Sensory Impairment and Fall Risk

By Rein Tideiksaar

The vast majority of falls in elders result from the accumulated effects of multiple factors related to age and chronic disease (e.g., sensory impairment, muscle weakness, cognitive impairment, gait and balance disorders, bladder dysfunction) and their interaction with unsafe environments (Sattin, 1992).

Accumulated effects.

The sensory systems play a crucial role in controlling balance. Any loss or failure of balance caused by age or disease-related sensory impairments is an important cause of falling. This article discusses the sensory components of balance control, the contribution of such sensory impairments as visual and auditory or hearing dysfunction to fall risk, and the management of sensory impairment in elders at risk of falling.

BALANCE

The basic task of balance is to help us stay erect when standing, to know where we are in relation to space and gravity, and to help us walk and move about without falling. The ability to maintain balance is a complex process that is largely dependent on the coordinated efforts of several sensory components described below. These are visual, vestibular, proprioceptive, and auditory inputs (Horak, Shupert, and Mirka, 1989). The organization of these systems is managed by the balance system's centers in the brain. During an episode of instability, the resulting balance loss is detected by the sensory system, which sends signals to muscles and joints in the body. In reply, a set of coordinated, protective sensory and motor responses are initiated to bring the body back into balance, thus avoiding a fall.

Proprioception. The term refers to one's sense of position and movement in the feet and legs and represents a primary source of sensory input that is required for balance. Proprioceptive input provides the body with information on the immediate environment, and allows the body to orient itself during standing and motion with respect to the support of the ground surface and the positioning of body segments (the head, trunk, and extremities). As people age, the capabilities of the proprioceptive system decline, thereby increasing the risk of instability. Although healthy elders rely to a great extent on proprioceptive feedback to maintain their balance, under conditions in which this information is reduced or missing, visual input becomes more critical. Vision can augment proprioceptive feedback or counteract its loss. To compensate for poor balance, many elders ambulate by looking down to view the correct placement of their feet.

Vision. Seeing is the mainstay of balance. The eyes—through such features as visual acuity, contrast sensitivity, and depth perception—provide the body with information on the placement of and the distance from objects in the environment, the type of surface on which movement will take place, the position of the body, and the intensity of effort or degree of difficulty of the required movement. The eyes help sense obstacles and potential dangers, and they form motor memories that help guard against falls. Vision also provides the information the person needs to think ahead of time and to gauge the timing and control of movement. The more difficult the activity or the greater the precision and speed needed to accomplish the movement, the greater the importance of vision. When visual input is diminished by age-related changes, balance becomes more difficult to maintain. This concept is demonstrated when an elder stands with eyes closed or walks into a dark room; in both instances, balance becomes unsteady.

The vestibular system. This system located in the inner ear works in conjunction with the visual and proprioceptive systems to achieve balance—it helps to maintain stable visual perception and body orientation as a person moves about the environment. During episodes of balance displacement, vestibular receptors in the inner ear detect movement and prompt antigravity muscles to execute compensatory head, trunk, and limb movements, serving to correct imbalance. In other words, the vestibular system regulates balance by sensing that the body has been placed out of balance and signaling the neuromuscular system to activate one or more movements to ensure that a fall does not take place. With increasing age, vestibular input diminishes. Consequently, when an elder slips or trips or loses balance, his or her chance of regaining stability and avoiding a fall declines as the person ages. However, when proprioceptive and visual inputs are available, the vestibular system plays a minor role in controlling balance, because proprioceptive and visual inputs are more sensitive to imbalance than is the vestibular system.

The auditory system. Hearing contributes directly to stability through the detection and interpretation of auditory stimuli, which helps to orient the individual, particularly when other sensory systems are not functioning optimally.

Usually, some redundancy occurs in the sensory information necessary to maintain balance, and the failure of one source of input such as vision can be counteracted with feedback from intact proprioceptive and vestibular systems. However, deprivation in more than one system is likely to result in a lower balance threshold, which increases the risk of falling.

Changes in Vision and Hearing

Elders are disproportionately affected by sensory impairments (e.g., visual or hearing loss). Elders account for about 30 percent of all visually impaired individuals and 37 percent of all hearing-impaired individuals (Desai et al., 2001). Visual impairment, as a consequence of both age-related changes and ocular diseases, is strongly associated with increased risk of both falls and injurious falls (Ivers et al., 1998; Lord and Dayhew, 2001). Falls related to visual impairment are usually caused by their adverse effect on balance and by the inability of the affected individual to detect slip and trip hazards in the environment. Apart from vestibular dysfunction (i.e., dysfunction caused by degeneration of the structures of the inner ear), which can result in poor balance and falls, fall risk caused by auditory or hearing impairment is less well understood. Some of the likely causes of falls are the consequences of hearing impairment—such as social isolation, loneliness, frustration, and depression induced by a sense of helplessness or loss of self-confidence—or the inability to hear environmental warning sounds like the blowing of a car horn or people approaching on a crowded sidewalk.

Age-related changes. There are several age-related changes in vision and hearing that place elders at risk of falling. The ability of the eyes to adjust to varying levels of light and darkness diminishes as people age. As a result, the eyes of older people require more time to adjust to changes in environmental lighting. Adaptation to the dark is especially affected by aging and may compromise a person's visual capacity, particularly under conditions of low illumination (e.g., when walking about during nighttime

hours). A greater sensitivity of the aging eye to glare can also lead to visual dysfunction. Common sources of glare include sunlight shining through windows and reflecting off waxed floors or glossy table tops and bright light from unshielded light bulbs directed toward the eye. Restriction of a person's visual field leads to an inability to see objects in the pathway that lies outside the person's view, increasing the likelihood of slips and trips. A loss of visual acuity and contrast sensitivity can make the perception of objects in the environment more difficult. In particular, a failure to detect low contrast objects can lead to unsafe ambulation. If not visualized clearly, objects such as door thresholds and carpet edges can cause elders to trip. Surfaces of furniture and fixtures like chair and toilet seats that are not visually distinguishable can interfere with safe transfers from bed to chair or from chair to toilet, for example. The loss of visual acuity or contrast sensitivity is more evident under conditions of low illumination. A decline in depth perception can cause the visual detection of certain floor surfaces (e.g., patterned carpet designs) to appear as elevations or depressions on the ground, surfaces that elders prefer to step around or avoid walking on entirely. In addition, a loss of depth perception makes it difficult to perceive objects that lie in areas of shadow, low illumination, or excessive brightness.

Table 1
Major Causes of Visual Impairment in Elders

VISUAL DISORDER	EFFECT ON VISION
Cataracts	"Hazy" vision and intolerance of glare are common complaints. Visual acuity, contrast sensitivity, and color perception are affected.
Diabetic retinopathy	No initial symptoms, then vision becomes blurred and patchy (irregular blotches across the visual field). Night vision is affected.
Glaucoma	Glaucoma causes tunnel-like vision, blurring, and poor peripheral vision. Dark adaptation and glare tolerance are affected.
Macular degeneration	There is a decrease in central visual acuity; objects appear distorted. Glare tolerance, color vision, and dark/light adaptations are affected.

Similar to vision, the auditory system undergoes changes with age. Sensorineural hearing loss, referred to as presbycusis, is caused by degenerative changes in the inner ear. Decreased sensitivity to high-frequency tones, which begins in the thirties and continues into the eighth decade of life, is the hallmark of presbycusis. This hearing loss often occurs in both ears and affects speech discrimination (i.e., elders can hear people talking, but they cannot make out the words) and the ability to distinguish low-volume sound, especially from loud background noise. Because the process of hearing loss is gradual, people who have presbycusis may not realize that their hearing is impaired. This lack of awareness can make communicating and conveying preventive information somewhat difficult.

Visual and hearing disorders. Visual disorders occurring in combination with age-related changes in visual function can lead to significant visual impairments. When associated with poor environmental illumination, visual function can be impaired further, to the degree that hazardous ground surfaces (e.g., spills, upended rug edges, steps, or door thresholds) are difficult to see, which predisposes a person to trips and slips. The most prevalent ocular disorders that affect visual function are cataracts, glaucoma, macular degeneration, and diabetic retinopathy. These conditions, sometimes referred to as the "Big Four," cause a multitude of symptoms that increase fall risk (see Table 1).

Conductive hearing loss caused by middle-ear infections, an accumulation of wax, or an obstructed eustachian tube may increase the risk of falling. These disorders frequently first

become evident with symptoms of vertigo and dizziness, which can lead to instability and falls. In addition, ototoxic medications (i.e., drugs that have the potential to cause damage to the inner ear structures) may cause dizziness and temporary or permanent loss of hearing. Common categories of ototoxic medications include aspirin and aspirin-containing products, nonsteroidal anti-inflammatory drugs (NSAIDS), antibiotics, some diuretics, and certain chemotherapeutic agents. Symptoms of ototoxicity can include an awareness of a hearing loss or the progression of an existing loss, tinnitus (noises in the ears) in one or both ears, and development of vertigo or a spinning sensation usually aggravated by motion.

Dual Sensory Impairment

Approximately one-half of visually impaired elders also have hearing impairment (Klaver et al., 1998). The combination of both visual and hearing impairment is referred to as dual sensory loss or impairment. Research is emerging regarding the profound psychological and functional consequences of dual sensory impairment in elders and the contribution of this situation to fall risk (Keller et al., 1999; Lupsakko et al., 2002). While there is little doubt that the combination of vision and hearing impairment can dramatically increase the risk of falling, little knowledge exists regarding the precise mechanisms that place individuals at risk.

Sensory impairment, and in particular dual sensory loss, represents an important risk factor for falls. Any sign of visual or hearing loss should trigger a referral to an otolaryngologist (ear, nose, and throat specialist), an ophthalmologist, and sometimes an audiologist for further evaluation and treatment. In many cases, either eyeglasses or hearing aids are sufficient to correct the impairments. Sometimes, simple measures—such as switching from multifocal eyeglasses, which tend to impair depth perception, to nonmultifocal glasses—can make a tremendous difference in terms of reducing fall risk. In addition, a multitude of aids and gadgets can help elders compensate for their sensory loss, or else help them make better use of their remaining vision and hearing. However, more research directed toward developing options for visual and hearing impairment is also needed. For example, we know that devices such as hearing aids and telephone amplifiers can help individuals with sensory impairment, but the majority of elders who could potentially benefit from these devices choose not to use them.

Elders who do not use recommended sensory aids should not be abandoned, but rather given hope and encouragement. There are many alternative interventions that can teach elders to use their remaining vision and hearing as efficiently as possible, or else to modify their activities so that everyday tasks can be completed with less sensory input. Referring elders to rehabilitation services, such as a low vision and hearing clinic, can help to maximize their remaining vision and hearing and, in many cases, slow the impairment's progress. Elders will also gain a measure of safety by being better able to see and hear, which helps to minimize fall risk.

In those individuals with sensory impairment, the coexistence of multiple intrinsic and extrinsic risk factors makes the task of managing fall risk much more complex. The success of preventing falls in elders with visual or hearing impairment is dependent on identifying fall risk, ensuring a proper evaluation of all risk factors discovered, and designing targeted interventions to reduce risk. Although fall risk factors, such as recent falls, visual impairment, muscle weakness, or altered cognition, can increase the susceptibility to falls, the true measure of fall risk is more accurately reflected by its effect on an individual's mobility (i.e., whether they can ambulate and transfer in a safe manner). Any impairment of balance or mobility that results is a strong predictor of falls.

Ideally, observing the individual's mobility in his or her home setting is the best way to assess the effect of risk factors. Maneuvers to assess include the elder's ability to maintain balance while transferring from a chair, bed, or toilet; getting in and out of the bathtub; walking up and down stairs; standing with eyes open and closed (i.e., any loss of stability with eyes closed suggests proprioceptive impairment); reaching up and bending down from a standing position; and ambulating with or without assistive devices, as applicable. Watching the elder

ambulate in different locations (living room, bedroom, bathroom, kitchen, hallways, and stairs) takes into account that the space limitations, furnishings, floor surfaces, and illumination of space are dissimilar and represent different risks. At the same time, the assessor should note environmental features that interfere with safe mobility, such as unstable furnishings, misplacement of grab rails, upended carpet edges, clutter, and poor illumination. Correcting any environmental hazards can improve the elder's mobility, thereby helping to reduce fall risk. In addition, elders with sensory impairments may become more confident moving about in safer surroundings. The following case study illustrates the management approach to elders with a combination of dual sensory loss and fall risk.

THE CASE OF M.J.

M.J. is an 82-year-old woman being treated in our postfall counseling program. This program is designed to identify causes and consequences of falls and fall risk and to provide targeted multidisciplinary interventions aimed at reducing fall risk and enhancing ability to perform everyday mobility tasks. M.J. has experienced several noninjurious falls at home over the past three months. Her falls have taken place while walking to the bathroom, reaching up into her kitchen cabinets, getting in and out of her bathtub, and getting up from her toilet. After two of M.J.'s falls, she was unable to get up following falling and had to crawl on all fours to her living room, where she used the support of a chair to get up from the floor.

Medical history. M.J. has a diagnosis of diabetes mellitus (treated with oral hypoglycemic medications), arthritis (treated with high doses of nonsteroidal anti-inflammatory medications), frequent nighttime urination (approximately four to five trips every night), glaucoma and cataracts, and impaired hearing. M.J. complains of a recent worsening of her hearing and occasional dizzy spells made worse with movement.

Psychological history. M.J. is very fearful about falling. In particular, she is fearful of going outdoors by herself and fearful of environments and situations that may cause her to lose her balance and fall (e.g., walking at night, getting in and out of the bathtub, and moving to and from the toilet). She also expresses a fear that she will fall and be unable to get up, especially in her bathtub. As a result, she has restricted her activities. She does not leave her apartment by herself and no longer bathes in her tub. M.J. complains of feeling depressed about her situation and not being able to go to church or visit with friends. Previously, M.J. had been independent in her daily activities, but now her falls have dramatically affected her feelings of safety.

Functional history. M.J. exhibits both gait and balance impairment. She complains that her walking and balance are worse at night when she's going to the bathroom. M.J. has a cane and two-wheeled walker, but she doesn't use either device. The cane does not help her balance, and her walker is difficult to use, particularly when she is walking outdoors, because its rear legs drag on the pavement, causing her to lose balance. Additionally, M.J. has difficulty moving to and from toilet and bathtub. She has no bathroom grab rails or other equipment to support her safe mobility.

Social history. M.J. lives alone in a small, cluttered one-bedroom apartment. Before her falls, M.J. enjoyed going to church on Sundays and visiting daily with friends who live in her apartment building. M.J. has a 54-year-old married son who lives ten miles away. Because of his busy job and family obligations (three small children from a second marriage), he is only able to visit with his mother once a week. During this time, he does his mother's grocery shopping and cleans her apartment. He is very worried about his mother's safety and is considering placing her in a nursing home.

Interventions. M.J.'s plan of care included the following:

- Education and counseling to explain her falls, fall risk factors, and risk-reduction strategies. All educational materials used were adapted to her visual impairment.
- Modifications of intrinsic fall risk factors (medical management of her diabetes and arthritis, and treatment of her nighttime urination problem, which was caused by a urinary tract infection). Her dose of NSAIDS, which was the reason for her dizzy spells, was decreased without adverse effects.

- Adjustment of her walker to an appropriate height and equipping the walker's rear legs with tennis ball shoes, which improved her walking balance and permitted her to walk safely outdoors without difficulties.
- Durable medical equipment to support safe movement to and from toilet and bathtub. All equipment was color-contrasted for easy visibility.
- A home-based exercise program to improve muscle strength, flexibility, balance, and coordination. After a while, M.J. gained enough strength and confidence to leave her home without the assistance of another person, and she attended a group exercise program at a local senior center.
- A personal emergency-response system in the event of further falls. The system was modified to accommodate her vision and hearing impairment.
- Home hazard modification, which consisted of making sure there were clear travel paths in hallways and through rooms, rearranging furniture to eliminate trip hazards (e.g., relocating a low-lying coffee table that she had previously tripped over), maintaining bright and consistent levels of lighting throughout the apartment, and placing commonly used kitchen items and utensils at waist level to minimize the risk of balance loss.

Following the interventions, M.J.'s mobility and ability to perform everyday activities improved. She was no longer fearful or homebound, and she participated in more social activities like going to church and visiting with her friends. She was also less depressed. M.J. continued to experience occasional falls (mostly caused by "hurrying about" and exceeding her balance capabilities), but she felt much more confident about her ability to minimize fall risk.

Conclusion

Vision and hearing impairments are associated with increased fall risk. The goal of preventing falls among people with these impairments is to identify coexisting intrinsic and extrinsic fall risk factors, and attempt multidisciplinary interventions aimed at reducing risk factors and enhancing the individual's effectiveness in addressing concerns related to mobility.

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