A Review of Balance Instruments for Older Adults

Susan L. Whitney, Janet L. Poole, Stephen P. Cass

Key Words: aged • measurement scales • reliability of tests

Objective. The purpose of this article is to review balance instruments developed within the past 10 years that can be used in the clinic or home environment. The use of such instruments may assist in identifying older adults who are at risk for falling, a major problem that can result in impaired function and loss of independence.

Method. Six instruments were reviewed: the Berg Balance Scale (Berg), the Clinical Test of Sensory Interaction and Balance (CTSIB), the Functional Reach Test, the Tinetti Balance Test of the Performance-Oriented Assessment of Mobility Problems (Tinetti), the Timed “Up and Go” Test (TU&GT), and the Physical Performance Test (PPT). Considered were what aspects of balance are assessed, time needed to administer the instrument, tools or equipment needed, evidence of reliability and validity, advantages and disadvantages, and the target population.

Results. The Berg, Tinetti, and PPT measure a variety of aspects of balance, whereas the Functional Reach, TU&GT, and CTSIB measure more narrow aspects of balance. All six instruments have been used with older adults and do not require much equipment. The instruments differ in their reliability and validity.

Conclusion. Familiarity with balance instruments can be helpful in selecting the one most appropriate for clinical setting and clients in order to institute appropriate prevention programs, such as environmental modifications and lifestyle adaptations.

An estimated 30% to 50% of adults 65 years of age and older and 40% of adults over the age of 80 experience one or more falls annually (Baker & Harvey, 1985; Perry, 1985; Sattin, 1992). Falls impair function and are a leading cause of death due to accident in these age groups (Baker & Harvey, 1985; Sattin, 1992). Walker and Howland (1991) and Poole and Whitney (1995) urged occupational therapists to recognize risk factors for falls because falls can compromise quality of life. When persons fear falling, they often restrict their daily activities. Risk factors include medical conditions (e.g., postural hypotension, anemia), medications, fear of falling, environmental factors (e.g., poor lighting, loose rugs), and problems with balance and mobility (Rubenstein & Robbins, 1984; Tinetti, Speechley, & Ginter, 1988; Walker & Howland, 1991). Occupational therapists often evaluate clients’ physical environments, using checklists and the assessments reviewed by Letts et al. (1994). Because they are involved in postfall rehabilitation and in recommending environmental modifications or lifestyle adaptations, we believe that occupational therapists also should consciously evaluate balance and mobility as part of their evaluation of daily living skills.

There are several assessments for evaluating balance that
are appropriate for occupational therapy settings and clients. Maintaining balance requires the interaction of the skeletal, neuromuscular, and sensory systems. In this article, we reviewed balance measures that assess these systems.

Method
We established four criteria for selecting instruments to review: (a) developed within the past 10 years, (b) evidence of reliability and validity, (c) applicable in the occupational therapy clinic or home environment, and (d) inexpensive and easy to administer. Six instruments met our criteria: the Berg Balance Scale, the Clinical Test of Sensory Interaction and Balance, the Functional Reach Test, the EquiTest™ platform and motion analysis system, the Functional Test of Sensory Interaction and Balance (CTSIB), or the Sensory Organization Test as it has also been called, assesses static balance under six combinations of sensory conditions—three visual and two support-surface conditions (see Table 1) (Shumway-Cook & Horak, 1986). The visual conditions involve the eyes open, eyes closed, and visual input through a visual conflict dome. The dome restricts peripheral vision and gives inaccurate visual input as it moves in phase with a person's head movement; that is, it stabilizes visual input such that postural sway is no longer correlated with visual flow. The support-surface conditions are standing on the floor or other hard, flat surface and standing on foam, which reduces the accuracy of proprioceptive information from the ankles. The CTSIB is based on research showing the interaction of the somatosensory, visual, and vestibular systems on postural stability. It is a clinical version of a more sophisticated computerized force platform and motion analysis system, the EquiTest™ (Nashner, 1990). The time that a person can maintain a position is recorded on a posture grid that can be used to quantify the amount of postural sway (Horak, 1987; Shumway-Cook & Horak, 1986). The test can also be scored by recording whether the client falls under each condition (Weber & Cass, 1993).

The Functional Reach Test is a dynamic measure of stability during a self-initiated movement (Duncan, Weiner, Chandler, & Studenski, 1990). Functional reach is the difference in inches between a person's arm length and maximal forward reach with the shoulder flexed to 90° while maintaining a fixed base of support in standing. The distance is measured with a yardstick mounted on the wall at the level of the person's shoulder. The Functional Reach Test has been expanded to include reaching to both sides and behind (Newton, 1996).

The Tinetti Balance Test of the Performance-Oriented Assessment of Mobility Problems (Tinetti) is a performance test of balance and gait during maneuvers used during normal daily activities (Tinetti, 1986). The balance portion consists of nine maneuvers (see Table 1), which are graded on an ordinal scale as either normal, adaptive, or abnormal. The gait portion rates seven gait characteristics as normal or abnormal. There are a total of 16 points on the balance portion and 12 points on the gait portion.

The Timed "Up and Go" Test (TU&GT) is a modified, timed version of the "Get-Up and Go" Test (Mathias, Nayak, & Issacs, 1986; Podsadlo & Richardson, 1991). It measures the time it takes a person to rise to standing from a standard armchair, walk a distance of 3 m, turn, walk back to the chair, and sit down.

The nine-item Physical Performance Test (PPT) assesses physical functional capabilities (Reuben & Siu, 1990; Reuben, Siu, & Kimpau, 1992; Rozzini, Frisoni, Bianchetti, Zanetti, & Trabucchi, 1993). Seven of the nine items are related to static and dynamic balance; the other two items are feeding and writing (see Table 1). Items are scored on an ordinal scale from 0 (unable to do) to 4 (the fastest). A maximum of 36 points is possible for nine items and 28 for seven items. Most of the items are timed.

Administration Time
All six balance instruments take little time to administer. The Functional Reach Test is the quickest (1–2 min), followed by the TU&GT, the CTSIB, the Tinetti, the PPT, and the Berg (about 15 min). None of the instruments require training, but instructions and scoring for the Berg, the Tinetti, and the PPT must be secured from original articles (Berg et al., 1989; Reuben & Siu, 1990; Tinetti, 1986).

Tools or Equipment Needed
The tools needed for each instrument are listed in Table 1.
The TU&GT requires the fewest number of tools to administer, whereas the Berg and the PPT require the most; however, these tools are easily obtainable and common to most clinics and homes. The Functional Reach Test only requires a yardstick, a level, and Velcro®. Under ideal conditions, the yardstick is secured to the wall such that it can be adjusted in height. In less-than-ideal conditions, such as a client's home, the yardstick can be held by the therapist or a family member. The CTSIB requires only the foam and the dome, but the dome is rather time consuming to construct.

Reliability

Reliability of an instrument is the consistency with which it measures the attribute it is supposed to be measuring (Polit & Hungler, 1987). For an evaluation-type measure such as a balance instrument, the equivalence of a single-observer agreement (intrarater reliability) or multiple-observer agreement (interrater reliability) as well as the stability of the instrument over time (test-retest reliability) are important. All six instruments have adequate interrater reliability (Berg et al., 1995), and CTSIB (Anacker & Gayton, 1989) have demonstrated adequate intrarater reliability. The Functional Reach (Weiner, Chandler, & Flexion parallel to a yard stick at Level SLS) and Balance Assessments table below presents the reliability data for these balance assessments.

### Table 1: Balance Assessments

<table>
<thead>
<tr>
<th>Test</th>
<th>Aspects of Balance Measured</th>
<th>Time (min)</th>
<th>Tools</th>
<th>Reliability</th>
<th>Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berg Balance Scale (Berg, Wood-Dauphinee, Williams, &amp; Gayton, 1989)</td>
<td>Sit to stand, stand to sit, Transfer bed to chair, Stand eyes closed, Stand feet together</td>
<td>15</td>
<td>Stopwatch</td>
<td>Intrarater (ICC = .98)</td>
<td>Barthel (r = .67)</td>
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<td>Chair</td>
<td>Intrarater (ICC = .98)</td>
<td>TU&amp;GT (r = .76)</td>
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<td></td>
<td>Bed</td>
<td>Intrarater (r = .88)</td>
<td>Tinetti (r = .91)</td>
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<td>Ruler</td>
<td>Internal consistency</td>
<td>Discriminated falls with vestibular disorders and controls</td>
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<td></td>
<td></td>
<td></td>
<td>Stool</td>
<td>(Cronbach’s alpha = .96)</td>
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<td>Podsiadlo &amp; Richardson, 1991</td>
<td>Stand both feet, eyes open and closed, Stand both feet, dome, eyes open</td>
<td>5-7</td>
<td>Dome, Dense foam</td>
<td>Intrarater (68%-100% agreement)</td>
<td>Fugl-Meyer (rho = .77) Discriminated groups with vestibular disorders and controls</td>
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<td></td>
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<td>Stand foam, eyes open and closed</td>
<td>Test-retest (r = .99)</td>
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<td>Stand foam, dome, eyes open</td>
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<td>Reuben &amp; Siu, 1990</td>
<td>Turn head</td>
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<td>Thorburn &amp; Newton, 1996</td>
<td>Walk 50 ft</td>
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<td></td>
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<td>Climb stairs</td>
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<td>Write a sentence</td>
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<td>Simulate eating</td>
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<td></td>
<td>Physical Performance Test (Reuben &amp; Siu, 1990)</td>
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<td></td>
<td>Put on or remove a jacket, Pick up penny from floor</td>
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<td>IADL (r = .50, r = .80)</td>
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<td>Katz (r = .65, r = .50)</td>
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<td>Tinetti gait (r = .78, r = .69)</td>
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</table>

Note. IADL = instrumental activities of daily living.

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what it is intended to measure (Polit & Hungler, 1987). Three types of validity are generally studied: content, criterion, and construct. All instruments, except the TU&GT, report content validity, which relates to the extent to which the instrument represents the concept of interest.

When compared to a measurement standard, all six instruments report one type of criterion validity, concurrent validity (see Table 1). The measurement standard used to establish concurrent validity was generally scores on another balance instrument such as the Tinetti, the Berg, single leg stance, or walking speed. Scores on the Berg correlated with scores on the Tinetti and the TU&GT (Berg, Wood-Dauphinie, Williams, & Maki, 1992). Scores on the CTSIB correlated with scores on the Fugl-Meyer Assessment (DiFabio & Badke, 1990), and scores on the foam condition of the CTSIB and the Equitest have a high percentage of agreement (DiFabio & Badke, 1990; Weber & Cass, 1993). Scores on the Functional Reach Test correlated with scores on walking speed, tandem walk, mobility skills, single leg stance (Weiner et al., 1993), and center of pressure (Duncan et al., 1990). Scores on the Tinetti correlated with scores on the Berg (Berg et al., 1992) and stride length and single leg stance (Berg et al., 1992). The TU&GT scores correlated with scores on the Berg and gait speed (Podsiadlo & Richardson, 1991). The PPT scores correlated with the gait scores on the Tinetti (Reuben & Siu, 1990). Activities of daily living measures were also used to establish concurrent validity for the Berg (Berg et al., 1992), the PPT (Reuben & Siu, 1990), and the TU&GT (Podsiadlo & Richardson, 1991).

Predictive validity, the second type of criterion validity, is the ability of an instrument to predict future status. The Berg, Functional Reach, and Tinetti have established predictive validity. On the Berg, a score of < 45 was shown to be predictive of multiple falls in older adults (Berg et al., 1992). However, a later study reported that this cutoff score was not sensitive in identifying persons who fall but was specific in identifying persons who do not fall and that the Berg predicted a person’s use of an ambulatory aid (Thorbahn & Newton, 1996). A Functional Reach score of ≤ 6 in. was shown to be predictive of falls in elderly male veterans (Duncan, Studenski, Chandler, & Prescott, 1992; Studenski et al., 1994). On the Tinetti, four items related to balance (unsteady sitting down, unable to stand in single stance, unsteady turning, unsteady when nudged) and three items related to gait (increased trunk sway, increased path deviation, speed), in combination, predicted falls (Tinetti et al., 1988). Persons who scored < 18 had an increased risk of falls for the gait and balance items (Lewis, 1993). Predictive validity is less established for the CTSIB, the PPT, and the TU&GT. There is some evidence for predictive validity of the CTSIB, as persons who had fallen two to three times in the 6 months before the study had more difficulty standing on the foam (Anacker & DiFabio, 1992). The PPT is predictive of institutionalization as a consequence of problems with mobility (Reuben et al., 1992). No information on predictive validity is reported for the TU&GT.

Few of the six balance instruments documented construct validity, the degree to which the instrument is concerned with the underlying construct, in this case, balance (see Table 1). The CTSIB discriminated between persons with vestibular disorders and persons in an age-matched control group (Cohen, Blatchly, & Gombash, 1993), and persons identified as fallers had more difficulty standing on foam than did persons identified as nonfallers (Anacker & DiFabio, 1992). Functional Reach scores have been shown to improve over the course of rehabilitation (Weiner et al., 1993). The Berg discriminated between persons who use varying ambulation aids and differentiated persons with stroke from persons without stroke (Berg et al., 1995; Thorbahn & Newton, 1996). Scores on both the Berg and the Tinetti improved after persons received training in mobility and balance (Harada, Chiu, Fowler, Lee, & Reuben, 1995). Construct validity is not reported for the PPT and the TU&GT.

### Advantages and Disadvantages

The Berg measures many different aspects of balance and needs very little equipment to administer. However, the 15 min needed to administer the test is longer than that needed by the other instruments. The advantages of the CTSIB are that it is easy to administer and takes only 5 min to 7 min to administer. However, it assesses only the sensory aspects of static balance and not the ability to resist static loads or perturbations to balance. The advantages of the Functional Reach Test are that it is quick to administer, it is precise, and is sensitive to changes as a result of balance training (Weiner et al., 1993); however, it only measures movement in one direction—forward. The advantages of the Tinetti are that it assesses many different aspects of balance and is simple and quick to administer; however, it may not be sensitive to changes in balance. The advantage of the TU&GT is that it can be administered quickly with minimal equipment, but only a few aspects of balance (i.e., rising, walking, turning) are tested. In addition, predictive validity has only been partially established for the untimed version. The advantages of the PPT are that it is easy to score, takes only 10 min to administer, and measures balance during performance of a variety of tasks. The disadvantage is that it requires more equipment than do the other instruments (see Table 1).

### Target Population

All six instruments were developed for adults who are over
65 years of age, and several have been used to measure balance in persons with identifiable pathology. The CTSIB has been used with persons with hemiplegia (DiFabio & Badke, 1990) and vestibular disorders (Cohen et al., 1993). The Berg has been used with persons with hemiplegia (Berg et al., 1995). The PPT has been used with persons with Parkinson’s disease (Reuben & Siu, 1990). The CTSIB and the FunctionalReach Test have been used with children (Deitz, Richardson, Awatzer, Crowe, & Odiorine, 1991; Donahoe, Turner, & Worrell, 1994; Richardson, Awatzer, Crowe, & Deitz, 1992).

Conclusions and Recommendations

As all of the balance instruments reviewed are relevant to occupational therapists, the choice of an instrument will depend on what aspects of balance are to be measured and what the results will be used for. All six instruments measure balance during voluntary, self-initiated movements and may be used in either the home or clinic because they require minimal equipment and time (15 min is the longest). The Berg, Tinetti, and PPT all measure balance during performance of dynamic maneuvers, such as reaching up and bending down to retrieve objects, turning, moving from standing to sitting, and balancing while standing or sitting. These maneuvers are involved in the performance of daily self-care, work, and leisure activities. The Tinetti and PPT also measure balance during gait. The other three instruments measure more narrow aspects of balance, for example, forward reach (Functional Reach); moving from sit to stand and back, turning, and gait (TU&GT); and sensory contributions to balance (CTSB). The CTSIB can help therapists determine whether the vestibular, visual, or somatosensory systems are impaired and, therefore, which sensory strategies can be retrained or which compensation strategies can be taught. For example, a person who has problems when vision is occluded may want to leave on a nightlight or carry a flashlight for dimly lit areas.

If therapists plan to use the results to determine change over time or the outcome of an intervention program, then the timed instruments (i.e., TU&GT, PPT) or the ratio measurement (i.e., FunctionalReach) are more sensitive to change than the instruments with ordinal measurements (i.e., Berg, Tinetti, CTSIB). If the results are to be used to predict falls, only the Berg, FunctionalReach, and Tinetti have actual cutoff scores predictive of falls. These three instruments may also be helpful in setting objective goals for clients.

To use these instruments in research, therapists will want to be aware of their reliability and validity. For example, the Berg and the FunctionalReach Test have more evidence for reliability and validity than do the other instruments, specifically interrater reliability, concurrent and construct validity, predictive validity, and a cutoff score for falls.

Because balance requires the interaction of many systems, one single instrument may not be able to predict falls. Furthermore, persons most vulnerable to falls may limit their activities or not put themselves in precarious situations. Therefore, a comprehensive assessment of fall risk needs to include not only a determination of balance, but also an examination of other factors such as a person’s environment and pattern of everyday activities.

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References


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