resistance-training program for older adults should focus on exercises that load the spine and enhance posture, such as lat pull-downs, seated rows, abdominal crunches, and prone spine extensions. In addition, exercises to protect and strengthen the hips are important (e.g., squats, lunges, and hip adductor/abductor exercises). Although the American College of Sports Medicine (ACSM) guidelines recommend that individuals over the age of 50 lift relatively light weights for 10 to 15 repetitions, keep in mind that more resistance and fewer repetitions are required for optimal strength preservation and bone maintenance and building (i.e., 75 to 80% 1 RM for six to eight repetitions). Therefore, starting a resistance-training program at a lower intensity is appropriate, but the ultimate goal is to get the older adult training with greater levels of resistance to promote strength and preserve bone mass. For power, an older individual's exercise program should include a combination of various directional lunges to enhance reaction time and to train the lower body to respond to balance challenges in different planes of movement. Of course, multidirectional lunges require advanced skills and should be attempted only when the individual is physically and mentally prepared to take on the task.

As with any resistance-training program, the principle of gradual progression must be followed to ensure the participant's safety and the effectiveness of the workout. Older adults should choose a weight or resistance that allows them to perform between eight and 15 repetitions before fatiguing. Once they can consistently complete 15 repetitions of an exercise, they should be encouraged to increase the amount of weight or level of resistance by 2 to 5%. Many strength activities can be performed seated or standing. Unstable or weak participants should begin performing strength-training exercises in a seated position to minimize the stability requirements and reduce their risk of falling during the movement. Once a participant is able to consistently demonstrate correct form during an exercise and exercise performance improves, he or she is ready to add a balance component. This can be achieved by first having the individual perform the strength activity seated on a compliant, or relatively unstable, surface (e.g., a Dyna-discTM placed on a chair, balance ball). The next balance progression of standing on a compliant or moving surface (e.g., foam pad, rocker board) can be added once the participant consistently demonstrates correct form and improved performance in the seated position.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Muscular Strength and Power (Continued)

ACSM General Exercise Guidelines for Healthy Adults

Resistance

- *Frequency*

  2-3 days per week; allow 48 hours rest between workouts
- *Intensity*

  1 set of 3-20 reps to volitional fatigue (e.g., 19-20 RPE) or stop 2-3 reps before volitional fatigue (e.g., 16 RPE). 1 set of 10-15 reps for older adults (over 50 years of age)
- *Time*

  Working the 8-10 major muscle groups and pairing a 1-sec. concentric contraction with a 2-sec. eccentric contraction, or a 2-sec. concentric contraction with a 4-sec. eccentric contraction
- *Type*

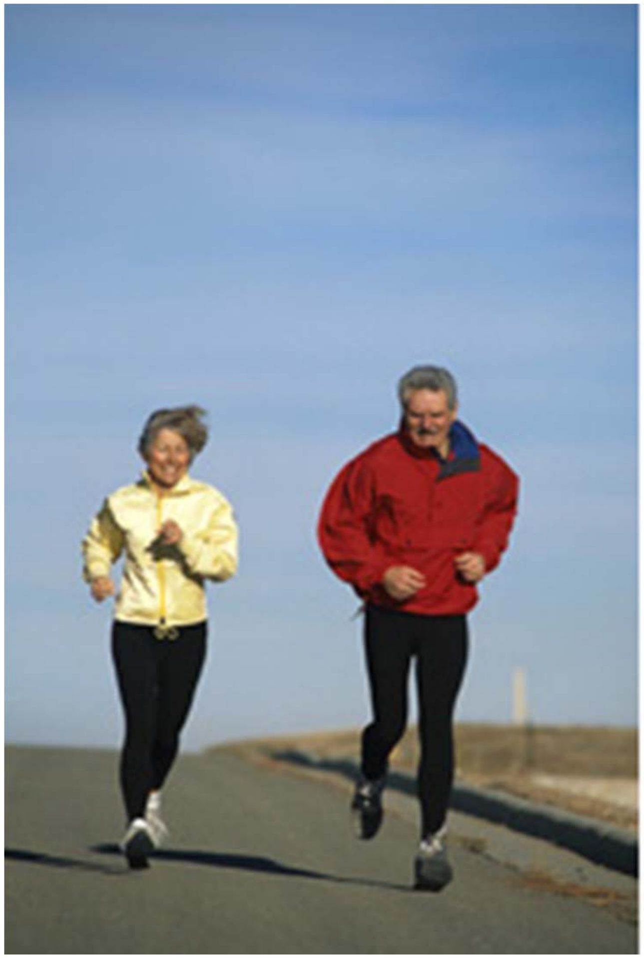
  Free weight, machines, elastic resistance, calisthenics

Source: ACSM (2006). Reprinted from ACSM's Guidelines for Exercise Testing and Prescription (7th ed.) with permission from Lippinott Williams & Wilkins.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Cardiorespiratory Endurance

Aerobic exercise guidelines for older adults are consistent with the current American College of Sports Medicine guidelines for the average healthy adult. Although aerobic capacity tends to decline at a rate of 5 to 15% per decade after age 30, studies have shown that at least half of this decline could be avoided by participating in a regular exercise program. Aerobic exercise for older individuals should focus on a variety of low-impact weightbearing modalities to combat bone and muscle loss. For inactive individuals, 30 minutes of moderate aerobic activity, such as walking, most days of the week is sufficient for enhancing health and well-being. Gradually increasing aerobic exercise intensity and duration is an appropriate goal for those who want increased body-fat reduction and improved cardiovascular fitness.



Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Cardiorespiratory Endurance (Continued)

ACSM General Exercise Guidelines for Healthy Adults

Cardiorespiratory

- *Frequency*
  3-5 days per week
- *Intensity*
  40/50-85% heart rate reserve
- *Time*
  20-60 minutes
- *Type*
  A variety of weightbearing modalities (e.g., walking, jogging, elliptical training, stair climbing)

Source: ACSM (2006). Reprinted from ACSM's Guidelines for Exercise Testing and Prescription (7th ed.) with permission from Lippinott Williams & Wilkins.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Flexibility

As one ages, maintaining flexibility becomes increasingly important. Loss of range of motion impairs most functions needed for good mobility. Maintaining lower-body flexibility is vital for preventing low-back pain, musculoskeletal injury, and gait abnormalities, and in reducing the risk of falling. Limited range of motion in the shoulder girdle has been associated with pain and postural instability. Both upper- and lower-body flexibility decrease with age, but can be improved through stretching. A flexibility program for an older adult should include a consistent routine of stretches for the important postural muscles of the chest, trunk, hips, and thighs. Although ASCM recommends stretching two to three days per week, a daily flexibility program performed after an appropriate warm-up consisting of static stretches for the whole body can do much to enhance an older person's flexibility.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Flexibility (Continued)

ACSM General Exercise Guidelines for Healthy Adults

Flexibility

- *Frequency*

  Minimum of 2-3 days per week; ideally, 5-7 days per weeks
- *Intensity*

  To the point of mild discomfort
- *Time*

  A 15-30 second static hold for 2-4 repetitions
- *Type*

  A variety of weightbearing modalities (e.g., walking, jogging, elliptical training, stair climbing)

Source: ACSM (2006). Reprinted from ACSM's Guidelines for Exercise Testing and Prescription (7th ed.) with permission from Lippinott Williams & Wilkins.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

Conclusion

Falls represent one of the biggest threats to the health and functional independence of older adults. Unfortunately, falls are common among older adults and often result in debilitating fractures. Thus, taking steps to prevent falls in the older adult population is a worthwhile task. Factors contributing to falls include problems with balance, mobility, vision, lower-extremity weakness, and/or blood pressure or circulation. These problems are often compounded by illness, medication, or environmental stressors that can lead to a fall. The following preventative measures to help reduce falls in the elderly have been suggested: regular vision checks; careful monitoring of medications that may cause dizziness, low blood pressure, or confusion; and addressing environmental challenges or obstacles that can lead to falls. Perhaps most important, the adoption of a regular physical-activity program that includes cardiorespiratory exercise, resistance and flexibility training along with balance and mobility activities is crucial to keeping older adults active, healthy, and functional into old age.

Berg Balance Scale

Source: Berg, K.O. et al. (1992). Measuring balance in the elderly: Validation of an instrument. *Canadian Journal of Public Health*, 2, S7–S11. Reprinted with permission.

Name: ____ Date of Test: ____________

1. Sit to stand

Instructions: "Please stand up. Try not to use your hands for support."
Grading: Please mark the lowest category that applies.
( ) 0 Needs moderate or maximal assistance to stand
( ) 1 Needs minimal assistance to stand or to stabilize
( ) 2 Able to stand using hands after several tries
( ) 3 Able to stand independently using hands
( ) 4 Able to stand with no hands and stabilize independently

2. Standing unsupported

Instructions: "Please stand for 2 minutes without holding onto anything."
Grading: Please mark the lowest category that applies.
( ) 0 Unable to stand 30 seconds unassisted
( ) 1 Needs several tries to stand 30 seconds unsupported
( ) 2 Able to stand 30 seconds unsupported
( ) 3 Able to stand 2 minutes with supervision
( ) 4 Able to stand safely for 2 minutes
If person is able to stand 2 minutes safely, score full points for sitting unsupported (item 3). Proceed to item 4.

3. Sitting with back unsupported with feet on floor or on a stool

Instructions: "Sit with arms folded for 2 minutes."
Grading: Please mark the lowest category that applies.
( ) 0 Unable to sit without support for 10 seconds
( ) 1 Able to sit for 10 seconds
( ) 2 Able to sit for 30 seconds
( ) 3 Able to sit for 2 minutes under supervision
( ) 4 Able to sit safely and securely for 2 minutes

4. Stand to sit

Instructions: "Please sit down."
Grading: Please mark the lowest category that applies.
( ) 0 Needs assistance to sit
( ) 1 Sits independently, but has uncontrolled descent
( ) 2 Uses back of legs against chair to control descent
( ) 3 Controls descent by using hands
( ) 4 Sits safely with minimal use of hands

5. Transfers

Instructions: "Please move from chair to chair and back again." (Person moves one way toward a seat with armrests and one way toward a seat without armrests.) Arrange chairs for pivot transfer.

Grading: Please mark the lowest category that applies.

( ) 0 Needs two people to assist or supervise to be safe
( ) 1 Needs one person to assist
( ) 2 Able to transfer with verbal cueing and/or supervision
( ) 3 Able to transfer safely with definite use of hands
( ) 4 Able to transfer safely with minor use of hands

6. *Standing unsupported with eyes closed

Instructions: "Close your eyes and stand still for 10 seconds."

Grading: Please mark the lowest category that applies.

( ) 0 Needs help to keep from falling
( ) 1 Unable to keep eyes closed for 3 seconds but remains steady
( ) 2 Able to stand for 3 seconds
( ) 3 Able to stand for 10 seconds with supervision
( ) 4 Able to stand for 10 seconds safely

7. *Stand unsupported with feet together

Instructions: "Place your feet together and stand without holding on to anything."

Grading: Please mark the lowest category that applies.

( ) 0 Needs help to attain position and unable to hold for 15 seconds
( ) 1 Needs help to attain position, but able to stand for 15 seconds with feet together
( ) 2 Able to place feet together independently, but unable to hold for 30 seconds
( ) 3 Able to place feet together independently and stand for 1 minute with supervision
( ) 4 Able to place feet together independently and stand for 1 minute safely

The following items are to be performed while standing unsupported.

8. *Reaching forward with outstretched arm

Instructions: "Lift your arm to 90º. Stretch out your fingers and reach forward as far as you can." (Examiner places a ruler at end of fingertips when arm is at 90º. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the person is in the most forward lean position.)

Grading: Please mark the lowest category that applies.

( ) 0 Needs help to keep from falling
( ) 1 Reaches forward, but needs supervision
( ) 2 Can reach forward more than 2 inches safely
( ) 3 Can reach forward more than 5 inches safely
( ) 4 Can reach forward confidently more than 10 inches

9. *Pick up object from the floor from a standing position

Instructions: "Please pick up the shoe/slipper that is placed in front of your feet."
Grading: Please mark the lowest category that applies.
( ) 0 Unable to try/needs assistance to keep from losing balance or falling
( ) 1 Unable to pick up shoe and needs supervision while trying
( ) 2 Unable to pick up shoe, but comes within 1–2 inches and maintains balance independently
( ) 3 Able to pick up shoe, but needs supervision
( ) 4 Able to pick up shoe safely and easily

10. * Turn to look behind over left and right shoulders while standing

Instructions: "Turn your upper body to look directly over your left shoulder. Now try turning to look over your right shoulder."
Grading: Please mark the lowest category that applies.
( ) 0 Needs assistance to keep from falling
( ) 1 Needs supervision when turning
( ) 2 Turns sideways only, but maintains balance
( ) 3 Looks behind one side only; other side shows less weight shift
( ) 4 Looks behind from both sides and weight shifts well

11. * Turn 360º

Instructions: "Turn completely in a full circle. Pause, then turn in a full circle in the other direction."
Grading: Please mark the lowest category that applies.
( ) 0 Needs assistance while turning
( ) 1 Needs close supervision or verbal cueing
( ) 2 Able to turn 360º safely but slowly
( ) 3 Able to turn 360º safely to one side only in less than 4 seconds
( ) 4 Able to turn 360º safely in less than 4 seconds to each side

12. * Place alternate foot on bench or stool while standing unsupported

Instructions: "Place each foot alternately on the bench (or stool). Continue until each foot has touched the bench (or stool) four times." (Recommend use of 6-inch-high bench.)
Grading: Please mark the lowest category that applies.
( ) 0 Needs assistance to keep from falling/unable to try
( ) 1 Able to complete fewer than two steps; needs minimal assistance
( ) 2 Able to complete four steps without assistance, but with supervision
( ) 3 Able to stand independently and complete eight steps in more than 20 seconds
( ) 4 Able to stand independently and safely and complete eight steps in less than 20 seconds

13. * Stand unsupported with one foot in front

Instructions: "Place one foot directly in front of the other. If you feel that you can't place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot." (Demonstrate this test item.)

Grading: Please mark the lowest category that applies.

( ) 0 Loses balance while stepping or standing
( ) 1 Needs help to step, but can hold for 15 seconds
( ) 2 Able to take small step independently and hold for 30 seconds
( ) 3 Able to place one foot ahead of the other independently and hold for 30 seconds
( ) 4 Able to place feet in tandem position independently and hold for 30 seconds

14. * Standing on one leg

Instructions: "Please stand on one leg as long as you can without holding onto anything."

Grading: Please mark the lowest category that applies.

( ) 0 Unable to try or needs assistance to prevent fall
( ) 1 Tries to lift leg, unable to hold 3 seconds, but remains standing independently
( ) 2 Able to lift leg independently and hold up to 3 seconds
( ) 3 Able to lift leg independently and hold for 5 to 10 seconds
( ) 4 Able to lift leg independently and hold more than 10 seconds

Total score_______/56

Note: Perform only items 6 though 14 (*) in the modified version of the scale. Maximum score for modified version is 36 points.

Score Interpretation:
0–20: Wheelchair bound
21–40: Walking with assistance
41–56: Independent

Interpretation of Individual Test Item Results on the Berg Balance Scale (BBS)

Item	Possible Impairments	Recommended exercises
1. Sit to stand	1. Lower- and/or upper-body weakness 2. Poor dynamic COG control 3. Abnormal weight distribution	Wall sits; UB and LB exercises with resistance (quadriceps, biceps/triceps, hip abductors/adductors) Seated/standing balance activities emphasizing forward weight shifts Standing balance activities with eyes closed (controlled sway in A-P and lateral directions)
2. Stand for 2 minutes	1. Poor gaze stabilization 2. Lower-body weakness 3. Abnormal weight distribution in standing	Teach gaze fixation and stabilization techniques Wall sits; LB exercises with resistance COG standing balance activities
3. Sit for 2 minutes	1. Poor trunk stabilization and/or UB weakness 2. Abnormal perception of true vertical	UB exercises with resistance (own body); seated balance activities on compliant surfaces Standing against wall with eyes closed; somatosensory cues
4. Stand to sit	1. Poor dynamic COG control 2. Lower- and/or upper-body weakness 3. Poor trunk flexibility	Seated/standing balance activities emphasizing backward weight shifts UB and LB exercises with resistance (own body/resistance band; emphasize eccentric component) Flexibility exercises emphasizing trunk rotation/flexion; seated and standing
5. Transfer (chair to chair)	1. Poor dynamic control of COG 2. Lower- and/or upper-body weakness	Seated/standing balance activities emphasizing multidirectional weight shifts UB and LB exercises with resistance
6. Stand with eyes closed (10 sec)	1. Poor use of somatosensory inputs; visual dependency and/or fear of falling 2. Lower-body weakness	Seated/standing balance activities with eyes closed; verbally emphasize use of surface cues Wall sits; LB exercise with resistance
7. Stand with feet together (1 min)	1. Poor COG control 2. Weak hip abductors/adductors	Standing balance activities with reduced BOS Lateral leg raises/weight shifts against resistance
8. Standing forward reach	1. Poor dynamic COG control (reduced limits of stability) 2. Lower-body weakness 3. Reduced ankle ROM	Seated/standing COG activities emphasizing leaning away from and back to midline LB exercises with resistance (body/resistance band); emphasize dorsiflexors; gastrocnemius/soleus muscles Flexibility exercises (emphasize dorsiflexion)

Note: A-P = anterior-posterior direction; BOS = base of support; COG = center of gravity; LB = lower body; UB = upper body.

Item	Possible Impairments	Recommended exercises
9. Pick up object	1. Poor dynamic COG control	Seated/standing COG activities emphasizing leaning away from and back to midline
	2. Poor upper- and lower-body flexibility	Selected exercises to improve UB and LB flexion
	3. Lower-body weakness	LB exercises with resistance (body/resistance band)
	4. Vestibular impairment (dizziness)	Head and eye movements; habituation exercises
10. Turn to look behind	1. Poor dynamic COG control	Standing weight shifts in lateral direction
	2. Poor neck and/or trunk flexibility	Selected exercises emphasizing rotation of neck, shoulders, and hips
	3. Lower-body weakness	LB exercises with resistance; ball movement exercises in standing position
11. Turn in a circle	1. Poor dynamic COG control	Standing weight transfer activities; gait pattern enhancement (turns, directional changes)
	2. Possible vestibular impairment (e.g. dizziness)	Head and eye movement coordination exercises
	3. Lower-body weakness	LB exercises with resistance; emphasize hip and knee flexion; hip abduction/adduction
12. Dynamic toe touch	1. Poor dynamic COG control	Standing weight shifts in lateral/A-P directions
	2. Lower-body weakness	LB exercises with resistance; emphasize hip and knee flexion; hip abduction/adduction
13. Tandem stance	1. Poor static and dynamic COG control	Standing A-P weight shifts and transfers; reduced BOS activities
	2. Lower-body weakness	LB exercises with resistance (body/resistance band); emphasize hip abductors/adductors
	3. Poor gaze stabilization	Practice focusing on visual targets in front of and at head height during standing and moving activities
14. Stand on one leg	1. Poor static and dynamic COG control	Standing A-P weight shifts and transfers; reduced BOS activities
	2. Lower-body weakness	LB exercises with resistance (body/resistance band); emphasize hip abductors/adductors
	3. Poor gaze stabilization	Practice focusing on visual targets during standing and moving activities

Note: A-P = anterior-posterior direction; BOS = base of support; COG = center of gravity; LB = lower body; UB = upper body.

Fullerton Advanced Balance Scale

The Fullerton Advanced Balance Scale is designed to measure changes in multiple dimensions of balance in higher functioning community-dwelling older adults.

Test Administration Instructions for the Fullerton Advanced Balance (FAB) Scale

1. Stand with feet together and eyes closed

Purpose: Assess ability to use ground cues to maintain upright balance while standing with reduced base of support

Equipment: Stopwatch

Testing procedures: Demonstrate the correct test position and then instruct the participants to move the feet independently until they are together. If some participants are unable to achieve the correct position due to lower extremity joint problems, encourage them to bring their heels together even though the front of the feet are not touching. Have participants adopt a position that will ensure their safety as the arms are folded across the chest and they prepare to close the eyes. Begin timing as soon as the participant closes the eyes. (Instruct participants to open the eyes if they feel so unsteady that a loss of balance is imminent.)

Verbal instructions: "Bring your feet together, fold your arms across your chest, close your eyes when you are ready, and remain as steady as possible until I instruct you to open your eyes."

2. Reach forward to retrieve an object (pencil) held at shoulder height with outstretched arm

Purpose: Assess ability to lean forward to retrieve an object without altering the base of support; measure of stability limits in a forward direction

Equipment: Pencil and 12-inch ruler

Testing procedures: Instruct the participant to raise the preferred arm to 90° and extend it with fingers outstretched. (Follow with a demonstration of the correct action.) Use the ruler to measure a distance of 10 inches from the end of the fingers of the outstretched arm. Hold the object (pencil) horizontally and level with the height of the participant's shoulder. Instruct the participant to reach forward, grasp the pencil, and return to the initial starting position without moving feet, if possible. (It is acceptable to raise the heels as long as the feet do not move while reaching for the pencil.) If the participant is unable to reach the pencil within 2–3 seconds of initiating the forward lean, indicate to the participant that it is okay to move the feet in order to reach the pencil. Record the number of steps taken by the participant in order to retrieve the pencil.

Verbal instructions: "Try to lean forward to take the pencil from my hand and return to your starting position without moving your feet from their present position." After allowing 2–3 seconds of lean time: "You can move your feet in order to reach the pencil."

3. Turn 360° in right and left directions

Purpose: Assess ability to turn in a full circle in both directions in the fewest number of steps without loss of balance

Equipment: None

Testing procedures: Verbally explain and then demonstrate the task to be performed, making sure to complete each circle in four steps or less and pause briefly between turns. Instruct the participant to turn in a complete circle in one direction, pause, and then turn in a complete circle in the opposite direction. Count the number of steps taken to complete each circle. Allow for a small correction in foot position before a turn in the opposite direction is initiated.

Verbal instructions: "Turn around in a full circle, pause, and then turn in a second full circle in the opposite direction."

4. Step up, onto, and over a 6-inch bench

Purpose: Assess ability to control center of gravity in dynamic task situations; also a measure of lower-body strength and control

Equipment: 6-inch-high bench (18- by 18-inch stepping surface)

Testing procedures: Verbally explain and demonstrate the step up, onto, and over the bench in both directions before the participant performs the test. Instruct the participant to step onto the bench with the right foot, swing the left leg directly up and over the bench, and step off the other side, then repeat the movement in the opposite direction with the left leg leading the action. During performance of the test, watch to see that the participant's trailing leg (a) does not make contact with the bench or (b) swing around, as opposed to directly over, the bench.

Verbal instructions: "Step up onto the bench with your right leg, swing your left leg directly up and over the bench, and step off the other side. Repeat the movement in the opposite direction with your left leg as the leading leg."

5. Tandem walk

Purpose: Assess ability to dynamically control center of mass with an altered base of support

Equipment: Masking tape

Testing procedures: Verbally explain and demonstrate how to perform the test correctly before the participant attempts to perform it. Instruct the participant to walk on the line in a tandem position (heel-to-toe) until you tell them to stop. Allow the participant to repeat the test one time if unable to achieve a tandem stance position within the first two steps. The participant may elect to step forward with the opposite foot on the second trial. Score as interruptions any instances where the participant (a) takes a lateral step away from the line when performing the tandem walk or (b) is unable to achieve correct heel-to-toe position during any step taken along the course. Do not ask the participant to stop until 10 steps have been completed.

Verbal instructions: "Walk forward along the line, placing one foot directly in front of the other such that the heel and toe are in contact on each step forward. I will tell you when to stop."

6. Stand on one leg

Purpose: Assess ability to maintain upright balance with a reduced base of support.

Equipment: Stopwatch

Testing procedures: Instruct the participant to fold the arms across the chest, lift the preferred leg off the floor, and maintain balance until instructed to return the foot to the floor. Begin timing as soon as the participant lifts the foot from the floor. Stop timing if the legs touch, the preferred leg contacts the floor, or the participant removes the arms from the chest before 20 seconds have elapsed. Allow the participant to perform the test a second time with the other leg if they are unsure as to which is the preferred limb.

Verbal instructions: "Fold your arms across your chest, lift your preferred leg off the floor (without touching other leg), and stand with your eyes open as long as you can."

7. Stand on foam with eyes closed

Purpose: Assess the ability to maintain upright balance while standing on a compliant surface with eyes closed

Equipment: Stopwatch; two Airex pads, with a length of nonslip material placed between the two pads and an additional length of nonslip material between the floor and first pad if the test is being performed on an uncarpeted surface

Testing procedures: Instruct the participant to step onto the foam pads without assistance, fold the arms across the

chest, and close the eyes when ready. (Demonstrate the correct standing position on foam.) Make sure the position adopted ensures the safety of the participant. Position the foam pads close to a wall in all cases and in a corner of the room if the participant appears unsteady. Begin timing as soon as the eyes close. Stop the trial if the participant (a) opens the eyes before the timing period has elapsed, (b) lifts the arms off the chest, or (c) loses balance and requires manual assistance to prevent falling. (Instruct participants to open their eyes if they feel so unsteady that a loss of balance is imminent.)
Verbal instructions: "Step up onto the foam and stand with your feet shoulder-width apart. Fold your arms over your chest, and close your eyes when you are ready. I will tell you when to open your eyes."

8. Two-footed jump for distance
Purpose: Assess upper- and lower-body coordination and lower-body power
Equipment: 36-inch ruler
Testing procedures: Instruct the participant to jump as far but as safely as possible while maintaining a two-footed stance. Demonstrate the correct movement prior to the participant performing the jump. (Do not jump much more than twice the length of your own feet when demonstrating.) Observe whether the participant leaves the floor with both feet and lands with both feet. Use the ruler to measure the length of the foot and then multiply by two to determine the ideal distance to be jumped.
Verbal instructions: "Try to jump as far but as safely as you can with both feet."

9. Walk with head turns
Purpose: Assess ability to maintain dynamic balance while walking and turning the head
Equipment: Metronome set at 100 beats per minute
Testing procedures: After first demonstrating the test, allow the participant to practice turning the head in time with the metronome while standing in place. Encourage the participant to turn the head at least 30º in each direction (e.g., "Turn your head to look into each corner of the room."). Observe how far the participant is able to turn the head during the standing head turns. A 30º head turn is required during the walking trial. Instruct the participant to walk forward while turning the head from side to side and in time with the auditory tone. Begin counting steps as soon as the participant deviates from a straight path while walking or is unable to turn the head the required distance to the timing of the metronome.
Verbal instructions: "Walk forward while turning your head from left to right with each beat of the metronome. I will tell you when to stop."

10. Reactive postural control
Purpose: Assess ability to efficiently restore balance following an unexpected perturbation
Equipment: None
Testing procedures: Instruct the participant to stand with his or her back to you. Extend your arm with the elbow locked and place the palm of your hand against the participant's back between the scapula. Instruct the participant to lean back slowly against your hand until you tell him or her to stop. Quickly flex your elbow until your hand is no longer in contact with the participant's back at the moment you estimate that a sufficient amount of force has been applied to require a movement of the feet to restore balance. You may actually begin releasing your hand while you are still giving the instructions. This release should be unexpected, so do not prepare the participant for the moment of release.
Verbal instructions: "Slowly lean back into my hand until I ask you to stop."

Score Sheet for Fullerton Advanced Balance (FAB) Scale

Name:____ Date of Test:_______________

1. Stand with feet together and eyes closed

( ) 0 Unable to obtain the correct standing position independently
( ) 1 Able to obtain the correct standing position independently but unable to maintain the position or keep the eyes closed for more than 10 seconds
( ) 2 Able to maintain the correct standing position with eyes closed for more than 10 seconds but less than 30 seconds.
( ) 3 Able to maintain the correct standing position with eyes closed for 30 seconds but requires close supervision
( ) 4 Able to maintain the correct standing position safely with eyes closed for 30 seconds

2. Reach forward to retrieve an object (pencil) held at shoulder height with outstretched arm

( ) 0 Unable to reach the pencil without taking more than two steps
( ) 1 Able to reach the pencil but needs to take two steps
( ) 2 Able to reach the pencil but needs to take one step
( ) 3 Can reach the pencil without moving the feet but requires supervision
( ) 4 Can reach the pencil safely and independently without moving the feet

3. Turn 360º in right and left directions

( ) 0 Needs manual assistance while turning
( ) 1 Needs close supervision or verbal cueing while turning
( ) 2 Able to turn 360º but takes more than four steps in both directions
( ) 3 Able to turn 360º but unable to complete in four steps or fewer in one direction
( ) 4 Able to turn 360º safely taking four steps or fewer in both directions

4. Step up, onto, and over a 6-inch bench

( ) 0 Unable to step up onto the bench without loss of balance or manual assistance
( ) 1 Able to step up onto the bench with leading leg, but trailing leg contacts the bench or leg swings around the bench during the swing-through phase in both directions
( ) 2 Able to step up onto the bench with leading leg, but trailing leg contacts the bench or swings around the bench during the swing-through phase in one direction
( ) 3 Able to correctly complete the step up and over in both directions but requires close supervision in one or both directions.
( ) 4 Able to correctly complete the step up and over in both directions safely and independently

5. Tandem walk

( ) 0 Unable to complete 10 steps independently
( ) 1 Able to complete the 10 steps with more than five interruptions
( ) 2 Able to complete the 10 steps with five or fewer interruptions
( ) 3 Able to complete the 10 steps with two or fewer interruptions
( ) 4 Able to complete the 10 steps independently and with no interruptions

6. Stand on one leg

( ) 0 Unable to try or needs assistance to prevent falling
( ) 1 Able to lift leg independently but unable to maintain position for more than 5 seconds
( ) 2 Able to lift leg independently and maintain position for more than 5 but less than 12 seconds
( ) 3 Able to lift leg independently and maintain position for more than 12 but less than 20 seconds
( ) 4 Able to lift leg independently and maintain position for the full 20 seconds

7. Stand on foam with eyes closed

( ) 0 Unable to step onto foam or maintain standing position independently with eyes open
( ) 1 Able to step onto foam independently and maintain standing position but unable or unwilling to close eyes
( ) 2 Able to step onto foam independently and maintain standing position with eyes closed for at least 10 seconds
( ) 3 Able to step onto foam independently and maintain standing position with eyes closed for more than 10 seconds but less than 20 seconds
( ) 4 Able to step onto foam independently and maintain standing position with eyes closed for 20 seconds

8. Two-footed jump for distance

( ) 0 Unable to attempt or attempts to initiate two-footed jump, but one or both feet do not leave the floor
( ) 1 Able to initiate two-footed jump, but one foot either leaves the floor or lands before the other
( ) 2 Able to perform two-footed jump, but unable to jump farther than the length of their own feet
( ) 3 Able to perform two-footed jump and achieve a distance greater than the length of their own feet
( ) 4 Able to perform two-footed jump and achieve a distance greater than twice the length of their own feet

9. Walk with head turns

( ) 0 Unable to walk 10 steps independently while maintaining 30º head turns at an established pace
( ) 1 Able to walk 10 steps independently but unable to complete required number of 30º head turns at an established pace
( ) 2 Able to walk 10 steps but veers from a straight line while performing 30º head turns at an established pace
( ) 3 Able to walk 10 steps in a straight line while performing head turns at an established pace but head turns less than 30º in one or both directions
( ) 4 Able to walk 10 steps in a straight line while performing required number of 30º head turns at established pace.

10. Reactive postural control

( ) 0 Unable to maintain upright balance; no observable attempt to step; requires manual assistance to restore balance
( ) 1 Unable to maintain upright balance; takes fewer than two steps and requires manual assistance to restore balance
( ) 2 Unable to maintain upright balance; takes fewer than two steps, but is able to restore balance independently
( ) 3 Unable to maintain upright balance; takes one to two steps, but is able to restore balance independently
( ) 4 Unable to maintain upright balance but able to restore balance independently with only one step

Interpretation of the Individual Test Items on the Fullerton Advanced Balance (FAB) Scale for Possible Underlying Impairments

Item	Possible impairments	Recommended exercises
1. Stand with feet together and eyes closed	1. Weak hip abductors/adductors 2. Poor COG control 3. Poor use of somatosensory cues	Lateral weight shifts against resistance; side leg raises against gravity/resistance Seated/standing balance activities emphasizing weight shifts in multiple directions Standing balance activities with eyes closed (controlled sway in A-P and lateral directions)
2. Reach forward to object	1. Reduced limits of stability 2. Reduced ankle ROM 3. Fear of falling 4. Lower-body muscle weakness	Seated/standing COG control activities Ankle circles, heel lifts, and drops from height Confidence-building activities—high success Wall sits; LB exercises with resistance
3. Turn in a full circle	1. Poor dynamic COG control 2. Possible vestibular impairment (e.g., dizziness) 3. Lower-body weakness	Standing weight-transfer activities; gait pattern enhancement (turns, directional changes) Head and eye movement coordination exercises LB exercises with resistance; emphasize hip and knee flexion; hip abduction/adduction
4. Step up and over	1. Poor dynamic COG control 2. Lower-body weakness 3. Reduced ROM at ankle, knee, hip	Seated/standing balance activities emphasizing backward weight shifts LB exercises with resistance (own body/resistance band; emphasize sustained unilateral stance positions) Flexibility exercises emphasizing hip/knee/ankle flexion; seated and standing
5. Tandem walk	1. Poor dynamic COG control 2. Poor use of vision 3. Weak hip abductors/adductors	Standing/moving COG control activities; emphasize A-P control during weight shifts Activities emphasizing gaze-stabilization techniques Side leg raise against gravity/resistance; lateral weight shift and lunge activities
6. Stand on one leg	1. Poor COG control 2. Lower-body muscle weakness 3. Poor use of vision	Standing A-P weight shifts and transfers; reduced BOS activities LB exercises with resistance (body/resistance band); emphasize hip abductors/adductors Activities emphasizing gaze stabilization
7. Stand on foam with eyes closed	1. Poor use of vestibular inputs for balance 2. Lower-body muscle weakness 3. Heightened fear of falling when vision absent	Seated/standing activities performed with reduced/absent vision on altered surfaces LB exercises with resistance (body/resistance band); emphasize quadriceps, gastrocnemius/soleus muscles Confidence-building activities with progressive reduction in availability of vision
8. Two-footed jump	1. Poor dynamic COG control 2. Poor upper- and lower-body coordination 3. Lower-body muscle weakness	Standing/moving COG activities emphasizing leaning away from and back to midline Selected exercises to improve UB and LB coordination; multiple task activities LB exercises with resistance (body/resistance band) performed at progressively faster speeds
9. Walk with head turns	1. Possible vestibular impairment 2. Poor use of vision 3. Poor dynamic COG control	Head and eye movement coordination exercises; gait pattern enhancement (turns, directional changes) Activities emphasizing gaze stabilization Standing/moving activities with head turns; progressively increase speed and frequency of head turns
10. Reactive postural test	1. Absent postural strategy (i.e., step) 2. Poor COG control 3. Lower-body muscle weakness	Activities emphasizing step strategy (i.e., resistance band release activity) Standing COG control activities; volitional stepping activities in multiple directions LB exercises with resistance; emphasize hip and knee flexion; hip abduction/adduction.

Note: A-P = anterior-posterior direction; BOS = base of support; COG = center of gravity; LB = lower body; UB = upper body.

Aging Gracefully: The Relationship between Balance Training and Fall Prevention

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