Using The Systems Framework For Postural Control To Analyze The Components Of Balance Evaluated In Standardized Balance Measures: A Scoping Review

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Running head: Components of balance in standardized measures

Title: USING THE SYSTEMS FRAMEWORK FOR POSTURAL CONTROL TO ANALYZE THE COMPONENTS OF BALANCE EVALUATED IN STANDARDIZED BALANCE MEASURES: A SCOPING REVIEW

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ABSTRACT

Objective: To identify components of postural control included in standardized balance measures for adult populations.

Data Sources: Electronic searches of Medline, Embase, and CINAHL databases using key word combinations of postural balance/equilibrium, psychometrics/reproducibility of results/predictive value of tests/validation studies, instrument construction/ instrument validation, geriatric assessment/disability evaluation, grey literature and hand searches.

Study Selection: Inclusion criteria were measures with a stated objective to assess balance, adult populations (aged 18 years and over), at least one psychometric evaluation, one standing task, a standardized protocol and evaluation criteria, and published in English. Two reviewers independently identified studies for inclusion. Sixty-six measures were included.

Data extraction: A research assistant extracted descriptive characteristics and two reviewers independently coded components of balance in each measure using the Systems Framework for Postural Control, a widely recognized model of balance.

Data synthesis: Components of balance evaluated in these measures were underlying motor systems (100% of measures), anticipatory postural control (71%), dynamic stability (67%), static stability (64%), sensory integration (48%), functional stability limits (27%), reactive postural control (23%), cognitive influences (17%), and verticality (8%). Thirty-four measures evaluated three or fewer components of balance, and one measure, the Balance Evaluations Systems Test, evaluated all components of balance.
Conclusions: Several standardized balance measures provide only partial information on postural control and omit important components of balance related to avoiding falls. As such, the choice of measure(s) may limit the overall interpretation of an individual’s balance ability. Continued work is necessary to increase implementation of comprehensive balance assessment in research and practice.

KEY WORDS: postural balance, accidental falls, aging, chronic disease, psychometrics

ABBREVIATIONS

BESTest- Balance Evaluation Systems Test
NIDRR- National Institute of Disability and Rehabilitation Research
PEDro- Physiotherapy Evidence Database
PRISMA- Preferred Reporting Items for Systematic Reviews and Meta-Analyses
Balance is a critical skill for fall avoidance (1), and balance impairment is common both in older adults and people living with chronic health conditions (2-4). Balance exercise can reduce falls (5-7), and comprehensive assessment is recommended for identifying impairments in postural control and informing the design of optimal balance exercise programs for fall prevention (8). However, a plethora of standardized balance measures exist (9), and extensive variation in their use has limited the ability to synthesize data on the effects of balance interventions. For example, a systematic review on the effectiveness of exercise interventions to improve balance in older adults identified 95 eligible trials (6) but was able to pool less than 50% of included studies because over 25 different standardized balance measures were used across individual trials. Varied use of balance measures is also seen in clinical practice, as illustrated in one survey of balance assessment practices among Canadian physical therapists that reported use of over 20 different measures (10). These issues emphasize the need for consensus on the use of outcome measures to increase understanding of the most effective components of exercise interventions (11).

Direction is needed to inform balance measurement recommendations, and given the absence of a gold standard method for evaluating balance (12), content validity should be a primary consideration. However, previous systematic reviews on standardized balance measures are limited by focusing only on clinical utility, task, and environment issues in a restricted subset of measures (13, 14) or narrow population (12). As such, there is a need to systematically examine the theoretical basis underlying existing balance measures (12). Contemporary postural control theory views balance as the product of integrated inputs and the body as a mechanical system that interacts with the nervous system in a continuously changing environment (15-17). Support for this theory has been provided by evidence from multiple laboratories who have demonstrated...
how imposed constraints or deficits in the underlying systems impair balance (18). Based on this view, the Systems Framework for Postural Control was proposed (8). It describes six major components required for the maintenance of postural control: i) constraints on the biomechanical system, ii) movement strategies, iii) sensory strategies, iv) orientation in space, v) dynamic control, and vi) cognitive processing (Table 1, column 1), and highlights that each underlying component and type of control could independently lead to a balance impairment. As such, this framework emphasizes the need for individual assessment of each component and treatment on a case-by-case basis (8).

Given its conceptual basis, comprehensive nature, and support from the physiological and biomechanical literature, the Systems Framework for Postural Control can help to clarify the components of balance captured in existing measures and inform decisions when selecting measures for evaluating balance and informing rehabilitative interventions. The objectives of this study were to 1) identify existing validated standardized measures of standing balance in adult populations; and 2) determine the components of postural control captured in each tool, as outlined by the Systems Framework for Postural Control. The review question was “what components of postural control are included in standardized balance measures whose validity and reliability are established in adult populations (18 years and older)?”

METHODS

Study design

A scoping review – a rigorous approach useful for identifying gaps in the existing literature (19) – was conducted. We applied Arksey and O’Malley’s 5-stage framework for conducting scoping reviews (19, 20) and incorporated recent recommendations for enhancing this methodology (20, 21), such as using an iterative approach to develop the research question,
defining relevant concepts, and including quality indicators in the eligibility criteria. The steps
are outlined below. PRISMA recommendations for systematic review conduct and reporting (22)
also informed the methodology, and were adopted where appropriate.

1. Develop a research question

What components of postural control are included in standardized balance measures whose
validity and reliability are established in adult populations (18 years and older)?

2. Search for relevant material

A professional librarian searched published literature indexed in MEDLINE (1946 to
February Week 4 2014), EMBASE (1974 to 2014 March 10), and CINAHL (1981 to October
March 11 2013), and the search strategies were reviewed by a second librarian. Combinations of
the following terms were used: postural balance/ equilibrium, psychometrics/ reproducibility of
results/ predictive value of tests/ validation studies, instrument construction/ instrument
validation, geriatric assessment/ disability evaluation. A sample search strategy for MEDLINE is
presented in Supplementary Data File 1. A comprehensive grey literature search was also
conducted to identify measures not captured by the database searches, including the Canadian
Agency for Drugs and Technologies in Health grey literature search checklist (23), as well as a
hand search of published narrative review articles describing balance measures identified in the
database search, and a search of the Physiotherapy Evidence Database (PEDro), a database of
randomised trials, systematic reviews and clinical practice guidelines for physiotherapy, to
identify additional measures.

3. Define study selection

Level one title and abstract screening criteria included: i) descriptive studies focused on
balance measurement; ii) in adult populations (aged 18 years and older); and iii) published in the
English language. Screening criteria were piloted on a random 10% sample of abstracts and clarified where necessary. We were specifically searching for the “index” publication – a measure’s first publication presenting its development and/or initial psychometric evaluation – as the definitive reference for the measure. However, in anticipation that not all measures would be published in a way that it would be possible to identify the first publication from the abstract, the names of all balance measures identified in the abstract screen were recorded for manual cross-checking and hand search for the index publication. Two research assistants independently screened the abstracts of studies identified in the database search using the screening criteria. Disagreements were resolved by the primary investigator (blinded), who also reviewed the list of all measures identified in the abstract screening and flagged relevant abstracts for a follow-up hand search.

Level two full-text screening criteria included: i) index publication; ii) have a stated objective or commonly used to assess balance; iii) include at least one standing task; iv) have both a standardized testing protocol and standardized evaluation criteria; and v) have a minimum of one psychometric property (validity or reliability) evaluated. The last criterion (minimum of one psychometric property evaluated) was included for quality assessment purposes to prevent measures with no empirical support from being considered. Hand searches were triggered at this phase if i) no psychometric data was reported in the index publication (to determine whether companion papers existed that would support inclusion of the measure in the review); or ii) it was not clear from the full-text whether the identified article was the index publication. Full-text screening was performed by two research assistants, with disagreements resolved by blinded (primary investigator). Two co-investigators (blinded and blinded) reviewed and approved the final list of included measures to confirm that all known relevant measures were included.
4. Chart the data

Descriptive data abstraction was performed by a research assistant and reviewed by blinded (primary investigator). The research assistant used a standardized template to extract the measures’ stated purpose and development methods, characteristics (evaluation parameters, number of items), and results of preliminary psychometric testing (reliability and/or validity data).

The components of balance evaluated in each measure were explored by coding the individual items and tasks according to the Systems Framework for Postural Control. Review of the framework by the research team suggested that in some cases, multiple constructs were captured in the original six domains (e.g. reactive and anticipatory postural control under ‘movement strategies’). As such, the six domains were adapted by [blinded – primary investigator] into nine operational definitions of balance components that may be uniquely evaluated. These operational definitions were reviewed and revised by [blinded – co-investigator] and [blinded – co-investigator] both prior to and iteratively during coding, and validated by one external reviewer with expertise in neurophysiology of postural control. The final operational definitions are presented in Table 1. Two investigators ([blinded – primary investigator] and [blinded – co-investigator]) independently reviewed the tasks and scoring criteria of each measure and identified on a binary scale (yes/ no) which balance components were included in each measure. Individual components were defined as included if they were inherent to task performance, even if not explicitly part of the measure’s evaluation criteria. Disagreements were resolved through consensus discussion with a third investigator (blinded [co-investigator]).

5. Collate, summarize and report results
Data abstraction and mapping results were tabulated and descriptive statistics (frequencies, percentages) were calculated for all variables using SAS version 9.2.

RESULTS

Data synthesis

The study selection process is illustrated in Figure 1. The MEDLINE, CINAHL and EMBASE searches yielded a total of 1213 records. The hand search and grey literature search yielded an additional 18 records, while the PEDro search did not produce any additional results. After duplicates were removed, 974 abstracts were identified for review. Of these, 847 records were excluded after the abstract screening, and 128 papers were selected for full-text review. Following full-text screening, 66 papers representing the index publication of a standardized balance measure for adults were included. Full references for the index publication of all included measures are provided in Supplementary Data File 2.

Measure characteristics

Supplementary Data File 3 presents selected characteristics of each measure. The 66 included measures were published between 1986 and 2014. Thirty-seven measures (56%) stated at least one component of balance included in the Systems Framework for Postural Control. Reported development methods for each measure ranged from no description (n=33, 50%), to expert or clinician consultation (n=12, 18%), to statistical analysis (e.g. Rasch analysis, item response theory, etc. n=13, 20%). The number of items in each measure ranged between 1 and 53, with a median of 9 items. Twelve measures (18%) included some graded progression in which participants must meet specific criteria to complete additional items. Thirty-eight measures (58%) were evaluated on a categorical scale (ranging between 2 and 9 categories), 26 (39%) used
a continuous scale, and 2 (3%) used a combination. Psychometric data published with the index publication is presented in Supplementary Data File 4.

Components of balance evaluated in each measure

Coding agreement by the two independent reviews was 87%, and 100% agreement was achieved following consensus discussion with the third investigator. Coding results identifying the components of balance included in each measure are presented in Table 2. Underlying motor systems were evaluated in all 66 measures (100%), anticipatory postural control in 47 measures (71%), dynamic stability in 44 measures (67%), static stability in 42 measures (64%), sensory integration in 32 measures (48%), functional stability limits in 18 measures (27%), reactive postural control in 15 measures (23%), cognitive influences in 11 measures (17%), and verticality in five measures (8%). Figure 2 illustrates the distribution of number of components evaluated in each measure. Thirty-four measures (52%) evaluated three or fewer less components of balance, 22 measures (33%) evaluated between four and six components of balance, nine measures (14%) evaluated seven or eight components of balance, and one measure evaluated all nine components of balance (Balance Evaluation Systems Test).

DISCUSSION

To our knowledge, this work represents the first attempt to synthesize the literature on standardized balance measures for adult populations and analyze the content of measures with respect to an established theoretical framework for postural control. The primary findings of this review are the large number of independently validated standardized measures available to assess balance in adults, and the high proportion of measures that assess only a few components of balance as identified by the Systems Framework for Postural Control. These findings highlight a
number of issues relevant to selecting standardized balance measures, as well as broader issues related to the theoretical basis of postural control.

With respect to the high number of standardized balance measures, although 66 distinct measures were included in the current study, it is important to note that there was significant overlap in the specific balance tasks performed. For example, alternating steps onto a stool or platform were common across multiple measures (e.g. Activity-based Balance Level Evaluation scale, Balance Evaluation Systems Test, Berg Balance Scale, Community Balance and Mobility scale). Moreover, some stand-alone measures were incorporated as tasks in larger tests, such as single leg stance and functional reach (included in Balance Evaluation Systems Test and Berg Balance Scale), and several “new” measures were developed as combinations, adaptations or evolutions of other balance measures (e.g. Equiscale, Postural Assessment for Stroke Scale, Unified Balance Scale). However, recent data on clinical balance assessment practices indicate that refined and/or newer standardized balance measures have yet to be widely adopted (10), therefore it is difficult to determine whether actual balance assessment is improving with these changes. Rather, the pool of balance measures continues to widen with additional combinations of tasks in a circuoutous fashion.

Although several components of balance were included in a high proportion of measures (such as underlying motor systems, anticipatory postural control, static stability and dynamic stability in more than two thirds of measures), certain functionally-relevant components were not included in most measures. For example, reactive postural control – corrective responses following instability – was included in only 23% of measures. The lack of measures evaluating reactive control is concerning because the ability to successfully recover from instability is the most critical component of balance for fall avoidance (24). Impaired reactive control is
independently associated with falls resulting in as much as a six-fold increase in fall incidence (25). Similarly, cognitive contributions to postural control and fall risk are well-established and only 17% of measures included a secondary cognitive task (1, 26). Finally, vertically was the least-commonly included component (8% of measures). Verticality and appropriate orientation to gravity are important for establishing an efficient stable “starting position” for balance (27), the absence of which may put an individual in an inherently less stable position which could lessen the likelihood of successful balance recovery, and for whom individuals with sensory or neurological conditions may be particularly at risk (18).

Half of the measures included in this review evaluated three or fewer components of postural control. Some of these tests are commonly used in clinical practice, such as the single leg stance test (10), and as such, users need to be aware of what balance information they are getting when they choose a limited-scope measure. These types of tests may be appropriate for screening or risk assessment, but not for treatment planning and intervention selection. For a comprehensive balance assessment, multiple measures can be combined, or users can select a measure that includes most or all components of balance. Only one measure contained an explicit evaluation of all nine components of postural control: the Balance Evaluation Systems Test (BESTest). Published in 2009, it was developed with the goal of helping clinicians identify underlying postural control systems that may be responsible for poor functional balance – the only identified measure with this specific purpose. However, the BESTest developers also authored the most comprehensive description of the Systems Framework for Postural Control, so it is not unexpected that this measure is the closest match. Four measures included eight components of balance (Clinical Gait and Balance Scale, Fullerton Advanced Balance Scale, Mini-BESTest, and Unified Balance Scale). From a theoretical perspective, these are the most complete standardized
balance measures available to date. However, none of these measures have yet been widely
adopted in clinical practice (10), highlighting the need to study factors influencing balance
assessment practices and use of standardized measures in more detail.

Limitations

Although the focus was on balance assessment for treatment planning and intervention
selection, theoretical construct is only one characteristic of a measure. Consideration of measure
purpose (e.g. risk assessment versus outcome measurement) would be beneficial for evaluating
appropriateness of individual measures for their intended function. Examination of evaluation
parameters would also be useful, as quantitative measurements may provide more precise
information than observed behaviours. Furthermore, this review did not consider the difficulty of
individual items related to a particular balance component, such as whether static stability was
assessed by normal or narrow stance, tandem stance, or single-leg stance. Nor did we consider
how dual task assessments were conducted and whether instructions were to prioritize the
postural or cognitive task. These are important functional distinctions not reflected in the current
analysis, and attempts to evaluate particular components of balance across the continuum of
difficulty likely have contributed to the proliferation of so many measures. Given the
complexities of standardized balance measurement, we suggest that readers interpret our findings
in conjunction with the previous reviews that address some of these issues (13, 14), and refer to
the Rehabilitation Measures Database – a NIDRR-funded, searchable website containing
evidence-based summaries of more than 250 rehabilitation measures (28).

In conducting this review, we identified a number of gaps in postural control theory that
require attention in order to move the field forward. First, while the systems-based nature of
postural control is accepted and supported throughout the literature, there is no gold-standard
description of all known components and their interactions. Second, the Systems Framework for Postural Control, the model selected for the current review, accounts for all balance components equally, without any hierarchy or order to the individual components. It also only considers standing balance, when sitting balance is an important functional task recognized in a number of the measures included in this review. Indeed, in this review we excluded measures that only included sitting balance (n=8) because they could not be captured in the model. Refinement of the theory to address such issues may more accurately reflect the nature of postural control in vivo, as well as facilitate increased efficiency of balance assessment in time and resource-constrained clinical environments. For example, reactive postural control may be considered a more challenging component than anticipatory control, and if an individual cannot effectively engage anticipatory strategies, it may not be appropriate to explicitly assess reactive control. Conversely, appropriate anticipatory actions do not necessarily indicate that reactive control is “normal”, requiring continued probing. Incorporating such logic to more standardized assessment strategies may preserve the theoretical integrity of balance measures while optimizing efficiency. Two included measures, the Balance Computerized Adaptive Testing system, and Hierarchical Balance Short Forms did incorporate such a system into their approach, but lacked consideration of all components of postural control in their models. Continued refinement of these systems from a comprehensive perspective may be a practical approach moving forward.

CONCLUSIONS

The theoretical components of postural control included in standardized balance measures for adults vary greatly, with some measures omitting important components relevant for avoiding falls. As such, the choice of measure may limit the overall interpretation of an individual’s
balance ability. Continued work is necessary to increase implementation of comprehensive 
assessment in research and practice, in order to facilitate individualized identification of balance 
deficits and customization of training programs.
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FIGURE LEGENDS

Figure 1. Study flow diagram

Figure 2. Number of balance components evaluated by measure
**Table 1. Components of Balance Operational Definitions**

<table>
<thead>
<tr>
<th>Domains in Systems Framework for Postural Control ( (8) )</th>
<th>Scoping review adaptation of component of balance and operational definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Biomechanical Constraints: degrees of freedom, strength, limits of stability</strong></td>
<td>1. Functional stability limits: Ability to move the center of mass as far as possible in the anterior-posterior or medio-lateral directions within the base of support</td>
</tr>
<tr>
<td></td>
<td>2. Underlying motor systems: E.g. strength, coordination</td>
</tr>
<tr>
<td></td>
<td>3. Static stability: Ability to maintain position of the center of mass in unsupported stance when the base of support does not change (may include wide stance, narrow, one legged stance, tandem- any standing condition)</td>
</tr>
<tr>
<td>2. <strong>Orientation in space: perception of gravity, verticality</strong></td>
<td>4. Verticality: Ability to orient appropriately with respect to gravity (E.g. evaluation of lean)</td>
</tr>
<tr>
<td>3. <strong>Movement strategies: reactive, anticipatory, voluntary</strong></td>
<td>5. Reactive postural control: Ability to recover stability following an external perturbation to bring the center of mass within the base of support through corrective movements (E.g. ankle, hip, stepping strategies)</td>
</tr>
<tr>
<td></td>
<td>6. Anticipatory postural control: Ability to shift the center of mass prior to a discrete voluntary movement (E.g. stepping- lifting leg, arm raise, head turn)</td>
</tr>
<tr>
<td>4. <strong>Control of dynamics: gait, proactive</strong></td>
<td>7. Dynamic stability: Ability to exert ongoing control of center of mass when the base of support is changing (E.g. during gait, postural transitions)</td>
</tr>
<tr>
<td>5. <strong>Sensory strategies: integration, reweighting</strong></td>
<td>8. Sensory integration: Ability to reweight sensory information (vision, vestibular, somatosensory) when input altered</td>
</tr>
<tr>
<td>6. <strong>Cognitive processing: attention, learning</strong></td>
<td>9. Cognitive influences: Ability to maintain stability while responding to commands during the task or attend to additional tasks (E.g. dual-tasking)</td>
</tr>
</tbody>
</table>
Table 2. Components of balance evaluated by standardized measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Static stability</th>
<th>Underlying motor systems</th>
<th>Functional stability limits</th>
<th>Verticality</th>
<th>Reactive postural control</th>
<th>Anticipatory postural control</th>
<th>Dynamic stability</th>
<th>Sensory integration</th>
<th>Cognitive influences</th>
<th>Other constructs not included in systems framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity-based Balance Level Evaluation (ABLE Scale) (29)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Sitting balance</td>
</tr>
<tr>
<td>Advanced Balance and Mobility Scale (ABMS) (30)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Balance Computerized Adaptive Testing (CAT) system (31)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Supine to sitting, and sitting</td>
</tr>
<tr>
<td>Hierarchical Balance Short Forms (HBSF) (32)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Sitting balance</td>
</tr>
<tr>
<td>Balance Error Scoring System (BESS) (33)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Modified Balance Error Scoring System (M-BESS) (34)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Balance Evaluation Systems Test (BESTest) (18)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Brief Balance Evaluation Systems Test (Brief BESTest) (35)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Mini Balance Evaluation Systems Test (Mini BESTest) (36)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Balance Outcome Measure for Elder Rehabilitation (BOOMER) (37)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Balance Screening Tool (BST) (38)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>BDL Balance Scale (39)</td>
<td>Yes</td>
<td>Yes</td>
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</tr>
<tr>
<td>High Level Mobility Assessment Tool (HiMAT) (96, 97)</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Cross Step Moving on Four Spots Test (CSFT) (98)</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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</table>
Records identified through database searching (n= 1213)
  MEDLINE (n = 405)
  CINAHL (n= 469)
  EMBASE (n= 339)

Additional records identified through other sources (n= 19)
  Hand search (n = 18)
  Grey literature (n= 1)
  PEDro database (n=0)

Records after duplicates removed (n = 974)

Records screened (n = 974)

Records excluded (n = 847)

Full-text articles assessed for eligibility (n = 128)

Studies included in review (n = 66)

Full-text articles excluded (n=62)
  Paper not describing new measure (n=15)
  No standardized protocol and evaluation criteria (n=14)
  Not a measure of balance (n = 11)
  No standing balance task (n=8)
  No or insufficient psychometric data available (n=6)
  Not English language (n=4)
  Conference abstract only (n=3)
  Test items not available (n=1)
Supplementary Data File 1. Sample Search Strategy

Database: Ovid MEDLINE(R), Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid OLDMEDLINE(R) <1946 to February Week 4 2014>

Search Strategy:

1 Postural Balance/ (11988)
2 Psychometrics/ (47676)
3 1 and 2 (75)
4 Disability Evaluation/ (31007)
5 Geriatric Assessment/ (15901)
6 "reproducibility of results"/ (230959)
7 5 or 6 (245565)
8 1 and 4 and 7 (98)
9 3 or 8 (162)
10 limit 9 to english language (156)
Supplementary Data File 2.
References for Studies included in Review


92. La Porta F, Franceschini M, Caselli S, Cavallini P, Susassi S, Tennant A. Unified Balance Scale: an activity-based, bed to community, and aetiology-independent


### Supplementary Data File 3. Measure Characteristics

<table>
<thead>
<tr>
<th>Measure</th>
<th>Reference</th>
<th>Stated purpose of measure</th>
<th>Components of balance purportedly assessed</th>
<th>Target adult population</th>
<th>Development methods</th>
<th>Number of items in test</th>
<th>Evaluation parameters</th>
<th>Number of scoring categories</th>
<th>Graded progression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Balance and Mobility Scale (ABMS) (30)</td>
<td>Kairy et al. Disabil Rehabil. 2003; 25(3): 127-35</td>
<td>To address shortcomings of previous balance measures that do not address adaptive and reactive control and do not assess the interaction between impairment and disability components of the task used</td>
<td>Postural control in standing and walking</td>
<td>Not specified</td>
<td>Not specified</td>
<td>12</td>
<td>Categorical</td>
<td>4</td>
<td>No</td>
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<tr>
<td>Balance Computerized Adaptive Testing (CAT) system (31)</td>
<td>Hsueh et al. Phys Ther. 2010; 90(9): 1336-44</td>
<td>To assess balance function in people with stroke</td>
<td>Entire range of balance function (items with wide range and even distribution of difficulty)</td>
<td>Stroke</td>
<td>Pool of 41 items identified on basis of predefined balance concepts, clinical expert consultation and field testing to finalize item description and scoring, items administered by 5 raters to 764 patients and item response theory model fit to data and item</td>
<td>34</td>
<td>Categorical</td>
<td>26 items have 2 scoring categories and 8 items have 3 scoring categories</td>
<td>No</td>
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<tr>
<td>Parameters estimated</td>
<td>Stroke</td>
<td></td>
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<tr>
<td>Hierarchical Balance Short Forms (HBSF) (32)</td>
<td>Sitting, standing and stepping balance</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Balance Error Scoring System (BESS) (33)</td>
<td>Not specified</td>
<td></td>
<td></td>
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<tr>
<td>Modified</td>
<td>Postural stability</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hunt et al.</td>
<td>To easily administer</td>
<td></td>
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<td></td>
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<tr>
<td>Modified BESS (33)</td>
<td>Concussion</td>
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Continuous (number of errors) 6
Continuous 4
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</thead>
<tbody>
<tr>
<td>Balance Evaluation Systems Test (BESTest) (18)</td>
<td>Horak et al. Phys Ther. 2009 May 1, 2009; 89(5): 484-98</td>
<td>To help physical therapists identify underlying postural control systems that may be responsible for poor functional balance</td>
<td>Biomechanical constraints, stability limits/verticality, anticipatory postural adjustments, postural responses, sensory integration and stability of gait</td>
<td>Not specified</td>
<td>Initial test proposed by Horak and Frank, then clinicians provided feedback on clarity, sensitivity and practicality at 38 workshops over 4 years, inter-rater reliability evaluated, then test revised</td>
<td>36</td>
</tr>
<tr>
<td>Brief Balance Evaluation Systems Test (Brief BESTest) (35)</td>
<td>Padgett et al. Phys Ther. 2012; 92(9): 1197-207</td>
<td>To assess balance performance in 6 specific contexts of postural control to allow for identification of specific balance systems responsible for poor balance</td>
<td>Mechanical constraints, limits of stability, anticipatory postural adjustments, postural responses to induced loss of balance, sensory orientation and gait</td>
<td>Not specified</td>
<td>Evaluated internal consistency of items in each section of the BESTest (18) and used item-total correlations to identify each section’s most representative item</td>
<td>8</td>
</tr>
<tr>
<td>Balance Outcome Measure for Elder Rehabilitation</td>
<td>Haines et al. Arch Phys Med Rehabil. 2007 Dec;</td>
<td>To be a global standing balance outcome measure for elder rehabilitation</td>
<td>Global standing balance (static, dynamic and function)</td>
<td>Older adults undergoing rehabilitation</td>
<td>Cross-sectional survey with expert panel, selection of four stand alone tests, multicenter</td>
<td>4</td>
</tr>
<tr>
<td>Instrument Name</td>
<td>Organization</td>
<td>Reference</td>
<td>Description</td>
<td>Purpose</td>
<td>Sample Size</td>
<td>Type</td>
</tr>
<tr>
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<tr>
<td>(BOOMER) (37)</td>
<td></td>
<td>88(12): 1614-21</td>
<td>prospective cohort randomly divided into development and validation datasets to perform item scaling</td>
<td></td>
<td>88(12): 1614-21</td>
<td>Categorical 5</td>
</tr>
<tr>
<td>Balance Screening Tool (BST) (38)</td>
<td>Mackintosh et al. Int J Ther Rehabil 2006; 13(12): 558-61</td>
<td>To screen balance in older adults to identify impairments requiring further investigation &amp; intervention</td>
<td>Static and dynamic standing balance</td>
<td>Developed by expert physiotherapists based on published evidence and clinical experience</td>
<td>6</td>
<td>Categorical</td>
</tr>
<tr>
<td>BDL Balance Scale (39)</td>
<td>Lindmark et al. Advances in Physiotherapy. 2012; 14(1): 3-9</td>
<td>To quantitatively measure balance at a relatively high level</td>
<td>Not specified</td>
<td>People of working age with neurologic impairments and mild-moderate balance disturbance</td>
<td>10</td>
<td>Categorical</td>
</tr>
<tr>
<td>Berg Balance Scale (BBS) (40)</td>
<td>Berg et al. Physiotherapy Canada. 1989; 41(6): 304-11</td>
<td>To measure balance in healthy individuals</td>
<td>Not specified</td>
<td>Geriatric (60 years and over)</td>
<td>14</td>
<td>Categorical</td>
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<tr>
<td>Short Form of the Berg Balance Scale (SFBBS) (41)</td>
<td>Chou et al. Phys Ther. 2006; 86(2): 195-204</td>
<td>To evaluate balance performance in people with stroke</td>
<td>Not specified</td>
<td>Not specified (validated in stroke)</td>
<td>7</td>
<td>Categorical</td>
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<tr>
<td>Scale</td>
<td>Reference</td>
<td>Purpose</td>
<td>Development and analysis method</td>
<td>Categorical</td>
<td>Levels</td>
<td>Acceptance</td>
</tr>
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<tr>
<td>Short Berg Balance Scale</td>
<td>Hohtari-Kivimaki et al. Aging- Clinical &amp; Experimental Research. 2012 Feb; 24(1): 42-6</td>
<td>To assess functional balance among community-dwelling aged with moderate or good physical functioning</td>
<td>Factor analysis of BBS (40), removing 5 items</td>
<td>9</td>
<td>Categorical</td>
<td>5</td>
</tr>
<tr>
<td>Brunel Balance Assessment</td>
<td>Tyson et al. Clin Rehabil. 2004; 18(7): 801-10</td>
<td>To assess the effects of specific stroke physiotherapy interventions for balance disability post stroke</td>
<td>14-point hierarchical prototype test proposed with progressively difficult tasks, validated by decreasing pass rates for each item, acceptable coefficients of stability and reproducibility</td>
<td>12</td>
<td>Categorical</td>
<td>2</td>
</tr>
<tr>
<td>Clinical Gait and Balance</td>
<td>Thomas et al. J Neurol Sci. 2004 1/15; 217(1): 89-99</td>
<td>To comprehensively measure all essential elements of gait and balance</td>
<td>Not specified</td>
<td>18</td>
<td>Categorical</td>
<td>10 items have 5 levels, 4 items have 3 levels, 2 items have 2 levels, 2 items have subgroups</td>
</tr>
<tr>
<td>Test Description</td>
<td>Author(s)</td>
<td>Purpose</td>
<td>Injury Type</td>
<td>Length</td>
<td>Data Type</td>
<td>Suggests Continuous (time) or Categorical (subjective numeric ranking system for sway)</td>
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<tr>
<td>Clinical Test of Sensory Interaction in Balance (CTSIB)</td>
<td>Shumway-Cook and Horak. Phys Ther. 1986 Oct; 66(10): 1548-50</td>
<td>To assess the influence of sensory interaction on postural stability in the standing patient with neurologic problems</td>
<td>People with neurologic problems</td>
<td>Not specified</td>
<td>Suggests continuous (time) or categorical (subjective numeric ranking system for sway)</td>
<td>6</td>
</tr>
<tr>
<td>Community Balance and Mobility Scale (CB&amp;M) (46)</td>
<td>Howe et al. Clin Rehabil. 2006; 20:8 85-95</td>
<td>To identify postural instability, evaluate change following intervention and inform rehabilitation team about balance and mobility status of ambulatory individuals with traumatic brain injury returning to community environment</td>
<td>Ambulatory people with traumatic brain injury</td>
<td>19</td>
<td>Categorical</td>
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<tr>
<td>Dynamic Gait Index (48)</td>
<td>Shumway-Cook et al. Phys Ther. 1997 Aug; 77(8): 812-9</td>
<td>To evaluate and document a patient’s ability to modify gait in response to changing task demands</td>
<td>Not specified</td>
<td>8</td>
<td>Categorical</td>
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<tr>
<td>Instrument</td>
<td>Reference</td>
<td>Purpose</td>
<td>Population</td>
<td>Response Options</td>
<td>Items</td>
<td>Categorical Scale</td>
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<tr>
<td>Four-item Dynamic Gait Index (4-DGI) (49)</td>
<td>Marchetti et al. Phys Ther. 2006; 86(12): 1651-60</td>
<td>To measure walking function in people with balance and vestibular disorders</td>
<td>Not specified</td>
<td>Not specified</td>
<td>People with balance and vestibular disorders</td>
<td>Rasch analysis of DGI (48)</td>
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<tr>
<td>Functional Gait Assessment (FGA) (50)</td>
<td>Wrisley et al. Phys Ther. 2004; 84(10): 906-18</td>
<td>To assess postural stability during gait with higher-level tasks</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Revised DGI (48) and added three new items</td>
<td></td>
</tr>
<tr>
<td>Dynamic One Leg Stance (DOLS) (51)</td>
<td>Blomqvist and Rehn. Advances in Physiotherapy. 2007; 9(3): 129-35</td>
<td>To investigate different aspects of balance</td>
<td>Dynamic body actions during one-legged stance, sensory subsystems</td>
<td>Not specified</td>
<td>Not specified</td>
<td></td>
</tr>
<tr>
<td>Equiscale (52)</td>
<td>Tesio et al. Funct Neurol. 1997 Sep-Oct;12(S): 255-65</td>
<td>To evaluate balance in people with multiple sclerosis</td>
<td>Multiple sclerosis and people with unilateral motor or sensory impairments</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Preliminary 10-item instrument derived from POMA (53) and BBS (40); trial-and-error procedure: administered to 55 patients 1-3 times and Rasch analysis used to explore psychometric validity; 2 items deleted because too easy and uninformative</td>
</tr>
<tr>
<td>Fast Evaluation of Mobility, Balance and Fitness</td>
<td>Di Fabio and Seay. Phys Ther. 1997 Sep; 77(9): 904-17</td>
<td>To assess risk of falling, ability to complete functional tasks and assess reports of fear, pain,</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
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<td>Test Description</td>
<td>Reference(s)</td>
<td>Purpose</td>
<td>Sub-tests/Components</td>
<td>Participants</td>
<td>Scoring/Brief</td>
<td>Applicability</td>
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<tr>
<td>Five Times Sit-to-Stand Test (5-STS) (55)</td>
<td>Whitney et al. Phys Ther. 2005; 85(10): 1034-45</td>
<td>To measure balance dysfunction</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Continuous (time)</td>
<td>N/A</td>
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<tr>
<td>Four Square Step Test (FSST) (56)</td>
<td>Dite and Temple. Arch Phys Med Rehabil. 2002; 83(11): 1566-71</td>
<td>Dynamic standing balance, rapid stepping, obstacle avoidance</td>
<td>Older adults</td>
<td>Not specified</td>
<td>Continuous (time)</td>
<td>N/A</td>
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<tr>
<td>Fullerton Advanced Balance (FAB) Scale (57)</td>
<td>Rose et al. Arch Phys Med Rehabil. 2006; 87(11): 1478-85</td>
<td>To identify balance problems of varying severity in functionally independent older adults and evaluate system(s) that might be contributing to balance problems</td>
<td>Sensory systems and strategies, internal representations, musculoskeletal components, anticipatory and adaptive mechanisms</td>
<td>Functionally independent older adults</td>
<td>Review of conceptual frameworks, scientific literature and previously published tests; developed test items and evaluated appropriateness of items, clarity of instructions, and scoring by clinical experts; pilot test of preliminary scale with older adults to establish appropriate test protocols, scoring procedures and better instructions</td>
<td>10</td>
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<tr>
<td>Functional</td>
<td>Duncan et al.</td>
<td>To assess anterior</td>
<td>Dynamic stability</td>
<td>Not</td>
<td>Continuous (time)</td>
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<tr>
<td>Test</td>
<td>Reference</td>
<td>Objectives</td>
<td>Outcome Measures</td>
<td>Categorical/Dimensional</td>
<td>Categorical/Dimensional</td>
<td>Categorical/Dimensional</td>
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<tr>
<td>Reach Test (58)</td>
<td>J Gerontol. 1990 Nov; 45(6): M192-7</td>
<td>and posterior dynamic stability</td>
<td>specified</td>
<td></td>
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<tr>
<td>Kansas University Standing Balance Scale (KUSBS) (61)</td>
<td>Kluding et al. J Geri Phys Ther. 2006; 29(3): 93-9</td>
<td>To measure balance in lower levels of function in more severely impaired people</td>
<td>Standing balance</td>
<td>Not specified</td>
<td>Developed over 2 years by physical therapists; scale developed for lower-functioning patients, to document progress in an objective and quantifiable way, quick to use, no math, no equipment; during development therapists were encouraged to talk to each other about experiences with scale, script of therapist instruction to</td>
<td>Categorical</td>
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<tr>
<td>Test Description</td>
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<td>Purpose</td>
<td>Outcome Measures</td>
<td>Data Type</td>
<td>Score Format</td>
<td>Limit of Use</td>
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<tr>
<td>Modified Figure of Eight Test (63)</td>
<td>Jarnlo and Nordell. Phys Theor Pract. 2003; 19(1): 35-43</td>
<td>To measure the ability to walk slightly in lateral direction to both sides in an eight in combination with a narrow step width.</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Modification of Figure of Eight Test (64)</td>
<td>1</td>
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<tr>
<td>Parallel Walk Test (PWT) (65)</td>
<td>Johansson et al. Physi Theor Pract. 1991; 7(2): 121-5.</td>
<td>To measure dynamic balance during gait.</td>
<td>Dynamic balance during gait</td>
<td>Older adults</td>
<td>Not specified</td>
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N/A: Not applicable; No: Not specified
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<tr>
<th>Assessment</th>
<th>Description</th>
<th>Authors and Year</th>
<th>Purpose</th>
<th>Measurement</th>
<th>Agreement</th>
<th>Data Type</th>
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<tr>
<td>Modified Performance Oriented Mobility Assessment (66)</td>
<td>A feature of both disease-oriented and gait analytic approaches</td>
<td>Fox et al. Arch Phys Med Rehabil. 1996 Feb; 77(2): 171-6</td>
<td>Rheumatologists and physical therapists to identify what observations should be included and how they should be made; adapted this work to make instrument with 8 position changes for balance and 8 gait observations; 90% agreement between raters when tested in 15 ambulatory people; added 5 balance maneuvers</td>
<td>Not specified</td>
<td>People aged 65 and over with a hip fracture</td>
<td>Continuous (time, angle, distance, contact between thigh and abdomen)</td>
<td>N/A</td>
</tr>
<tr>
<td>Postural Assessment Scale for Stroke Patients (PASS) (67)</td>
<td>To characterize recovery in physical capacity and functional independence after hip fracture</td>
<td>Benain et al. Stroke. 1999; 30(9): 1862-8</td>
<td>To assess and monitor postural control after stroke; to assess subject performance</td>
<td>Maintenance of a given posture and to ensure equilibrium in changing postures (lying, sitting, standing)</td>
<td>Stroke</td>
<td>Adapted items from Fugl-Meyer assessment (68)</td>
<td>Categorical only</td>
</tr>
<tr>
<td>Short Form of Postural Assessment Scale for Stroke</td>
<td>To measure balance function in people with stroke</td>
<td>Chien et al. Neurehabil Neur Repair. 2007 Jan-Feb; 21(1):</td>
<td>Balance in lying, sitting or standing position</td>
<td>Stroke</td>
<td>Selected items from PASS (67) with highest internal consistency and greatest</td>
<td>Categorical</td>
<td>5</td>
</tr>
<tr>
<td>Test Name</td>
<td>Author(s)</td>
<td>Year</td>
<td>Details</td>
<td>Patients (SFPASS) (69)</td>
<td>81-90</td>
<td>Postural responsiveness in development cohort of patients, and compared 5, 6, and 7-item versions of SFPASS with 3 and 5 assessment levels</td>
<td>5, 6, and 7-item versions of SFPASS with 3 and 5 assessment levels</td>
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<tr>
<td>Postural Control and Balance for Stroke Scale (70)</td>
<td>Pyöriä et al.</td>
<td>Archs Phys Med Rehabil. 2005; 86(2): 296-302</td>
<td>To assess postural changes, sitting balance and standing balance with items of varying difficulty in the same clinical instrument</td>
<td>Sitting balance, static standing balance, and postural change tasks</td>
<td>Stroke</td>
<td>Yes when using the number of trials effective balance approach</td>
<td>Yes when using the number of trials effective balance approach</td>
</tr>
<tr>
<td>Postural Stress Test (PST) (71)</td>
<td>Wolfson et al. J Am Geriatr Soc. 1986 Dec; 34(12): 845-50</td>
<td></td>
<td>To safely, quantitatively assess the postural response</td>
<td>Postural responses</td>
<td>Older adults</td>
<td>Yes when using the number of trials effective balance approach</td>
<td>Yes when using the number of trials effective balance approach</td>
</tr>
<tr>
<td>Pull/ Retropulsion Test (72)</td>
<td>Visser et al. Arch Phys Med Rehabil. 2003 Nov; 84(11): 1669-74</td>
<td></td>
<td>To assess the ability to maintain balance</td>
<td>Balance reactions</td>
<td>Not specified</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Push and Release Test (73)</td>
<td>Jacobs et al. J Neurol. 2006;</td>
<td></td>
<td>To reliably assess postural stability with sensitivity to fall</td>
<td>Postural response to a sudden release of a subject pressing</td>
<td>Not specified; developed</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Test Description</td>
<td>Author(s) and Publication Date</td>
<td>Description</td>
<td>Outcome Measure</td>
<td>Original Source</td>
<td>Notes</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sensory Organization Test (SOT) (75)</td>
<td>Ford-Smith et al. Arch Phys Med Rehabil. 1995; 76(1): 77-81</td>
<td>To assess ability to make effective use of visual, vestibular, and proprioceptive inputs separately and the ability to suppress inaccurate sensory information</td>
<td>Not specified</td>
<td>Not specified</td>
<td>6</td>
<td>Continuous (2 outcomes per condition)</td>
<td>N/A</td>
</tr>
<tr>
<td>Head-Shake Sensory Organization Test (HS-SOT) (76)</td>
<td>Pang et al. Phys Ther. 2011 Feb; 91(2):2 46-53</td>
<td>To enhance the SOT (75) to improve delineation of balance performance</td>
<td>Not specified</td>
<td>Not specified</td>
<td>6</td>
<td>Continuous (equilibrium score as percentage from 0 - 100%)</td>
<td>N/A</td>
</tr>
<tr>
<td>Short Physical Performance Battery (SPPB) (77)</td>
<td>Guralnik et al. J Gerontol. 1994 Mar;49(2): M85-94</td>
<td>To assess lower extremity function</td>
<td>Not specified</td>
<td>Not specified</td>
<td>6</td>
<td>Categorical for standing and walking items but continuous (time) for rise from sitting item</td>
<td>Timed standing: side-by-side stand = 2, semi-tandem = 5, tandem = 3. Walking</td>
</tr>
<tr>
<td>Item</td>
<td>Categories depending on time</td>
<td>Task 1</td>
<td>Task 2</td>
<td>Task 3</td>
<td>Task 4</td>
<td></td>
<td></td>
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<tr>
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</tr>
<tr>
<td>Side-Step Test (78)</td>
<td></td>
<td>To assess dynamic standing balance in the frontal plane</td>
<td>Dynamic standing balance ability in the frontal plane</td>
<td>Stroke</td>
<td>Not specified</td>
<td>1</td>
<td>Continuous (distance)</td>
</tr>
<tr>
<td>Single Leg Hop Stabilization Test (79)</td>
<td></td>
<td></td>
<td>To assess postural control during a functional performance task</td>
<td>Postural control</td>
<td>Not specified</td>
<td>Adapted the modified Bass test described by Johnson and Nelson (80)</td>
<td>20</td>
</tr>
<tr>
<td>Single leg Stance Test (81)</td>
<td></td>
<td>To quantify standing balance</td>
<td>Standing balance</td>
<td>Not specified</td>
<td>Not specified</td>
<td>1 or 2 (if one leg or both legs tested)</td>
<td>Continuous (time)</td>
</tr>
<tr>
<td>Spring Scale Test (SST) (82)</td>
<td></td>
<td></td>
<td>To assess and quantify effective limits of anterior-posterior stepping for the purposes of fall risk assessment</td>
<td>Reactive and proactive balance</td>
<td>Communit y dwelling older adults</td>
<td>Not specified</td>
<td>2</td>
</tr>
<tr>
<td>Standing Test for Imbalance and Disequilibrium (SIDE) (83)</td>
<td></td>
<td></td>
<td>To classify static standing balance ability for fall prevention</td>
<td>Static standing balance</td>
<td>Not specified</td>
<td>4</td>
<td>Categorical</td>
</tr>
<tr>
<td>Star Excursion Balance Test (SEBT) (84)</td>
<td></td>
<td></td>
<td>To challenge the postural control systems of well-conditioned, physically active individuals recovering</td>
<td>Dynamic balance</td>
<td>Well-conditioned, physically active individuals</td>
<td>Not specified</td>
<td>8</td>
</tr>
<tr>
<td>Test Description</td>
<td>Reference</td>
<td>Purpose</td>
<td>Population</td>
<td>Measure</td>
<td>Criteria</td>
<td>Result</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
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<td>--------------------------------------------------------------------------</td>
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<td></td>
</tr>
<tr>
<td>Step Test (ST) (85)</td>
<td>Hill et al. Physiotherapy Canada. 1996; 48(4): 257-62</td>
<td>To meet the need for a clinically useful test of balance that incorporates dynamic single limb stance</td>
<td>Dynamic standing balance</td>
<td>Stroke</td>
<td>Not specified 6</td>
<td>Continuous (number of steps up to 7.5 cm in 15 and 30 s and 15 cm in 15 s on each leg)</td>
<td>N/A</td>
</tr>
<tr>
<td>Tandem Stance (86)</td>
<td>Hile et al. Phys Ther. 2012 Oct; 92(10): 1316-28</td>
<td>To assess postural stability by narrowing the base of support</td>
<td>Not specified</td>
<td>Not specified</td>
<td>2 Continuous (time)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Time on Ball Test (87)</td>
<td>Bruinsma et al. Clin Kin. 2008; 62(1): 1-3</td>
<td>Not specified</td>
<td>Dynamic balance</td>
<td>Not specified</td>
<td>1 Continuous (time)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Timed Up-and-Go Test (TUG) (88)</td>
<td>Podsiadlo et al. J Am Geriatr Soc. 1991; 39(2): 142-8</td>
<td>To quickly assess basic mobility skills</td>
<td>Not specified</td>
<td>Not specified</td>
<td>1 Continuous (time)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Expanded Timed Up-and-Go Test (ETUG) (90)</td>
<td>Botolfsen et al. Phys Res Int. 2008 Jun; 13(2): 94-106</td>
<td>To address shortcomings of the Get-up-and-Go (89) and TUG (88) tests</td>
<td>Not specified</td>
<td>Not specified</td>
<td>5 Continuous (time)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>TURN180 (91)</td>
<td>Simpson et al. Physiotherapy 2002; 88(6): 342-53</td>
<td>To be a simple, clinically useful test of dynamic postural control in frail elderly people</td>
<td>Dynamic postural stability</td>
<td>Frail older adults</td>
<td>2 Continuous (counting number of steps)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Unified Balance Scale</td>
<td>La Porta et al. J Rehabil</td>
<td>To be a single tool with proven</td>
<td>Quiet stance, anticipatory postural</td>
<td>People with a Literature review identifying BBS (40)</td>
<td>27 Categorical</td>
<td>2-5, depending</td>
<td>No</td>
</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Journal</td>
<td>Title</td>
<td>Authors</td>
<td>Method</td>
<td>Control</td>
<td>Design</td>
</tr>
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<tr>
<td>Med. 2011 Apr; 43(5): 435-44</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

**Measurement properties**, allowing the measurement of balance “from bed to community” regardless of the etiology of the neurological lesion causing the loss of balance.

- Adjustments/transitions, responses to external perturbations, sensory orientation, stability during gait.
- Neurologic lesion
- **POMA** (53), and FAB Scale (57), classical psychometric methods, Rasch analysis

**Unilateral Forefoot Balance Test** (93)

- Not specified
- High level balance
- Post menopausal women
- Unpublished pilot study with 31 health volunteers (16 female, mean age = 35 years) assessing inter-rater and test-retest reliability. Pilot inter-rater ICC = 0.99 and test-retest ICC = 0.95
- Continuous (time)
- N/A
- No

**Timed Up-and-Go Assessment of Biomechanical Strategies (TUG-ABS)** (94)

- To systematically evaluate biomechanical strategies used during performance of the TUG test
- Not specified
- Stroke
- Literature review, opinions of PTs, observations of TUG performance, expert panel content validation
- Categorical
- 15
- No

**Posture and Postural Ability Scale (PPAS)** (95)

- Rodby-Bousquet et al. Clin Rehab. 2014. 28: 82-90
- To evaluate posture and postural ability in people with severe disabilities
- Posture and postural ability in lying, sitting, and standing
- Cerebral Palsy
- Adaptation of pediatric Physical Ability Scale
- 4 tasks, 53 items assessed
- Categorical scale
- 7 categories for postural ability, 2 categories for quality of posture
- No

**High Level**

- Williams et al.
- To assess people with high level mobility
- Brain
- Item generation
- 9 tasks, 13
- Categorical
- 5
- No
| Mobility Assessment Tool (HiMAT) (96, 97) | C.A. Brain Inj. 2005. 19: 833-843 | high level mobility and balance problems | | proposed by expert clinicians, internal consistency and Rasch analysis determined final set | | | | |
| Cross Step Moving on Four Spots Test (CSFT) (98) | Yamaji & Demura. Arch Phys Med Rehabil. 2013. 94:1312-9 | To evaluate crossover steps in older adults | Crossover steps | Older adults (aged 65+) | Not reported | 9 | Continuous (time to complete 9 steps) | N/A | No |
### Supplementary Data File 4.

Preliminary psychometric characteristics evaluated in standardized balance measures with index publication

<table>
<thead>
<tr>
<th>Measure</th>
<th>Reliability tested</th>
<th>Reliability type</th>
<th>Reliability sample size</th>
<th>Reliability score</th>
<th>Validity tested</th>
<th>Validity type</th>
<th>Validity Method</th>
<th>Validity sample size</th>
<th>Validity score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity-based Balance Level Evaluation Scale (ABLE) (29)</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td>1. Content validity 2. Discriminant validity</td>
<td>1. 3-round Delphi process. 2. Compare scores across 3 functional groups (walker, stander, wheel-chair user)</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td>Advanced Balance and Mobility Scale (ABMS) (30)</td>
<td>Yes</td>
<td>Inter-rater reliability</td>
<td>12 people with recent stroke (mean age= 65 years), 6 healthy community-dwelling people (mean age= 71 years), 5 physiotherapist raters</td>
<td>ICC=0.97</td>
<td>Yes</td>
<td>Construct validity</td>
<td>Compared scores between high and low functioning people with stroke (based on gait speed cutoff of 0.7 m/s), and healthy older adults</td>
<td>12 people diagnosed with recent stroke (mean age= 65 years), 6 healthy community-dwelling people (mean age= 71 years)</td>
<td>Significant differences in scores across groups (p&lt; 0.05)</td>
</tr>
<tr>
<td>Balance Computerized Adaptive Testing (CAT) system (31)</td>
<td>Yes</td>
<td>1. Inter-rater reliability 2. Item reliability</td>
<td>1. 5 raters administered 41 items 2. 764 patients with stroke and stimulation study using data of patients who had participated in item pool development</td>
<td>Raw sum score of initial 41 items ICC=0.95 2. Item simulation study average reliability = 0.94</td>
<td>Yes</td>
<td>Concurrent validity</td>
<td>Correlated to Berg Balance Scale (40)</td>
<td>56 people with stroke (mean age= 62 years)</td>
<td>Pearson r=0.88</td>
</tr>
<tr>
<td>Hierarchical Balance Short Forms (HBSF) (32)</td>
<td>Yes</td>
<td>Item reliability</td>
<td>Simulation of data from 764 people with stroke</td>
<td>Average reliability &gt;= 0.93</td>
<td>Yes</td>
<td>Concurrent validity</td>
<td>Correlated to Berg Balance Scale (40)</td>
<td>85 people with stroke (mean age= 64 years)</td>
<td>Spearman p=0.97</td>
</tr>
<tr>
<td>Balance Error Scoring System</td>
<td>Yes</td>
<td>1. Inter-rater reliability 2.</td>
<td>1. 3 raters, 18 NCAA Division I</td>
<td>ICC range = 0.78 - 0.93 2.</td>
<td>Yes</td>
<td>Concurrent validity</td>
<td>Correlated to forceplate target sway</td>
<td>111 NCAA Division I varsity male</td>
<td>Pearson r range = 0.31 -</td>
</tr>
<tr>
<td>(BESS) (33)</td>
<td>Yes</td>
<td>Test-retest reliability</td>
<td>varsity male athletes (mean age = 10 years); 2 NCAA Division I varsity male athletes (mean age = 20 years)</td>
<td>Significant difference between repeated sessions for double-leg stance-foam target sway</td>
<td>athletes (mean age = 20 years)</td>
<td>0.79</td>
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</tr>
<tr>
<td>Modified Balance Error Scoring System (M-BESS) (34)</td>
<td>Yes</td>
<td>Internal consistency</td>
<td>144 high school football athletes (mean age = 16 years)</td>
<td>Reliability=0.88</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance Evaluation Systems Test (BESTest) (18)</td>
<td>Yes</td>
<td>Inter-rater reliability (evaluated once, then test revised and evaluated again)</td>
<td>Reliability session 1: 12 ambulatory adults with a range of balance function (age range = 50 - 80 years) Reliability Session 2: 11 subjects, including 4 from first session (age range = 67 - 88 years)</td>
<td>Total score ICC=0.91; sub-section ICC range = 0.79 - 0.96</td>
<td>Concurrent validity</td>
<td>Correlated score of most experienced rater to Activity-Specific Balance Confidence Scale (99)</td>
<td>12</td>
<td>Total score r=0.685, sub-section r range = 0.41 - 0.78</td>
<td></td>
</tr>
<tr>
<td>Brief Balance Evaluation Systems Test (Brief BESTest) (35)</td>
<td>Yes</td>
<td>Inter-rater reliability</td>
<td>3 raters, 20 participants with and without diagnosed neurological disorders or injuries</td>
<td>Total score ICC=0.99</td>
<td>Discriminant validity</td>
<td>Compared scores between people with and without neurological diagnosis and multiple sclerosis</td>
<td>20 participants with and without neurological diagnosis or injuries</td>
<td>Scores were significantly different between people with and without neurological diagnosis (p&lt; 0.01)</td>
<td></td>
</tr>
</tbody>
</table>
| Mini Balance Evaluation Systems Test (Mini BESTest) (36) | Yes | 1. Item separation index 2. Person separation | 115 people with balance disorders (mean age = 63 years) | 1. Item separation index=7.35, r=0.98; 2. Person separation | Outlier-sensitive mean-square statistic | 115 people with balance disorders (mean age = 63 years) | Mean square statistic scores for all items ranged between 0.7-
<table>
<thead>
<tr>
<th>Index</th>
<th>Internal consistency</th>
<th>Separation index</th>
<th>Construct validity</th>
<th>Concurrent validity</th>
<th>Correlated to</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance Outcome Measure for Elder Rehabilitation (BOOMER) (37)</td>
<td>No</td>
<td>784 people (mean age= 74 years)</td>
<td>Internal consistency range= 0.87 - 0.89</td>
<td>Yes</td>
<td>Correlated to Functional Independence Measure (FIM) (100), Modified Elderly Mobility Scale (MEMS) (101)</td>
<td>272 people (mean age= 75 years)</td>
</tr>
<tr>
<td>Balance Screening Tool (BST) (38)</td>
<td>Yes</td>
<td>1. Intra-rater reliability 2. Inter-rater reliability</td>
<td>1. 16 community dwelling older adults (mean age= 70 years) 2. 14 falls risk assessment community care clients (mean age= 77 years)</td>
<td>Yes</td>
<td>Correlated to Berg Balance Scale (40)</td>
<td>16 community dwelling older adults and 14 falls risk assessment community care clients</td>
</tr>
<tr>
<td>BDL Balance Scale (39)</td>
<td>Yes</td>
<td>1. Inter-rater reliability 2. Test-retest reliability 3. Internal consistency</td>
<td>1. 2 raters 2 &amp; 3. 30 people with mild- moderate balance problems (mean age= 53 years), 35 people with no balance problems</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berg Balance Scale (BBS) (40)</td>
<td>Yes</td>
<td>1. Inter-rater reliability 2.</td>
<td>1. Inter-rater total score</td>
<td>Yes</td>
<td>1. Content validity</td>
<td>1. Panel of 32 geriatric patients and health</td>
</tr>
<tr>
<td>Test Description</td>
<td>Yes</td>
<td>Internal consistency</td>
<td>Therapists 2 &amp; 3. 14 people aged 65+ years</td>
<td>ICC=0.98 2. Cronbach’s alpha= 0.96. 3. Intra-rater total score ICC=0.99</td>
<td>2. Criterion validity</td>
<td>Correlated scores with 3 global ratings of balance (good, fair, poor)</td>
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<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>Short Form of the Berg Balance Scale (SFBBS) (41)</td>
<td>Yes</td>
<td>Internal consistency</td>
<td>113 people with stroke</td>
<td>Cronbach’s alpha=0.96</td>
<td>Yes</td>
<td>1. Concurrent validity 2. Convergent validity 3. Predictive validity</td>
</tr>
<tr>
<td>Short Berg Balance Scale (42)</td>
<td>Yes</td>
<td>Internal consistency</td>
<td>519 people (mean age= 72 years)</td>
<td>Cronbach’s alpha=0.69</td>
<td>Yes</td>
<td>Concurrent validity</td>
</tr>
<tr>
<td>Brunel Balance Assessment (BBA) (43)</td>
<td>Yes</td>
<td>1. Internal consistency 2. Test-retest reliability 3. Inter-rater reliability</td>
<td>1. 80 people post stroke (mean age= 67 years) 2. 37 people post stroke patients (mean age = 66 years), 3.2 raters</td>
<td>Cronbach’s alpha= 0.93. 2. Kappa coefficient= 1. 3. Kappa coefficient= 1</td>
<td>Yes</td>
<td>Criterion-related validity</td>
</tr>
<tr>
<td>Clinical Gait and Balance Scale (GABS) (44)</td>
<td>Yes</td>
<td>Intra-rater reliability</td>
<td>10 people with Parkinson’s Disease</td>
<td>Kappa coefficient range= 0.315-0.839</td>
<td>Yes</td>
<td>Concurrent validity</td>
</tr>
</tbody>
</table>

**Note:** The table provides a summary of the internal consistency, test-retest reliability, inter-rater reliability, criterion-related validity, concurrent validity, and correlation with specific outcomes and scales for various balance assessments. The data includes the number of people tested, their age range, and the statistical measures used to assess reliability and validity.
<table>
<thead>
<tr>
<th>Test Description</th>
<th>Validation &amp; Reliability</th>
<th>Methodology Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical Test of Sensory Interaction in Balance (CTSIB) (45)</strong></td>
<td>Yes (105)</td>
<td>1. <strong>Test-retest reliability</strong> 2. <strong>Inter-rater reliability</strong> 1. 22 people (mean age = 21 years) 2. 2 raters 1. Pearson r = 0.99 2. Pearson r = 0.99 No N/A N/A N/A</td>
</tr>
<tr>
<td><strong>Community Balance and Mobility Scale (CB&amp;M) (46)</strong></td>
<td>Yes</td>
<td>1. Inter-rater reliability 2. Intra-rater reliability 3. Test-retest reliability 4. Teams of 2 physical therapists 2 &amp; 3. 32 people with traumatic brain injury attending neuro-rehabilitation (mean age = 34 years) 1. ICC = 0.98 2. ICC = 0.98 3. Immediate ICC = 0.98 and test-retest 5 days apart ICC = 0.90 Yes 1. Content validity 2. Construct validity 1. Physical therapists’ ratings of importance of scale items on 5-point scale from “not at all important” to “extremely important”, correlation to global balance rating. 2. Compared to gait velocity 36 people with traumatic brain injury attending neuro-rehabilitation (mean age = 31 years) 1. Physical therapist global balance scale r = 0.62; 2. Self-paced gait velocity r = 0.53, maximal gait velocity r = 0.64</td>
</tr>
<tr>
<td><strong>Dynamic Balance Assessment (DBA) (47)</strong></td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Dynamic Gait Index (48)</strong></td>
<td>Yes</td>
<td>1. Concurrent validity 2. Discriminant validity 1. Correlated to BBS (40), assistive device use, history of imbalance, self-perceived balance. 2. Compared scores between fallers and non-fallers 44 community-dwelling people (mean age = 76 years) 1. Correlation range = 0.44 - 0.76 2. Significant difference in score between groups (p &lt; 0.001)</td>
</tr>
<tr>
<td><strong>Four-item Dynamic Gait Index (4-DGI) (49)</strong></td>
<td>Yes</td>
<td>1. Subject separation 2. Item difficulty separation 3. Internal consistency 131 people (with balance and vestibular disorders and healthy controls) 1. r = 0.79 2. r = 0.99 3. Internal consistency correlation range = 0.75-0.82 Yes Discriminant validity Compared scores between fallers and non-fallers 34 people who had reported falls in the past 6 months and 89 subjects who had not reported falls in previous 6 months Scores were significantly different between fallers and non-fallers (p &lt; 0.01)</td>
</tr>
<tr>
<td><strong>Functional Gait Assessment (FGA) (50)</strong></td>
<td>Yes</td>
<td>1. Intra-rater reliability 2. Inter-rater 2. 10 clinicians. 1 &amp; 3. 6 people with vestibular 1. ICC = 0.83 2. ICC = 0.84 3. Cronbach Yes Concurrent validity Correlated to DGI (48), Activities-Specific Balance Confidence 6 people with vestibular disorders (mean age = 56 years) Correlation range = 0.1 - 0.8</td>
</tr>
<tr>
<td>Test Name</td>
<td>Age Range</td>
<td>Reliability</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
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<td>-------------</td>
</tr>
<tr>
<td>ABC Scale (99)</td>
<td>59 years</td>
<td>Yes</td>
</tr>
<tr>
<td>Dizziness Handicap Inventory (107)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equiscale (52)</td>
<td>59 years</td>
<td>Yes</td>
</tr>
<tr>
<td>Fast Evaluation of Mobility, Balance and Fitness (FEMBAF) (54)</td>
<td>59 years</td>
<td>Yes</td>
</tr>
<tr>
<td>Test Name</td>
<td>Concurrent Validity</td>
<td>Discriminant Validity</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
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<td>-----------------------</td>
</tr>
<tr>
<td>Five Times Sit-to-Stand Test (5-STS) (55)</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Four Square Step Test (FSST) (56)</td>
<td>Yes</td>
<td>1. Inter-rater reliability 2. Test-retest reliability</td>
</tr>
<tr>
<td>Fullerton Advanced Balance (FAB) Scale (57)</td>
<td>Yes</td>
<td>1. Test-retest reliability 2. Intra-rater reliability 3. Inter-rater reliability</td>
</tr>
<tr>
<td>Functional Reach Test (58)</td>
<td>Yes</td>
<td>1. Test-retest reliability</td>
</tr>
<tr>
<td>Multidirectional Reach Test (59)</td>
<td>Yes</td>
<td>1. Internal consistency 2. Test-retest reliability</td>
</tr>
<tr>
<td>Test Description</td>
<td>Yes/No</td>
<td>Reliability 1</td>
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<tr>
<td>Hierarchical Assessment of Balance and Mobility (HABAM) (60)</td>
<td>Yes</td>
<td>Inter-rater reliability</td>
</tr>
<tr>
<td>Kansas University Standing Balance Scale (KUSBS) (61)</td>
<td>Yes</td>
<td>1. Intra-rater reliability 2. Inter-rater reliability</td>
</tr>
<tr>
<td>Limits of Stability Test (LOS) (62)</td>
<td>Yes</td>
<td>Test-retest reliability</td>
</tr>
<tr>
<td>Modified Figure of Eight Test (63)</td>
<td>Yes</td>
<td>1. Inter-rater reliability 2. Test-retest reliability</td>
</tr>
</tbody>
</table>

Correlation with TUG: forward reach r= -0.442, backward reach r= -0.333, right reach r= -0.26 and left reach r= -0.31
<table>
<thead>
<tr>
<th>Test Name</th>
<th>Yes</th>
<th>Inter-rater reliability</th>
<th>Intrarater reliability</th>
<th>Study Group</th>
<th>ICC range</th>
<th>Yes/No</th>
<th>N/A</th>
<th>N/A</th>
<th>Correlation range</th>
<th>Significant differences in scores between fallers and non-fallers (p&lt; 0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel Walk Test (PWT) (65)</td>
<td>Yes</td>
<td>1. Inter-rater reliability 2. Test-retest reliability</td>
<td>1. 2 raters. 2.36 elderly fallers (mean age = 81 years)</td>
<td>1. ICC range = 0.71 - 0.99. 2. ICC range = 0.70 - 0.90</td>
<td>Yes</td>
<td>1. Concurrent validity 2. Discriminative validity</td>
<td>1. Correlated to tandem (86) and parallel stance tests, and tandem walk tests. 2. Compared scores between fallers and non-fallers</td>
<td>61 older adult fallers and non-fallers</td>
<td>Correlation range = 0.28-0.49, significant differences in scores between fallers and non-fallers (p&lt; 0.05)</td>
<td></td>
</tr>
<tr>
<td>Performance Oriented Mobility Assessment (POMA) (53)</td>
<td>Yes (111)</td>
<td>Inter-rater reliability</td>
<td>26 residents of a skilled nursing home (mean age= 80 years), 3 student physical therapists (phase 1), 9 physical therapy clinicians (phase 2)</td>
<td>Phase 1: Kappa range = 0.4 - 1.0; Phase 2: Kappa range = 0.4- 0.75</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Modified Performance Oriented Mobility Assessment (66)</td>
<td>Yes</td>
<td>Inter-rater reliability</td>
<td>23 people post hip fracture (mean age=81 years), 4 raters</td>
<td>Kappa range = 0.1 - 0.4. ICC range = 0.08 - 0.92</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Postural Assessment Scale for Stroke Patients (PASS) (67)</td>
<td>Yes</td>
<td>1. Inter-rater reliability 2. Intrarater reliability</td>
<td>1. 2 unique raters; 2. 12 people with stroke</td>
<td>1. Average k-coefficient= 0.72 (range= 0.45 -</td>
<td>Yes</td>
<td>1. Construct validity 2. Predictive validity</td>
<td>1. Correlated scores with motricity, somatosensory</td>
<td>70</td>
<td><strong>Strong correlations with the transferring and locomotion sections of FIM, with</strong></td>
<td></td>
</tr>
<tr>
<td>Short Form of Postural Assessment Scale for Stroke Patients (SFPASS) (69)</td>
<td>Yes</td>
<td>Internal consistency</td>
<td>287 people with stroke (mean age= 65.5 years)</td>
<td>Cronbach's alpha=0.93</td>
<td>Yes</td>
<td>1. Concurrent validity 2. Convergent validity 3. Predictive validity</td>
<td>1. Compared to PASS (67) at 14 days post stroke. 2. Correlated to Fugl-Meyer motor test (68) and Barthel Index (102); 3. Correlated to Barthel Index (102) 90 days post-stroke</td>
<td>287 people with stroke (mean age= 65.5 years)</td>
<td>1. ICC=0.98; 2.Barthel Index r=0.86 and Fugl Meyer r = 0.75. 3. r=0.48</td>
<td>motricity, sensibility, and spatial neglect scores, negative correlations with postural stabilization (r=0.48; P&lt; 0.0001) and postural orientation with respect to gravity (r=0.36; P=0.05); strong correlation to total FIM score (r=0.75; P&lt; 0.0001)</td>
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<tr>
<td>Postural Control and Balance for Stroke Scale (70)</td>
<td>Yes</td>
<td>1. Internal consistency 2. Inter-rater reliability 3. Intra-rater reliability</td>
<td>1 &amp; 3.19 people (1-8 weeks post stroke). 2. 5 raters</td>
<td>1. Cronbach alpha = 0.96. 2. total score ICC=0.95. 3. total score ICC=0.96</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Postural Stress Test (PST) (71)</td>
<td>Yes</td>
<td>Inter-rater reliability</td>
<td>51 (22 nursing home residents with 2 or more</td>
<td>Cronbach's alpha= 0.99</td>
<td>Yes</td>
<td>Discriminant validity</td>
<td>Compared scores between three groups</td>
<td>51 (22 nursing home residents with 2 or more</td>
<td>Significant difference in scores</td>
<td></td>
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<tr>
<td>Test</td>
<td>Yes/No</td>
<td>Inter-rater reliability</td>
<td>Score Description</td>
<td>Yes/No</td>
<td>Validity/Validity</td>
<td>Yes/No</td>
<td>Overall Validity</td>
<td>Between groups (p&lt; 0.05)</td>
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<tr>
<td>Pull/Retropulsion Test (72)</td>
<td>Yes</td>
<td>Inter-rater reliability</td>
<td>Weighted Kappa mean range= 0.57 - 0.98</td>
<td>Yes</td>
<td>Concurrent criterion validity 2. Predictive validity</td>
<td>1. Compared scores between unstable Parkinson's, stable Parkinson's, and health control groups; 2. Sensitivity and specificity</td>
<td>42 people with Parkinson's Disease (mean age= 64 years) and 15 healthy volunteers (mean age= 64 years)</td>
<td>1. Significant differences for all but two conditions (p&lt; 0.05). 2. Predictive: sensitivity= 0.63, specificity= 0.88, positive predictive value= 0.86, negative predictive value= 0.69 and overall predictive accuracy= 0.75</td>
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<tr>
<td>Push and Release Test (73)</td>
<td>Yes</td>
<td>Inter-rater reliability</td>
<td>ICC range = 0.83-0.84</td>
<td>Yes</td>
<td>Discriminant validity</td>
<td>Compared scores between people with and without Parkinson's Disease</td>
<td>68 people with Parkinson's Disease (mean age= 67 years), 69 healthy people (mean age= 67 years)</td>
<td>Significant differences in scores between people with and without Parkinson's Disease (p&lt; 0.001)</td>
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<tr>
<td>Rapid Step Test (74)</td>
<td>Yes</td>
<td>1. Test-retest reliability 2. Inter-rater</td>
<td>1. ICC range= 0.71-0.97. 2. ICC= 0.98 for</td>
<td>Yes</td>
<td>Convergent validity</td>
<td>Correlated to balance and fall risk measures</td>
<td>34 women (12 healthy young, 12 healthy older and 10 balance-</td>
<td>Correlation range= 0.60 - 0.84</td>
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<tr>
<td>Test Description</td>
<td>Yes/No</td>
<td>Test-retest reliability</td>
<td>Impaired older adults</td>
<td>Primary session and 0.95 for follow-up</td>
<td>Impaired older adults</td>
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<tr>
<td>Sensory Organization Test (SOT) (75)</td>
<td>Yes</td>
<td>Test-retest reliability (completed for each condition for first trial and average of three trials)</td>
<td>40 community-dwelling adults aged 65+ years</td>
<td>First-trial ICC range = 0.15 - 0.70. 3-trial average ICC range = 0.26 - 0.68</td>
<td>N/A</td>
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<tr>
<td>Head-Shake Sensory Organization Test (HS-SOT) (76)</td>
<td>Yes</td>
<td>Test-retest reliability</td>
<td>77 people [56 young adults (mean age = 24 years) and 21 older adults (mean age = 58 years)]</td>
<td>Overall HS-SOT condition 2 ICC = 0.82, overall HS-SOT condition 5 ICC = 0.77</td>
<td>N/A</td>
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<tr>
<td>Short Physical Performance Battery (SPPB) (77)</td>
<td>Yes</td>
<td>Internal consistency</td>
<td>5104 community-dwelling people from 3 population studies (aged 65 and over)</td>
<td>Cronbach’s alpha = 0.76</td>
<td>N/A</td>
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<tr>
<td>Side-Step Test (78)</td>
<td>Yes</td>
<td>Test-retest reliability</td>
<td>28 people with hemiplegia (mean age = 67 years)</td>
<td>ICC = 0.97 (for both affected and unaffected legs)</td>
<td>N/A</td>
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<tr>
<td>Single Leg Hop Stabilization Test (79)</td>
<td>Yes</td>
<td>Inter-rater reliability</td>
<td>3 testers, 15 people (mean age = 21 years)</td>
<td>Landing score: ICC = 0.92 Balance scale: ICC = 0.70</td>
<td>N/A</td>
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<tr>
<td>Single leg Stance Test (81)</td>
<td>Yes (112)</td>
<td>Inter-rater reliability</td>
<td>42 people (mean age = 42 years)</td>
<td>ICC = 0.76</td>
<td>N/A</td>
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<tr>
<td>Test</td>
<td>Yes/No</td>
<td>Reliability Type</td>
<td>Participants</td>
<td>ICC/Coef</td>
<td>Validity Type</td>
<td>Comparison/Result</td>
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<tr>
<td>Spring Scale Test (SST) (82)</td>
<td>Yes</td>
<td>Test-retest</td>
<td>58 community-dwelling adults aged 65+ years (29 fallers and 29 non-fallers)</td>
<td>ICC=0.94</td>
<td>Yes</td>
<td>1. Convergent construct validity 2. Known groups validity 1. Correlated to gait speed, TUG (88), Single Leg Stance Test (81), and Tandem Stance (86); 2. Known groups: Compared to gait speed, TUG (88), Single Leg Stance Test (81), and Tandem Stance (86)</td>
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<tr>
<td>Standing Test for Imbalance and Disequilibrium (SIDE) (83)</td>
<td>Yes</td>
<td>Inter-rater</td>
<td>30 rehabilitation in-patients with neurological or musculoskeletal impairment (mean age= 57.4 years), 2 physiotherapists</td>
<td>Cohen’s k= 0.76</td>
<td>Yes</td>
<td>Criterion-related validity Correlated with BBS(40)</td>
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<tr>
<td>Star Excursion Balance Test (SEBT) (84)</td>
<td>Yes</td>
<td>1. Intra-rater</td>
<td>16 recreationally active, healthy young adults (mean age= 21 years)</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
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<td></td>
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<td>reliability 2. Inter-rater reliability</td>
<td>1. ICC range= 0.78 to 0.96. 2. ICC range= 0.35 - 0.84 on day 1 and 0.81 - 0.93 on day 2</td>
<td></td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Step Test (ST) (85)</td>
<td>Yes</td>
<td>Test-retest</td>
<td>14 healthy older adults (mean age= 72 years) and 21 people with stroke (mean age= 76 years)</td>
<td>Yes</td>
<td>Concurrent validity</td>
<td>Correlated to Functional Reach Test (58), gait velocity and stride length</td>
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<td>reliability</td>
<td>Healthy elderly ICC range= 0.90 - 0.94; Stroke ICC range= 0.88 - 0.97</td>
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<td></td>
<td>49 people (20 stroke and 29 healthy elderly, mean age= 71 years) Correlation range = 0.68 - 0.83</td>
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<tr>
<td>Tandem Stance (86)</td>
<td>Yes</td>
<td>1. Inter-rater</td>
<td>45 women (mean age= 63 years), 2 observers</td>
<td>Yes</td>
<td>Discriminant validity</td>
<td>Compared test performance by fall history</td>
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<td>reliability 2. Test-retest reliability</td>
<td>1. ICC= 0.99. 2. ICC range= 0.76-0.91</td>
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<td></td>
<td>N/A</td>
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<tr>
<td>Time on Ball</td>
<td>Yes</td>
<td>1. Intra-</td>
<td>10 college-aged</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Test (87)</td>
<td>session reliability 2. Inter-session reliability 3. Inter-rater reliability</td>
<td>students (mean = 20 years); 3. 2 testers</td>
<td>ICC= 0.203. 3. ICC= &gt; 0.98</td>
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<tr>
<td>Timed Up-and-Go Test (TUG) (88)</td>
<td>Yes</td>
<td>1. Inter-rater reliability 2. Intra-rater reliability</td>
<td>22 medically stable people attending Day Hospital over a 2-month period</td>
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<td>1. ICC= 0.99; 2. ICC =0.99</td>
<td>Yes</td>
<td>Concurrent validity</td>
<td>Correlated to BBS (40), Barthel Index (102) and gait speed</td>
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<td>60 elderly volunteer subjects (mean age= 80 years)</td>
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<td>BBS r= -0.72, gait speed r= -0.55, Barthel Index r= -0.51</td>
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<tr>
<td>Expanded Timed Up-and-Go Test (ETUG) (90)</td>
<td>Yes</td>
<td>1. Intra-rater reliability 2. Inter-rater reliability 3. Test-retest reliability</td>
<td>1 &amp; 3. 28 home-dwelling people (mean age = 80 years) with impaired mobility 2. 3 raters</td>
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<td>1. ICC=0.91. 2. ICC range = 0.86 - 0.96. 3. ICC range = 0.54 - 0.85</td>
<td>Yes</td>
<td>Concurrent validity</td>
<td>Compared to TUG (88) score</td>
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<td>28 home-dwelling people (mean age = 80 years) with impaired mobility</td>
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<td>Corrected Pearson= 0.85</td>
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<td>TURN180 (91)</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
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<tr>
<td>Unified Balance Scale (92)</td>
<td>Yes</td>
<td>Internal consistency</td>
<td>217 people with a neurological diagnosis (mean age= 59.5 years)</td>
<td>Cronbach's alpha value=0.98</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Unilateral Forefoot Balance Test (93)</td>
<td>Yes</td>
<td>Test-retest reliability</td>
<td>28 women (age range 58-69 years)</td>
<td>ICC=0.96</td>
<td>Yes</td>
<td>Concurrent validity</td>
<td>Compared to Single Leg Stance Test (81) with eyes closed</td>
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<td>142 women (mean age= 61.6 years)</td>
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<tr>
<td>r=0.63</td>
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<tr>
<td>Timed Up-and-Go Assessment of Biomechanical Strategies</td>
<td>Yes</td>
<td>1. Intra-rater reliability 2. Inter-rater reliability</td>
<td>22 people with stroke (mean age 54.7 years), 4 raters</td>
<td>Kappa coefficient ranges 0.36-1.0</td>
<td>Yes</td>
<td>1. Content validity 2. Criterion-related validity</td>
<td>1. Ranking by experts 2. Compared to Sit-to-Stand task</td>
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</table>
| | | | | | 13 people with stroke (mean age=63.4 years) | 1. Final set of items reached kappa values >0.72 2. Kappa ranges 0.29-
<table>
<thead>
<tr>
<th>Test</th>
<th>Yes</th>
<th>1. Inter-rater reliability 2. Internal consistency</th>
<th>Yes</th>
<th>Construct validity</th>
<th>Compared to Gross Motor Function Classification System</th>
<th>30 adults with cerebral palsy (age range 19-22 years)</th>
<th>Significant differences between known groups represented by gross motor function levels (p&lt; 0.02)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posture and Posture Ability Scale (PPAS) (95)</td>
<td></td>
<td>1. Kappa coefficient ranges 0.85-0.99</td>
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<tr>
<td>High Level Mobility Assessment Tool (HiMAT) (96, 97)</td>
<td></td>
<td>Cronbach’s alpha=0.99</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Cross Step Moving on Four Spots Test (CSFT) (98)</td>
<td></td>
<td>ICC= 0.833 in men, ICC=0.825 in women</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

ICC= Intra-class correlation coefficient