Promoting Functional Independence Among “At Risk” and Physically Frail Older Adults Through Community-Based Fall-Risk-Reduction Programs

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In recent years, a number of research investigations have been conducted in an effort to determine whether declining balance and mobility among older adults can be reversed or at least slowed. Unfortunately, the results of a number of these studies have not yielded positive outcomes. Three reasons are forwarded to account for these unsuccessful outcomes: the lack of a contemporary theory-based approach to the problem, the failure to use multiple and diverse measures of balance and mobility, and the failure to design multidimensional interventions that target the actual source(s) of the balance or mobility-related impairments. A model fall-risk-reduction program designed to address each of the shortcomings associated with previous research findings is presented. The program is group based and suitable for implementation in community-based and residential care facilities.

Key Words: balance, mobility, assessment, intervention

Decreased postural stability, often resulting in falls, is a significant problem for aging adults. It has been previously demonstrated that 32% of older adults residing in the community fall at least once per year, with serious injuries reported in 24% of those who fall. Among nursing-home residents, the number sustaining at least one fall annually increases to 50%, with 9% of those who fall likely to incur a serious injury (Ray et al., 1997). Clearly, falls among the older adult population, particularly those residing in long-term-care facilities, are a significant cause of morbidity and mortality. In the United States alone, it is estimated that 250,000 hip fractures occur as a direct result of falls annually, a figure that is expected to double by the year 2040 as a result of the rapidly growing older adult population (Morrison, Chassin, & Siu, 1998). These statistics, coupled with the knowledge that the annual direct and indirect costs of falls among older adults have been estimated to range from $75 billion to $100 billion, suggest an immediate need for intervention programs specifically designed to reduce the incidence of falls among older adults (Urton, 1991).

Associated with the age-related increase in fall rates is a corresponding decline in static and dynamic balance abilities (Overstall, Exton-Smith, Imms, &

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Johnson, 1977). This association suggests the need for intervention strategies that specifically focus on improving older adults' postural stability. In recent years, a number of research investigations have been conducted in an effort to determine whether deteriorating postural control in older adults can be reversed or at least slowed. A number of intervention techniques have subsequently been designed and implemented with a variety of older adult populations. Subject populations have ranged from the healthy to the frail, and the interventions have been conducted over varying lengths of time (e.g., 10 hr to 52 weeks). The types of interventions used have also ranged from those adopting a more global exercise approach (e.g., aerobic, flexibility, resistance, endurance exercises) to ones that target specific components of the postural-control system (e.g., integration of multiple sensory inputs, volitional and nonvolitional dynamic postural-control training). Unfortunately, the results emerging from a very large number of studies have not always yielded positive outcomes (Binder, Brown, & Birge, 1991; Hu & Woollacott, 1994a; Seidler & Martin, 1997; Shumway-Cook, Gruber, Baldwin, & Liao, 1997; Tinetti et al., 1994).

This review article is divided into two major sections. In the first section the goal is to identify and discuss at least three major reasons that certain intervention studies yield positive outcomes and others do not. The second section is devoted to describing a model fall-risk-reduction program that was designed to address each of the limitations identified. This model intervention program is currently being successfully implemented with groups of “at-risk” older adults in multiple community-based and residential care facilities.

**Features of Successful Fall-Risk-Reduction Interventions**

**ADAPTING A TARGETED PROGRAMMING APPROACH**

A careful comparison of the types of interventions conducted and balance-related measures used to first identify preintervention risk factors and then assess the effectiveness of the intervention reveals at least three possible reasons for the inconsistent findings. First, studies in which a global or diffusely targeted intervention approach is adopted result in little or no improvement in measures of mobility and balance or a reduction in fall risk (e.g., Bassett, McClamrock, & Schmelzer, 1982; McMurdo & Burnett, 1992; Mills, 1994; Reinsch, MacRae, Lachenbruch, & Tobis, 1992; Seidler & Martin, 1997; Skelton, Young, Greig, & Malbut, 1995). Exercises most often used in these types of interventions included general stretching and strengthening activities, aerobic exercise, walking, tandem walking, and an assortment of other more static balance activities (e.g., Romberg, tandem, and semitandem stances). Conversely, the few balance-training intervention studies that targeted multiple and specific dimensions of the postural-control system demonstrated significant short- and, in some cases, long-term improvements in balance and mobility (Rose & Clark, 2000; Shumway-Cook, Gruber, et al., 1997; Tinetti et al., 1994).

Province et al. (1995) suggest that the better outcomes associated with a targeted balance intervention might be a result of the fact that it addresses the balance deficits directly responsible for generating falls. More global exercise approaches to training are more likely to provide more indirect benefits (e.g.,
increased flexibility, muscle strength, and endurance) that are not, in and of themselves, likely to reduce fall risk. This conclusion is based on the findings emerging from a nationally funded set of clinical trials designed to assess the effectiveness of different intervention techniques (all including exercise as one component) aimed at reducing falls and frailty in elderly patients. The results of the Frailty and Injuries: Cooperative Studies of Intervention Techniques multisite project clearly indicated that interventions that emphasized dynamic balance training as opposed to general exercise were more effective in reducing fall risk, at least in the short term (Province et al.). Sowden and colleagues (1996) similarly concluded that interventions involving balance exercise, resistance training, and low-impact aerobic exercise appear to be the most promising methods for reducing falls in older adults after a systematic review of 36 clinical trials aimed at preventing falls.

USING MULTIDIMENSIONAL TESTS OF BALANCE AND MOBILITY

A second possible reason for the equivocal research findings stems from the failure to use multiple and, in some cases, appropriate measures of balance and mobility. In order to identify the source of the balance-related impairments that constitute risk factors contributing to an individual's heightened risk of falling, a multidimensional preintervention screening is necessary. Given the knowledge that not all older adults fall for the same reasons, a carefully chosen set of tests designed to identify underlying impairments in multiple systems (e.g., sensory, motor, cognitive) contributing to the functional limitations and heightened fall risk must be administered. Nonsignificant improvements are particularly evident in the case of interventions that emphasize dynamic balance activities (e.g., walking, dynamic strengthening and flexibility exercises) but then measure the effectiveness of the intervention using a single measure of balance intended to represent its multiple dimensions (i.e., postural sway; Barry, Steinmetz, Page, & Rodahl, 1967; Crilly, Willems, Trenholm, Hayes, & Delaquerriere-Richardson, 1989; Seidler & Martin, 1997). In other studies, one also finds the use of tests that pose little challenge to the postural control system (e.g., Bassett et al., 1982; Lichtenstein, Shields, Shiavi, & Burger, 1989; McMurdo & Burnett, 1992) or do not measure the dimensions of balance that were actually targeted during the intervention (e.g., static as opposed to dynamic balance measures, postural sway in single-sensory environment).

Adopting a Contemporary, Theory-Based Approach

Perhaps the most important reason that so many research studies have failed to yield significant intervention outcomes stems from the absence of a contemporary, theory-based approach to the issue. Unlike traditional theories, contemporary theories of motor control assume that multiple systems collaborate to control bodily orientation and locomotion. Whereas certain systems provide the sensorimotor processes that constitute the physiological basis of postural control, other systems (e.g., musculoskeletal, cognitive) constrain an individual's capability for achieving a particular goal-directed action. For example, even though an individual might exhibit above-average sensory and motor function, his or her ability to complete a task might be undermined by an inability to remember how to perform it because
of an impaired cognitive system. In another situation, the lack of adequate strength in the lower body might limit an individual’s ability to climb stairs or even rise from a chair despite above-average cognition and adequate sensory and motor function. Indeed, an individual’s inherent capability for successfully completing goal-directed actions is constrained by how well each of these systems functions, both in isolation and collaboratively. This contemporary view of human postural control has been referred to as the systems theory (see Shumway-Cook & Woollacott, 2000b, for a more detailed description of this theoretical model).

In addition to the intrinsic subsystems that both shape and, on occasion, constrain an individual’s motor behavior, two additional constraints on action play an important contributing role in shaping the action that emerges. According to both the systems theory and the ecological theory of perception and bodily orientation, these include the goals of the action being attempted and the properties of the environment in which the action is to take place (Riccio, Martin, & Stoffregen, 1992; Riccio & Stoffregen, 1988; Stoffregen & Flynn, 1994; Stoffregen & Riccio, 1988). Given that we currently reside on earth, gravitational and inertial forces are always acting on the upright body in any given environmental context. Although the influence of these external forces is minimal when an individual is performing a relatively simple task such as standing quietly on a broad, firm surface, these forces are magnified as the person begins to perform a more difficult task such as leaning out over his or her base of support or walking across a slippery surface.

One can expect that as the number of intrinsic systems exceeds a critical threshold of function, manifesting in balance-related impairments (e.g., muscle weakness, reduced range of motion, sensory loss), the older adult’s ability to accomplish a single daily task such as rising from a chair or climbing and descending stairs will be compromised. The added challenge of having to perform a second task simultaneously with the first (e.g., carry a bag of groceries, carry on a conversation) will further compromise action because of the need to divide attention between the two tasks. The inability to adequately divide attention between two tasks, one of which requires balance, has already been demonstrated in previous studies comparing older adults with a history of falls to a group of healthy peers (Shumway-Cook, Woollacott, Baldwin, & Kerns, 1997). In fact, it is hypothesized that age-associated changes in the allocation of attention might, in and of themselves, contribute to postural instability and increased falls in certain groups of older adults (Shumway-Cook & Woollacott, 2000a).

Existing environmental constraints (e.g., reduced lighting conditions, the absence of handrails on the stairs to be climbed) contribute one more element of complexity to the task situation and constitute a third important variable accounting for increased fall risk. In recognition of their compromised abilities, older adults either cease to engage in activities they perceive to place them at high risk of falling or they begin to limit the types of environments in which they are prepared to engage in those activities. Although these self-imposed restrictions on activity might decrease falls in the short term by reducing exposure, over the long term, diminished self-confidence and severe physical deconditioning will only serve to hasten the onset of physical frailty and increase the risk of falls (Tinetti, Speechley, & Ginter, 1988).

At a practical level, both contemporary theories of motor control discussed here reinforce the need to use multiple and appropriate tests designed to evaluate the
integrity of the multiple intrinsic systems known to influence postural control followed by interventions that specifically target the multiple-system impairments identified. The systematic manipulation of task goals or the practice environment would also seem to be necessary ingredients for any intervention designed to reduce the incidence of falls among the elderly. Patla and Shumway-Cook (1999), in an earlier scholarly review published in this journal, presented a similar multidimensional framework as a means to better understand and objectively measure mobility disability in the elderly. These authors also recognize the need to consider how the environmental context in which a particular action is undertaken constrains the actual behavior observed.

A Model Fall-Risk-Reduction Program

Having identified some of the important weaknesses associated with previous intervention research, the focus in this section of the review is to identify and then describe the core components of an intervention program designed to promote functional independence by reducing the risk for falls among “at risk” and physically frail older adults. More specifically, this section (a) describes a set of easy-to-administer tests that measure important dimensions of balance and mobility, (b) describes how each of these tests can be used to guide the selection of appropriate program activities, and (c) identifies and then describes the core components of an intervention program currently being implemented successfully in a number of community and residential care settings.

Previous research demonstrating the effectiveness of balance interventions adopting a multidimensional approach has been conducted almost exclusively in individualized settings (e.g., Rose & Clark, 2000; Shumway-Cook, Gruber, et al., 1997), but recent studies have begun to examine the effectiveness of this approach in structured group settings (Rose, Jones, & Lemon, 2001; Rose, Jones, Lemon, & Bories, 1999; Skelton & Dinan, 1999). The structured group program to be described in the remainder of this article is one that has been successfully implemented in multiple community and residential care-facility sites. The short-term effectiveness of the structured group program has already been demonstrated and is reported elsewhere (Rose et al., 1999, 2001).

Consistent with the theory-based approach described earlier, the program content is designed to systematically manipulate the demands of the task to be performed or the constraints imposed by the practice environment in a way that matches each individual’s intrinsic capabilities (see Figure 1). An important goal of the program is to challenge, but not exceed, the individual’s intrinsic capabilities by systematically introducing balance and mobility tasks of increasing complexity that are to be performed in a variety of practice environments that simulate those encountered during daily life.

PREPROGRAM SCREENING AND ASSESSMENT

The assessment of multiple dimensions of physical function—and balance and mobility, in particular—assists the practitioner in multiple ways. Not only does it facilitate the early identification of older adults who are beginning to experience above-threshold changes in multiple body systems, resulting in observable changes
in postural stability and mobility, but it also helps the practitioner develop an appropriate treatment plan that targets the identified system impairments. When re-administered on a regular basis, the objective data obtained from these multiple tests can be used to guide the selection or deletion of certain exercises, help the participant set appropriate short- and long-term goals, and motivate him or her to meet each of those goals. Finally, the overall effectiveness of the intervention can be documented.

Consistent with Nagi’s (1991) disability model, which describes a four-stage progression to disability (i.e., pathology, impairment, functional limitations, and disability), any screening of older adults, particularly those already experiencing balance and mobility problems, should include tests designed to assess the level of dysfunction in each of these four stages. Such a multistage assessment will provide the instructor with in-depth information that can then be used to plan the most appropriate intervention. In the assessment described in this section, information about each of these four stages is obtained, as well as important information about lifestyle and physical activity patterns. Recent evidence would suggest that lifestyle factors such as physical inactivity and disuse should be considered as important as pathology in contributing to frailty and disability in the later years (Chandler & Hadley, 1996; DiPietro, 1996; Rikli & Jones, 1997).

**Pathology/Disease and Physical Activity Patterns.** Information about pathology/disease and physical activity patterns is obtained from the medical and activity questionnaire administered before the screening. In addition to providing information about existing medical diagnoses and medications, participants are required to answer four questions related to physical activity and exercise patterns. For example, participants are asked how often they leave the house during the course of a week; whether they participate in regular physical exercise that is strenuous enough to cause a noticeable increase in breathing, heart rate, or perspiration and, if so, how many days per week; and the pace at which they walk (if they engage in the activity on a regular basis).
Impairments and Functional Limitations. In order to assess the level of dysfunction at the impairment and functional-limitations stages represented in Nagi's model, a number of physical-performance tests are administered during the course of the first week of the program. These tests are designed to assess the multiple-system impairments (e.g., motor, sensory, cardiovascular, musculoskeletal) that lead to functional limitations in the performance of activities requiring balance or mobility. The nature and extent of the functional limitations are also assessed during the same time period. Although greater objectivity and sensitivity of measurement are derived by using tests requiring more advanced technology (i.e., computerized posturography, isokinetic dynamometry, or electronystagmography), a number of clinical and field tests are currently available that provide valid and reliable information, require little or no equipment, and are relatively quick and easy to administer in community-based settings.

The impairment tests conducted include the Senior Fitness Test (SFT; Rikli & Jones, 1999a, 1999b), reach-in-four-directions test (Newton, 1997), and a modified version of the Clinical Test of Sensory Interaction in Balance (M-CTSIB; Shumway-Cook & Horak, 1986). The tests used to measure functional limitations include the Berg Balance Scale (BBS; Berg, Wood-Dauphinee, Williams, & Maki, 1992) and the 50-ft walk performed at a preferred and a fast speed.

Assessment of Physical Impairments. The underlying physical impairments associated with functional mobility in older adults are assessed using the SFT (formerly called the Fullerton Functional Fitness Test), developed by Rikli and Jones (1999a, 1999b). This six-item test battery includes measures of upper and lower body strength, flexibility, aerobic endurance, and dynamic balance and agility. When administered in accordance with the guidelines, the results derived from each test item can be compared with national norms developed for community-dwelling older adults ranging in age from 60 to 94 years. (Refer to Rikli and Jones, 2001, for a more detailed description of test-administration procedures and national performance norms.) This test has demonstrated reliability and validity and can be performed successfully by older adults ranging from a healthy to a physically frail level of function. Although it might be necessary to modify how certain test items are administered in the case of more frail older adults (e.g., allow use of hands on 30-s chair stand or asymmetrical leg lift on 2-min step-in-place), the results can still be used to identify each participant's immediate program needs and evaluate progress when administered in the same way at regular intervals throughout the program.

Assessment of Sensory-System Impairments. A modified version of the M-CTSIB (Shumway-Cook & Horak, 1986) is used to evaluate the older adults' ability to use different sensory strategies. Although unable to distinguish among different sensory-system impairments, this test can be used to identify whether the use of sensory information in different sensory environments is normal or abnormal. In the modified version of the test, participants are required to stand quietly for 30 s with feet shoulder-width apart and arms folded across the chest in each of four different sensory conditions: (a) eyes open, firm surface; (b) eyes closed, firm surface; (c) eyes open, foam surface; and (d) eyes closed, foam surface. As a timesaving measure, if the person is able to maintain balance for the duration of the first trial, the tester can proceed to the next sensory condition. If the person lifts his or her arms from the chest or loses balance during the first trial, however, it is important to repeat
the trial as a way of determining whether the person can "learn" to maintain balance if exposed to the particular sensory environment a little longer. To maintain a total possible test score of 120 s, repeated-trial scores are averaged. Increased sway or loss of balance observed in the eyes-closed, firm-surface condition indicates poor use of somatosensory input for balance, and increased sway or loss of balance in the two foam-surface conditions might indicate poor use of visual-vestibular input (i.e., eyes open, foam surface) or vestibular input alone (i.e., eyes closed, foam surface).

Although no cutoff scores have been developed for this test relative to fall risk, an instructor can use the information derived from each test condition to determine whether an individual's ability to use sensory input for maintaining upright balance is normal or abnormal. From a program-planning perspective, knowing which sensory conditions pose the greatest difficulty for an individual can also help the instructor select the most appropriate multisensory activities for that participant, as well as the initial level of difficulty.

Assessment of Motor Impairments. Possible motor impairments related to the voluntary planning or execution of movements are identified using the reach-in-four-directions test (Newton, 1997). This test is an expanded version of the functional-reach test (Duncan, Weiner, Chandler, & Studenski, 1990), which was used to measure forward reach only, and measures how far an individual is able to lean through his or her region of stability without altering the base of support in a forward, backward, and lateral direction. The participant extends an arm and attempts to lean as far as possible in each of the four directions without moving the feet or rising up onto the toes. The distance leaned in each direction is recorded in inches. This test provides the instructor with important information about the size of each individual's region of stability and the type of postural strategy (i.e., ankle and/or hip) used to achieve maximal lean. Although the distance leaned will be affected by the age and height of the participant, Newton suggests that the mean values obtained from her evaluation of 251 older adults can be used to determine above- and below-average performance on this test. The mean values recorded were 8.89 in. in a forward direction, 4.64 in. in a backward direction, and 6.86 and 6.61 in. in the right and left lateral directions, respectively.

Functional Limitations. Three tests are used to identify specific functional limitations related to balance and mobility. These include the Berg Balance Scale (BBS; Berg et al., 1992), a 50-ft walk performed at preferred and fast speeds, and the "walkie-talkie" test (Lundin-Olsson, Nyberg, & Gustafson, 1997). The BBS is used to identify both the nature and the range of functional limitations associated with the performance of daily activities requiring balance. It has been shown to be a highly reliable and valid test when used across a broad continuum of functional levels. In addition to providing valuable information about the types of balance activities that are most difficult to perform, this test can also be used to identify older adults who are appropriate for intervention (Harada et al., 1995). It is argued to be less useful, however, as a tool for identifying who will actually fall (Bogle Thorabahn & Newton, 1996; Chandler, 1996). It is recommended that older adults who score less than 46 out of a possible 56 points on the BBS would benefit from immediate intervention.

The second test used to identify functional limitations related to gait is a 50-ft (approximately 15 m) walk performed at both a preferred and a fast speed. Participants are required to walk a total distance of 70 ft (first at preferred speed and
then at maximal speed), with the distance between 10 and 60 ft being timed for the purpose of calculating gait velocity. The additional measure of stride length can be assessed by counting the number of steps taken by the right or left foot over the same 50-ft distance. This test serves as a useful measure of both overall gait speed and whether the older adult is able to adapt his or her gait speed to accommodate a change in task demands (i.e., walk at maximal speed). Gait-speed values can also be compared with a set of normative values published by Bohannon (1997). The normative values for preferred and maximal speeds were based on data collected on 230 healthy adults ranging in age from 20 to 79 years. The results of this test provide the instructor with the information needed to select the most appropriate gait-pattern-enhancement and -variation activities for each participant.

Finally, the walkie-talkie test is used to measure older adults’ ability to divide attention between tasks. This quick test can be administered as the instructor walks with the participant to the location where the 50-ft walk begins. A conversation is initiated by the instructor in the form of a question that requires a response from the participant. A positive score is recorded if the participant stops walking in order to respond to the question posed. Alternatively, if a person is able to continue walking while responding to the question, a negative score is recorded. A positive score on this test suggests that the person is unable to divide his or her attention between the tasks of walking and talking. The results of this test can be used to determine the nature of the task demands introduced during the early stages of the program. For example, an individual who records a positive score on this test would be best suited to performing activities with a single goal (e.g., standing quietly on a foam surface while fixating on a point in space), whereas a person recording a negative score would be able to engage in tasks that required multiple task demands (e.g., reaching for or catching objects while standing on a foam surface) much earlier in the program.

Disability. On the medical and physical activity questionnaire described earlier in this section, a composite self-report physical-function scale is also included that assesses a wide range of functional abilities, from those associated with basic activities of daily living (ADLS; e.g., bathing, dressing oneself) to instrumental or intermediate ADLS (housework, shopping) to advanced activities such as strenuous household, sport, and physical activities (e.g., digging in the garden, hiking, aerobic dance). This scale is an expanded version of three previously published scales and was developed by Rikli and Jones (1998). Participants are placed in advanced-, moderate-, or low-functioning categories on the basis of their responses. This score is used to assess a participant’s level of disability, not only at the time of entering the program but also at regular intervals during the program (see Rikli & Jones, 1998, for a more detailed description of the scale and scoring procedures).

Fear of Falling/Balance-Related Self-Confidence. In addition to the physical-performance measures obtained, instructors would be well served to assess each participant’s global fear of falling and more specific balance-related self-confidence. A simple question can be included on the health/activity questionnaire that asks participants if they are worried about falling. A seven-point Likert scale can then be used to determine their level of fear. Responses can range from not at all to moderately to extremely worried. A more specific measure of balance-related self-confidence can also be administered before the participant performs any of the
physical-performance tests. The Activities-Specific Balance Confidence Scale, developed by Powell and Myers (1995), provides a valid assessment of an individual’s confidence level when performing activities of daily living requiring balance (e.g., getting into and out of a car, climbing stairs, rising from a chair). This scale is particularly well suited for use with community-residing older adults. The Modified Falls Efficacy Scale (Hill, Schwarz, Kalogeropoulos, & Gibson, 1996) is an alternative scale that also provides an assessment of balance-related self-confidence in community-residing older adults.

The collective results of all of the tests administered, which can usually be completed within the first one or two training sessions, are then used to help the instructor determine what types of balance activities would be best suited to each individual’s needs, as well as the tasks or sensory environments most likely to place the participant at heightened risk of falling if performed without supervision.

CORE COMPONENTS OF THE MULTIDIMENSIONAL PROGRAM

Consistent with the theory-based approach described earlier, the program is designed to systematically manipulate the demands of the task to be performed or the constraints imposed by the practice environment in a way that matches each individual’s intrinsic capabilities (review Figure 1). An important goal of the FallProof® program is to challenge but not exceed the individual’s intrinsic capabilities by systematically introducing balance and mobility tasks of increasing complexity performed in a variety of practice environments that simulate those encountered during daily life.

The program content focuses on improving four central components essential to good balance and mobility. These components are (a) volitional and nonvolitional control of the center of gravity (COG), (b) sensory-integration skills, (c) selection and scaling of postural strategies, and (d) development of a flexible and adaptable gait pattern. Recognizing the importance of lower body strength, flexibility, and endurance to functional mobility, each of these physical parameters is also combined with many of the balance activities presented in the four program components. For example, upper and lower body strength and endurance are combined with balance activities that are performed against or with resistance (e.g., resistance bands, weighted balls) while seated, standing on stable or compliant surfaces, or stepping up onto and over benches of different heights. Other balance activities, particularly those presented in the COG, postural-strategy, and gait-pattern components of the program, are also designed to improve flexibility of the upper and lower body by requiring movements through a full range of motion.

Center-of-Gravity-Control Training. The balance and mobility activities presented in this component of the program are designed to improve older adults’ ability to maintain a more upright position in space, lean away from and return to midline with improved postural control, and move the body through space more quickly and confidently. In addition, the exercises are intended to improve selected physical-fitness parameters (e.g., aerobic endurance, strength, power, coordination, flexibility) that contribute to good balance and mobility. In order to accomplish each of these goals, however, it is important that the older adult first understand where the COG is relative to the base of support (i.e., feet and buttocks when sitting, feet when standing) and how to move it relative to the base when performing specific
tasks (e.g., rising from a chair, walking up a flight of stairs). These exercises are often labeled the “belly button” control exercises because they readily conjure up a visual image of what part of the body must be manipulated in order to maintain postural control while performing a variety of daily tasks in a variety of environmental contexts. These exercises are systematically progressed from seated to standing to moving task situations according to each individual’s capabilities and the demands associated with the task and practice environment.

**Multisensory Training.** Our ability to perceive where we are in space and how we should respond to changing sensory conditions during the course of our daily lives greatly depends on (a) the amount and quality of the information that we receive from our peripheral sensory receptors and (b) how we organize and integrate the incoming information from the different sensory sources once it has reached the central nervous system. It has also been well documented that each of the three sensory systems (visual, vestibular, and somatosensory) that contribute to balance and mobility experience significant changes as a function of the aging process. Visual acuity, contrast sensitivity, and depth perception decline; the threshold for detecting vibration and joint movement increases; and the number of sensory receptors (hair cells) in the vestibular apparatus declines. A reduction in the gain of the vestibular-ocular reflex with advancing age has also been documented (Wolfson, 1997).

Although older adults are generally able to compensate for small changes in each of these systems that occur with age, impairments associated with particular medical diagnoses (e.g., macular degeneration, peripheral neuropathy, Meniere’s disease) or severe deconditioning will adversely affect their postural-control system and limit both the types of activities they can successfully perform and the environments in which they can safely function. The activities presented in this component of the program are intended to optimize the functioning of the sensory systems that are not impaired while compensating for the system or systems that are known to be permanently impaired. The effectiveness of sensory-training programs on selected measures of balance has already been demonstrated for healthy older adult groups in previous research studies (Hu & Woollacott, 1994a, 1994b), providing a strong rationale for inclusion in a multidimensional fall-risk-reduction program targeting more frail older adults.

Participants’ vision is optimized by teaching them gaze-stabilization strategies during standing and locomotor activities, first when the head is stable and then when it is moving. Performing balance activities on a compliant or moving support surface will also promote the use of vision for controlling balance by disadvantaging the somatosensory system, thereby making it more difficult to obtain accurate sensory information from the surface. Conversely, in the case of older adults who are identified as visually dependent, balance activities that optimize the use of somatosensory information, particularly at the level of the surface, while making it more difficult to use vision to control balance are preferred. Lowering the room lights, having the participant wear sunglasses, or disadvantaging vision by introducing a second task that requires vision (e.g., reading, tracking, reaching for or catching objects) are effective ways to reduce an older adult’s reliance on vision to control balance. Vision can also be removed as a sensory input by having participants perform activities with their eyes closed once they reach a higher level of performance and feel comfortable doing so. In order to encourage the use of
somatosensory input for balance, however, it is important to ensure that all activities are performed on a firm, broad surface so that both the quality and amount of somatosensory information received are maximized.

Finally, a greater reliance on vestibular input for balance can be achieved by disadvantaging the visual and somatosensory systems. Performing a variety of balance activities on surfaces that are compliant and/or moving while vision is either engaged in performing a second task or the eyes are closed will encourage greater reliance on vestibular information for balance. Of course, knowing which multisensory activities are most appropriate for each participant requires a careful review of the medical history completed at the outset of the program (to ascertain whether certain sensory systems are permanently impaired as a result of an existing pathology) and the results of the M-CTSIB performed during the prescreening assessment.

Postural-Strategy Training. The goal of the activities presented in this component of the program is to improve an older adult’s ability to select and then appropriately scale the postural strategy that best suits the demands of the task presented or the environment in which it is being performed. As a consequence of age-associated declines in multiple parameters (e.g., muscle strength, flexibility and proprioception at the ankle joint, heightened fear of falling) and the increasing avoidance of certain activities or environments, the older adult’s ability to use the various postural strategies effectively is compromised.

At least three clearly defined postural strategies have been described in the postural-control literature (Horak, 1994; Nashner & McCollum, 1985) and are used to either control sway in an anterior-posterior direction or reestablish balance after a perturbation. These are referred to as the ankle, hip, and step strategies. Each of these discrete postural-control strategies and various combinations of them are most commonly used to help us maintain or control our balance while performing daily tasks in and around the home or moving about the community. Not only will the demands associated with the task being performed influence the type of postural strategy selected but so too will the environment in which the task is being performed. Helping the older adult become more efficient in selecting and implementing the most appropriate postural strategy for the task demands and environmental situation is the primary reason for incorporating this set of progressive activities into the program.

The ankle, hip, and step strategies can each be practiced by manipulating the task goal or environment in at least four different ways: (a) maintaining balance while standing on different support surfaces (e.g., firm, compliant, moving, narrow), (b) voluntarily swaying farther away from midline in different directions while standing on different support surfaces, (c) minimizing or controlling the amount of sway in response to progressively larger applications of external force, and (d) making subtle and not so subtle adjustments in body position in anticipation of a destabilizing limb movement.

Just manipulating the type of support surface on which an individual is standing can often trigger the use of a particular postural strategy. For example, when one is standing quietly on a firm, broad surface, sway can largely be controlled using an ankle strategy. Performing the same task on a narrow or unstable surface, however, necessitates the need for a hip strategy to maintain balance. This change in strategy is necessary because the surface against which the individual is pushing is more narrow than the length of the feet or the surface “gives” or moves as force
is being exerted, making it more difficult to balance using only the smaller muscle groups surrounding the ankle. In people who are experiencing balance and mobility problems, standing on these more difficult surface types can often result in the use of the step as opposed to hip strategy. The use of a stepping strategy might be prompted by a heightened sense of fear as the level of sway increases, a below-average region of stability, or the absence of a hip strategy.

Presenting balance activities that require progressively larger movements of the COG through space or greater speed will also facilitate the use of the ankle, hip, and/or step strategy. Swaying over a small distance at a slow speed can be largely controlled using an ankle strategy, whereas swaying over progressively larger distances and at a faster speed will force the use of a hip strategy if the individual is to avoid having to take a step because balance has been lost. Introducing activities that require subtle changes in body position in anticipation of a destabilizing limb movement also provides older adults with an opportunity to practice the different postural strategies. These types of activities might include stepping up and down steps of different heights, stepping over obstacles while walking, maneuvering around cones, or stepping on and off different surfaces. Anticipatory adjustments in body orientation and the full array of postural strategies are necessary when performing these types of activities.

Applying different levels of external force to an individual, particularly if it is unexpected, requires that individual to make a more automatic postural adjustment and therefore constitutes the most advanced set of exercises associated with this program component. What one observes, in a person with good balance abilities, is the selection of the postural strategy that best matches the level of force applied. For example, a small application of force (i.e., light push or pull) is usually responded to with a countermovement about the ankle joints. As the level of force increases, the larger muscles in the hip region are recruited because the ankle joints can no longer generate enough torque to adequately counter the destabilizing force. Finally, a large application of force (i.e., strong push or pull) most often results in a stepping action in an effort to quickly reestablish a good, stable base of support. These activities can once again be progressed from seated, to standing, to moving contexts, depending on the individual’s capabilities.

**Gait- Pattern-Enhancement and -Variation Training.** The ability to successfully move about in a variety of different environmental contexts that impose different timing (e.g., stepping on and off escalators, crossing busy streets) or spatial demands (e.g., stepping over obstacles, walking in crowded malls) requires a gait pattern that is both flexible and adaptable. The activities in this component of the program are designed to achieve both of these goals. For example, requiring older adults to start and stop quickly and walk with longer, shorter, or wider stride patterns in different directions will require them to vary the spatial and temporal characteristics of their gait pattern, making it more flexible in the long term.

Other activities designed to enhance and vary the gait pattern include walking on the toes or heels; stopping, starting, and turning on command; and stepping over obstacles, on and off different surface types, and up and down inclines. As the older adult becomes more confident in his or her balance abilities and demonstrates better overall performance, additional tasks can be added to force a more subconscious control of balance because of the need to divide attention between the multiple tasks. To accomplish this goal, activities that require the older adult to count backward by 3s, reach for or catch objects, or turn the head while walking should be incorporated
into the training program. These activities will further challenge each individual’s abilities while also rendering the practice environment more like the everyday performance environment.

**Individualizing the Level of Challenge in a Group Setting**

Although the task of meeting the individual needs of each participant requires more time and effort on the part of the instructor when working with a group of older adults with different functional limitations and system impairments, an individualized approach can be accomplished by first reviewing each individual’s test results, making a list of the major problems identified, and then summarizing how the demands associated with the task to be performed or the sensory environment in which it is performed should be manipulated in order to challenge but not exceed that individual’s capabilities (see Table 1 for selected examples). Knowing which impairments of the postural-control system are permanent or unchangeable (e.g., macular degeneration, sensation loss) and which are amenable to change (e.g.,

**Table 1 Manipulating the Level of Balance Challenge by Varying Task and Environmental Demands**

<table>
<thead>
<tr>
<th>Variable manipulated</th>
<th>Level of Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Easiest</td>
</tr>
<tr>
<td>Individual capabilities</td>
<td>Seated on chair with backrest, Dyna-Disc on support surface. Hands holding onto chair for support.</td>
</tr>
<tr>
<td>Task demands</td>
<td>Exercises performed with feet shoulder-width apart. Exercise progression only performed.</td>
</tr>
<tr>
<td>Environmental demands</td>
<td>All exercises performed with eyes open.</td>
</tr>
<tr>
<td></td>
<td>Firm, broad support surface below feet.</td>
</tr>
</tbody>
</table>

*Note.* Variables can be manipulated alone or in combination as skill level of participant increases.
strength, inappropriate selection of postural strategies) is also important when selecting program activities.

With careful planning and selection of appropriate tasks and practice environments, a group of individuals can often be engaged in the same exercise but each at a level that best matches his or her current abilities (See Table 1). For example, a group of individuals can be performing the same set of weight-shift activities but at different levels of task difficulty, simply by manipulating the type of surface on which they are sitting or standing or the position of their arms (e.g., holding seated support surface, positioned on thighs, folded across the chest) during the exercise. While some individuals perform a balance task while seated on a Dyna-Disc placed on a chair, others could be performing the same task while seated on a gym ball, with or without a ball holder below to add stability. Similarly, certain individuals in the same group might be able to tolerate greater challenge by performing the activity with arms folded across the chest and/or eyes closed. In the case of this activity, knowing how well an older adult performed on the BBS will largely determine the type of seated surface or level of instability that he or she can manage during the weight-shift activity, and the results of the M-CTSIB can be used to determine which system or systems can be safely manipulated during any given exercise or the type of surface on which the exercise should be initially performed.

As described in Table 1, manipulating the demands associated with a given balance activity can also be individualized within a group setting. Performing a balance activity while standing on one leg is generally more difficult than performing the same activity in a tandem stance or with the feet together, which, in turn, is more difficult than performing the task with a wide base of support. A review of selected items on the BBS that require each of these bases of support (i.e., Items 7, 13, and 14) can guide the decision on how to manipulate the base of support, thereby providing an appropriate amount of challenge for each individual.

Requiring a second task to be performed in addition to the primary task of balancing or walking will further increase the task demands by requiring older adults to divide their attention between two tasks. Counting or reciting a verse while standing on a foam square or reaching for objects at different heights while walking forces the participant to perform the balance task at a more subconscious level while focusing attention on the second task. When choosing to introduce this more advanced program activity, a review of the results of the walkie-talkie test will inform the instructor as to the individual’s readiness for dual-task situations. In some cases, it might be necessary to begin by first introducing a second task while the individual is seated before progressing to standing and then moving activities.

When designing activities for each of the program components, the overarching goal is to create balance- and mobility-related activities that simulate the same types of balance challenges encountered in daily life. For example, repeated opportunities should be provided for program participants to experience the challenge of interacting with compliant and moving surfaces, stepping over obstacles, ambulating in busy sensory environments, performing multiple tasks requiring divided attention, and being unexpectedly perturbed. These types of activities are intended to simulate daily activities such as walking over uneven terrain, stepping up onto and down from curbs, walking in crowded malls, talking or turning the head to check for oncoming traffic while walking, or responding to the unexpected pull of a dog on its leash.
Summary

Both contemporary theories of motor control and a number of intervention-research findings provide strong support for a multidimensional and targeted programming approach to reducing fall risk among older adult populations. Specifically, previous research points to the need to first identify the specific system impairments that are contributing to the overt problems in balance and mobility, using a diverse set of screening and assessment tools, to design an intervention that specifically targets the underlying impairments and systematically manipulates the capabilities of the individual, the demands of the task, and the practice environment. In the second section of this article, a model fall-risk-reduction program was described that combines each of the core components shown to characterize interventions with successful outcomes. This group-structured program is currently operating in multiple community-based and residential care facilities and yielding positive results in improving the functional abilities of at-risk and physically frail older adults’ balance and mobility. Group-structured fall-risk-reduction programs in community facilities serving seniors and conducted by trained instructors offer a meaningful and potentially cost-effective method of both preventing falls and reducing the risk of falls among older adults.

References


