Mobility assessment: Sensitivity and specificity of measurement sets in older adults

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Abstract

Objective—To identify quantitative measurement variables that characterize mobility in older adults, meet reliability and validity criteria, distinguish fall-risk and predict future falls.

Design—Observational study with 1-year weekly falls follow-up

Setting—Mobility laboratory

Participants—Community-dwelling volunteers (n=74; 65–94 years old) categorized at entry as 27 'Non-fallers' or 47 'Fallers' by Medicare criteria (1 injury fall or >1 non-injury falls in the previous year).

Interventions—None

Outcome Measures—Test-retest and within-subject reliability, criterion and concurrent validity; predictive ability indicated by observed sensitivity and specificity to entry fall-risk group (Falls-status), Tinetti Performance Oriented Mobility Assessment (POMA), Computerized Dynamic Posturography Sensory Organization Test (SOT) and subsequent falls reported weekly.

Results—Measurement variables were selected that met reliability (ICC > 0.6) and/or discrimination (p<.01) criteria (Clinical variables- Turn- steps, time, Gait- velocity, Step-in-tub-time, and Downstairs- time; Force plate variables- Quiet standing Romberg ratio sway-area,

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Maximal lean- anterior-posterior excursion, Sit-to-stand medial-lateral excursion and sway-area). Sets were created (3 clinical, 2 force plate) utilizing combinations of variables appropriate for older adults with different functional activity levels and composite scores were calculated. Scores identified entry Falls-status and concurred with POMA and SOT. The Full clinical set (5 measurement variables) produced sensitivity/specificity (.80/.74) to Falls-status. Composite scores were sensitive and specific in predicting subsequent injury falls and multiple falls compared to Falls-status, POMA or SOT.

Conclusions—Sets of quantitative measurement variables obtained with this mobility battery provided sensitive prediction of future injury falls and screening for multiple subsequent falls using tasks that should be appropriate to diverse participants.

Keywords

Outcome measures; Elderly; Geriatric assessment; Mobility limitations

Mobility disorders compromise quality of life and limit an older person's level of independence[1]. Maintenance of the center-of-gravity over the base-of-support[2] or balance is required for safe functional activity. However, mobility function is complex, including such tasks as maintaining stance during limb movements, performing transfers and stepping up or down[3].

Measurement of mobility is essential for developing and evaluating interventions to prevent chronic disability and acute morbidity. While existing screening tools are valuable to identify those not needing treatment, diagnostic and outcome measures are needed to assess efficacy. The most commonly used mobility assessments are self-reported capacity to climb stairs or walk one-half mile[4] and rating scales such as the Tinetti Performance Oriented Mobility Assessment[5] (POMA). Rating scales utilize subjective categorical determinations to create ordinal measurements, may be time-consuming, and are subject to inter-rater reliability concerns.

Objective performance indices (e.g. Short Physical Performance Battery[6]- 'SPPB', Timed-up-and-go- 'TUG'[7] or Sensory Organization Test-'SOT'[8]) are also commonly used. These continuous measures offer interval or ratio measurements and therefore finer performance distinctions. However, the tasks included may offer limited challenge to high-functioning individuals or include elements that are too difficult for impaired older adults. To address these issues, we developed a mobility battery based on activities of daily living (ADLs) that includes tasks representing progressively more difficult mobility components (see Appendix for details). The tasks progress with increasing complexity[9] and are designed to challenge performance abilities across the spectrum of older adults. Using progressively complex tasks including: standing balance, maximal leaning, reaching and pulling, sit-to-stand, gait, turns, stair descent and sideways step-in-tub offers the potential to avoid ceiling and floor effects[10].

Since there is no accepted gold-standard for mobility measurement, we compared the proposed measures with several that have achieved broad use. A recent history of falls has been used as an indicator of functional decline[11]. Because falls may preceed or follow mobility changes[12], we adopted the criteria of future injury or multiple falls as sentinel events for change in mobility status. Sensitivity rather than specificity was emphasized, as the focus was on recognizing individuals requiring intervention, rather than screening those who did not.

The purpose of this study was to identify quantitative measurement variables that characterize diverse mobility tasks in older adults, meet reliability and validity criteria

comparing favorably with other approaches, distinguish entry fall-risk group (Falls-status) by Medicare criteria and offer sensitivity to changes in mobility status as evidenced by subsequent falls.

METHODS

Subjects and Procedure

This study was approved by the Institutional Review Board at the University of Connecticut Health Center (UCHC). Subjects were recruited by letter using a mailing list provided by the UCHC Center on Aging, and initially screened by telephone. On their first visit 74 community-dwelling elders (CDE) provided informed consent, mental status, medical and falls histories and underwent physical examination by a physician. Exclusion criteria were: cognitive impairment (Mini Mental Status Exam[13], score <24), legally blind, obesity (BMI ≥ 30), and non-English speaking. To eliminate the influence of known pathology, volunteers with a diagnosis of neurological, orthopedic or visual disorders (e.g. Parkinson's disease, knee replacement or macular degeneration) directly impairing mobility were excluded. Common orthopedic limitations (e.g. osteoarthritis, knee pain) were not considered exclusion criteria.

Utilizing Medicare[14] fall-risk screening criteria, participants reporting ≥2 non-injury falls in the past year or ≥1 injury fall were categorized as 'Fallers'; remaining subjects were considered 'Non-Fallers'. Subjects also completed the Tinetti[5] (POMA; Appendix) and the Sensory Organization Test[8] (SOT; NeuroCom International, Appendix). The mobility battery was conducted on the subsequent visit, and Non-Fallers repeated the battery the same day to assess test-retest reliability. Test-retest data from Non-Fallers provided a preliminary reliability screen. Health changes and falls were reported weekly by postcard for up to a year or until ≥1 month of non-ambulatory status. Non-receipt of postcards, changes or falls triggered telephone inquiries. All follow-up participants were included in analyses of predictive validity.

Selection of Measurement Variables

We started with diverse measurement variables from the various tasks and sought to retain only those that were both reliable and repeatable. Measurement variables for each task derived from the biomechanics literature (Appendix) were assessed with semi-automated calculations using computer algorithms. Variables were evaluated for normality and normalized if necessary.

During mobility testing subjects practiced and rested as needed, then performed tasks at a self-selected pace 3 times (except where noted below) in their habitual manner. Tasks/ variables with very low test-retest reliability (Non-Faller intraday Pearson r<0.3) were excluded from consideration. Within-subject reliability of variables in the first session for all subjects was evaluated by computing the intra-class correlation (ICC, herein defined as the ratio of across-subject to total variance) using a linear mixed model[15] (LMM) with a random subject-specific intercept. Criterion-related validity was assessed with group means for each variable by ability to distinguish entry fall-risk group by Medicare criteria (Falls-status-Faller or Non-faller). Variables demonstrating moderate reliability (ICC>0.6)[16], and/or those that clearly distinguish Falls-status (p<0.01) were selected for further examination and categorized as clinical or force plate measures.

Tasks are further described in the Appendix, those with variables meeting the aforementioned criteria (underlined) were assessed as follows:

Quiet standing—The clinical Romberg test[17] of standing balance with eyes open and closed was conducted using a force plate (Advanced Mechanical Technology Inc). Data were collected for 1 minute and sway-area (enclosed center-of-pressure-COP path) was evaluated over the middle 30 seconds of 2 trials in each condition. The Romberg ratio compared eyes closed to open.

Maximal lean—Subjects leaned as far forward and backward as they could without bending their hips or knees or losing their balance. Anterior-posterior force plate COP excursion was calculated as the distance between the maximum forward and backward positions[18].

Sit-to-stand—Sitting (seat 41.4cm height) with arms crossed below the sternum and feet on the force plate, subjects were asked to stand. Sit-to-stand time was measured from onset of anterior-posterior force until vertical force reached body-weight. Sway-area was calculated from this point until variance was <1SD for >5s. Medial-lateral and anterior-posterior excursion values were determined for anterior-posterior and vertical[19] phases (Appendix).

Gait—Two self-paced out and back[20] walks (8.1m) were performed, average velocity was calculated and velocity for the fastest performance was used.

Turn—Subjects started 2 strides (self-selected 1.8–2.8m) from a chair. Time from the first step until the subject began to sit, and number of steps to turn taken were assessed.

Step-in-tub—Subjects stepped sideways (hips perpendicular) into a simulated tub (33cm high), a vertical grab bar was used if needed. Time from initiation of weight-transfer until end of 1-legged stance was measured.

Downstairs—Subjects descended 3 steps (17.8cm) using the handrail, if desired. Time from initiation of descent to touchdown was measured.

Creating Composite Scores

To evaluate these variables as mobility criteria, we created composite scores by standardizing each measure and summing the Z scores of subsets of individual variables. Using 9 selected measurement variables (5 Clinical: Gait- velocity, Turn- steps, Turn- time, Downstairs- time, and Step-in-tub- time; and 4 Force plate: Quiet standing- Romberg ratio sway-area, Maximal lean-anterior- posterior excursion, Sit-to-stand- medial-lateral excursion, and Sit-to-stand- sway-area upon standing), 5 measurement 'Sets' were created. Three sets are appropriate for use in clinical settings, and 2 when a force plate is available. All 5 clinical measures comprised the 'Full clinical set'. The 'Intermediate clinical set' excluded Step-in-tub- time and the 'Brief clinical set' further excluded Downstairs- time. There were 2 force plate sets; the 'Intermediate force plate set' included all 4 force plate measures, and the 'Brief force plate set' excluded Sit-to-stand-medial-lateral excursion and sway-area upon standing. By excluding more difficult tasks, 'Brief' sets may be appropriate for frail individuals; while elimination of tiring tasks for 'Intermediate' sets may enable assessment of those with marginal endurance.

Sensitivity and Specificity

Sensitivity and specificity were calculated by varying the composite score threshold and using Receiver Operator Characteristic (ROC) analysis to categorize individual performance. ROC analysis requires an established cut-off value or criterion[21]. Since no quantitative standards for mobility exist, we used published standards for POMA, SOT and

entry Medicare[14] fall-risk group (Falls-status) as criteria. POMA was considered normal if 1 item had a point deducted; and abnormal if 2 items had a point deducted, or one item had 2 points deducted[22]. SOT was considered normal[23] if the participant scored above the 70–79 year old mean (>729), and abnormal if below (≤729). The ability of the composite scores to accurately determine Falls-status was compared to POMA and SOT using these values. Next, concurrence between composite scores and Falls-status, POMA and SOT criteria was evaluated. Finally, we examined the potential of the composite scores, POMA and SOT to predict sentinel events using 2 prospective criteria: an Injury fall or Multiple falls (≥ 2 non-injury falls OR ≥1 injury falls) Confidence intervals for observed prospective sensitivity and specificity were calculated on the logit scale.

RESULTS

Participants were separated into Falls-status entry groups: 27 'Non-fallers' (age: range 65–87, 75.1±6.5 (mean±SD)) and 47 'Fallers' (age: range 70–94, 80.1±6.2). Fallers were older than the Non-fallers (Mann-Whitney, p=.008). There was no difference between Falls-status groups by sex (X^2=0.33, p=0.56). Four clinical and 2 force plate variables demonstrated both reliability (ICC>0.6) and fall-status discrimination (p<.01). Two force plate Sit-to-stand variables and the Number of Steps measure from the Turn task, which distinguished Falls-status (p<.01) were also included in further analyses. The distributional properties of Number of Steps (either 3 or 4) precluded calculation of reliability. Table 1 shows statistical profiles of these 9 variables. Prospective follow-up was completed by 62 participants, 12 declined weekly follow-up. Falls and medical changes were reported by postcard for up to 1 year or until subjects were non-ambulatory for a month. Five reached endpoint after sending postcards for 3–32 weeks due to stroke, serious illness or injury sequelae.

There was no difference in Falls-status entry groups with 4/27(15%) Non-fallers and 8/47(17%) Fallers declining follow-up (p=0.80). During follow-up 3/23(13%) Non-fallers and 9/39(23%) Fallers sustained an Injury fall (p=0.51), while 17/23(74%) Non-fallers and 23/39(59%) Fallers were Multiple fallers (p=.24). Our community-dwelling volunteers were separated into 2 entry groups and statistical criteria were used to select measures that accurately identified their Falls-status. No treatment or intervention was undertaken; therefore in subsequent analyses of the proposed measures, no statistical inference was employed. We report the observed sensitivity/specificity of the measurement sets utilizing various criteria.

Entry Falls-status Criterion

The sensitivity/specificity with which the 5 measurement sets identified entry Falls-status group was compared to POMA and SOT (Figure 1). The full clinical set produced both sensitivity and specificity (.80 and .74 respectively). Removing step-in-tub time (intermediate clinical set) markedly decreased specificity (from .74 to .52). When both downstairs and step-in-tub times were removed (brief clinical set), both sensitivity (from .80 to .57) and specificity (from .74 to .59) were decreased. The brief forceplate set provided higher sensitivity (.77) than both the intermediate (.75) and brief (.57) clinical sets. By comparison, both POMA and SOT scores showed lower sensitivity and high specificity (POMA, .51 and 1.00; and SOT, .32 and .93 respectively) to entry falls status.

Concurrent Validity

Concurrence of the 5 measurement sets with Falls-status, POMA and SOT is shown in Table 2. Sets were sensitive to POMA, though less so to Falls-status and SOT. The Full clinical set was the most sensitive overall, identifying those who would fail the POMA criterion with 100% sensitivity, Falls-status 80% and SOT 79%. The Intermediate clinical set

demonstrated 83–75% sensitivity to these criteria, while both Brief sets were sensitive to POMA (71%). Only the Full and Intermediate clinical sets offered concurrence with SOT.

Predictive Validity

Predictive ability of measurement sets was evaluated by prospective criteria obtained during 1-year follow-up of 62 participants. The sensitivity/specificity with which each set predicted a participant's subsequent Injury fall (12/62) or Multiple falls (40/62) during the follow-up period is compared to that of entry group Falls-status, POMA and SOT criteria in Figure 2. Entries in the upper right-hand quadrant demonstrate both sensitivity and specificity.

Mobility measurement sets were more sensitive and less specific than Falls-status, POMA or SOT score when predicting an Injury fall (Figure 2a). The Brief force plate set yielded the highest sensitivity (.68) to Injury falls, and should allow testing of frail individuals. For Multiple falls (Figure 2b), SOT, POMA, and Falls-status showed sensitivity, but not specificity. Measurement sets offered both sensitivity and specificity, the Intermediate force plate set showing the highest sensitivity (.78).

DISCUSSION

A battery of common mobility activities was reduced to 9 physical performance measurement variables representing 7 tasks through evaluation of their reliability and ability to discriminate entry Falls-status. Measurement sets that would be appropriate to frail or easily-fatigued, as well as high-functioning individuals, were constructed with combinations of these 9 variables (5 clinical and 4 force plate). Composite scores created from the measurement sets identified Falls-status with superior sensitivity compared with POMA and SOT and concurred with these measures. Finally, these sets predicted individuals who would suffer an Injury fall and those who would not experience Multiple falls better than Falls-status, POMA or SOT criteria.

Maurer and Commenges[24] emphasize the importance of sensitivity when measures are intended to assess changes and demonstrate its' basis in validity and reliability. We deliberately set a moderate reliability[16] standard because a measure lacking high reliability may discriminate if the differences between groups are sufficiently large, as was observed with Sit-to-stand variables. Whereas Full and Intermediate clinical sets had excellent concurrence with POMA and SOT, those excluding complex tasks (Brief clinical, Intermediate and Brief force plate) concur less well with POMA, and insufficiently with SOT. POMA and SOT demonstrated high specificity to Falls-status, supporting their value for screening those who may *not* require intervention. Both of these widely-used measures provide disappointing sensitivity to entry Falls-status and subsequent Injury falls. They were insufficient for situations requiring *both* sensitivity and specificity.

Raiche and colleagues[25] found POMA to be sensitive (70/52 specificity) to 1 or more falls among 225 CDE. With a high cutoff score, 125 tested positive, but the sensitivity dropped rapidly with other cutoffs. They recommended including more challenging items or those addressing medical factors associated with falls. In a residential care facility[26], POMA predicted those requiring further PT assessment (68/78) but not as well as simple gait velocity (80/89) in this population. We hoped to identify measures that could be used together to permit accurate evaluation in diverse situations. Quantitative measurement sets offer several advantages; with fewer components than POMA (3–5 compared to 16), clinical assessments take less time and qualitative judgment is eliminated. Turns, necessitating control of 3-dimensional movement, may provide an important addition to gait for frailer individuals. Inclusion of downstairs and step-in-tub tasks may eliminate the ceiling effect. In CDE, downstairs captured a wider spectrum of ADL limitations than climbing up[27].

The SOT offers the potential to differentiate sensory deficits, but requires special equipment unavailable in many settings. DiFabio[8] found that static posturography was more sensitive and equally specific when screening for vestibular deficits. We examined clinical and force plate variables separately and found that force plate measurements were especially good predictors. They provided tasks appropriate for older adults with existing impairments including standing balance, maximal leaning to stress the postural control system and sit-to-stand measures incorporating lower body strength.

Predictive ability is the hallmark of assessments that can identify individuals requiring intervention and sensitivity to change is critical to outcome evaluation. While appropriate for screening, Medicare Falls-status seems inadequate for these purposes, as very similar proportions of Fallers and Non-Fallers experienced an Injury fall or became Multiple fallers during follow-up. However, this may reflect self-selective enrollment by respondents who volunteered for mobility and falls studies because of underlying concerns.

Measurement sets offered superior sensitivity to participants who later sustained an Injury fall, as well as specificity to those who did *not* subsequently have Multiple falls. The personal cost of injury falls is significant, frequently resulting in ADLs assistance for longer than 6 months[28]. Whereas multiple falls increase fall-risk, one injury fall substantially increases risk[14] and generates additional 1-year medical costs of $27,745–30,038[29]. Only quantitative measurement sets provided sensitivity to Injury falls. Sets requiring as few as 2 variables (when a force plate is available), may provide an opportunity to focus scarce resources by identifying and treating those at risk for injuries.

Each of the tasks selected using statistical criteria are individually important components of mobility. Gait has been called a "physical vital sign"[30] and velocity may even be measured in the home-care setting[31]. A consensus report found preferred pace to predict adverse outcomes in community-dwellers[32]. Measurement of maximal lean[33], sit-to-stand[34] and stair descent[35] offer opportunities to identify remediable deficits. Step-in-tub[36], sit-to-stand[37] or turning[38] to sit tasks may highlight needed home safety modifications or unrealistic self-efficacy[39]. The Romberg ratio demonstrates visual and somatosensory contributions to quiet standing[40].

Sets of quantitative measures are proposed to suit diverse older adults and avoid ceiling and floor effects that are commonly encountered. Stepping into a simulated tub presents the most complex task, included for high-functioning individuals. The time to complete this real-life task permits assessment of weight transfer and single-leg stance abilities without ceiling effects observed with 1-legged standing in SPPB[6]. Changes in SPPB cannot be detected clinically[41], possibly because frail participants cannot complete repeated sit-to-stands, resulting in a floor effect. Brief sets omit this task and Intermediate sets, for the easily-fatigued, use 3 single performances with as-needed rest. Sit-to-stand, gait and turning are components of TUG[7], which utilizes one combined score rather than single measurements. Our reliability and discrimination values were obtained for the individual measures and sets are composed of tasks considered appropriate for different settings and participant abilities.

Limitations

To establish the statistical underpinnings of the measurement variables we excluded frail older adults and those with existing disorders known to impair mobility. Our study was not intended to establish cut-off values for identification of mobility impairment and these healthy community-dwellers offer limited generalizability. Future studies must include a broader range of participants and patient cohorts.

Conclusions

The proposed battery offers diverse real-life mobility challenges that may accommodate different circumstances and varied levels of participant function. Mobility measurement variable sets distinguished Falls-status and concur with POMA and SOT. These quantitative measures offer superior sensitivity in predicting Injury falls and provide both sensitive and specific prediction of Multiple falls.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Abbreviations

ADLs	Activities of Daily Living
BMI	Body Mass Index
CDE	Community-Dwelling Elders
ICC	Intra-class correlation
LMM	Linear mixed model
POMA	Performance Oriented Mobility Assessment
ROC	Receiver operating characteristics
SOT	Sensory Organization Test
SPPB	Short Physical Performance Battery
TUG	Timed Up and Go

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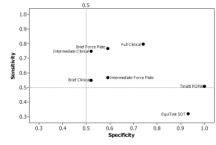
Figure 1. Sensitivity and Specificity of Measurement Sets, POMA and SOT to Entry Fall-Risk Group
Sensitivity and specificity values were calculated using entry Falls Status (Faller or Non-faller) as the criterion. Composite scores consisted of: Full Clinical set- Gait velocity, Turn steps, Turn time, Downstairs time, and Step-in-tub time; Intermediate Clinical set- Gait velocity, Turn steps, Turn time, Downstairs time; Brief Clinical set- Gait velocity, Turn steps, Turn time; Brief Force Plate set- Romberg ratio and Maximum lean; Tinetti POMA criterion- total of subscales where ≤26/28 was the threshold[22]; EquiTest SOT criterion- total score where ≤729 was the threshold[23].
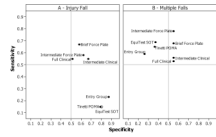
Figure 2. Predictive Value of Mobility Measurement Sets, Group, POMA and SOT
Sensitivity and specificity values were calculated using two falls criteria (Injury fall or Multiple falls) from weekly reports during the 1-year follow-up period. Composite scores consisted of: Full Clinical set-Gait velocity, Turn steps, Turn time, Downstairs time, and Step-in-tub time; Intermediate Clinical set- Gait velocity, Turn steps, Turn time, Downstairs time; Brief Clinical set- Gait velocity, Turn steps, Turn time; Intermediate Force Plate set-Romberg ratio, Maximum lean, M-L excursion and Sit-to-stand sway-area; Brief Force Plate set- Romberg ratio and Maximum lean; Tinetti POMA criterion- total of subscales where ≤26/28 was the threshold[22]; EquiTest SOT criterion- total score where ≤729 was the threshold[23].

Table 1

Characteristics of Clinical and Force Plate Measurement Variables

	Reliability	Mean (Standard Deviation)		p-value
	Intra-Class Correlation	Non-Fallers (n=27)	Fallers (n=47)	Non-Fallers vs. Fallers[*]
Clinical Variables				
Gait- Velocity (meters/second)	0.745	0.86 (0.13)	0.64 (0.18)	<0.001
Turn- Steps (number)	[†]	3.04 (0.20)	3.31(0.46)	<0.001[‡]
Turn- Time (seconds)	0.709	1.06 (0.32)	1.48 (0.77)	0.002
Downstairs- Time (seconds)	0.626	3.47 (0.69)	4.45 (0.90)	<0.001
Step-in-tub- Time (seconds)	0.702	1.90 (0.52)	2.93 (1.22)	<0.001
Force Plate Variables[§]				
Quiet Standing- Romberg ratio, sway-area (square centimeters)	0.993	6.77 (1.35)	11.55 (11.87)	0.007
Maximal Lean- Anterior-Posterior excursion (centimeters)	0.754	16.28 (3.58)	12.93 (3.48)	<0.001
Sit-to-stand- sway-area (square centimeters)	0.367	3.27 (6.58)	7.47 (3.44)	0.001
Sit-to-stand- Medial-Lateral excursion (centimeters)	0.562	2.54 (1.68)	4.04 (3.66)	0.006

Notes:

[*] P values obtained with linear mixed models;

[†] only two values observed, ICC cannot be calculated;

[‡] P values obtained using a logistic quasi-likelihood model.

Table 2

Concurrent Validity of Quantitative Measurements with Existing Standards Sensitivity (lower limit of confidence interval, upper limit of confidence interval) Specificity (lower limit of confidence interval, upper limit of confidence interval)

	Entry Falls-status[*]	POMA Score[†]	EquiTest SOT[‡]
Clinical Measurement Sets			
Full Complement: Gait velocity,			
Turn Time, Turn # of Steps,	A-0.8 (0.65, 0.9)	1.0	0.79 (0.51, 0.93)
Down 3 Stairs, Step in Tub	B-0.74 (0.55, 0.87)	.57 (0.43, 0.7)	0.66 (0.52, 0.77)
Intermediate: Gait velocity,	A-0.75 (0.59, 0.86)	0.83 (0.59, 0.95)	0.79 (0.51, 0.93)
Turn Time, Turn # of Steps,	B-0.52 (0.34, 0.7)	0.71 (0.57, 0.82)	0.74 (0.6, 0.84)
Down 3 Stairs			
Brief: Gait velocity, Turn Time,	A-0.57 (0.43, 0.71)	0.71 (0.5, 0.85)	0.41 (0.21, 0.65)
Turn # of Steps	B-0.59 (0.4, 0.76)	0.5 (0.36, 0.64)	0.54 (0.41, 0.67)
Force Plate Measurement Sets			
Intermediate: Quiet Standing,	A-0.55 (0.41, 0.69)	0.63 (0.42, 0.79)	0.53 (0.3, 0.74)
Maximal Leaning, Sway Area,	B-0.52 (0.34, 0.7)	0.52 (0.38, 0.65)	0.51 (0.38, 0.64)
Medial/Lateral Excursion			
Brief: Quiet Standing, Maximal	A-0.77 (0.62, 0.87)	0.75 (0.54, 0.88)	0.47 (0.26, 0.7)
Leaning	B-0.59 (0.4, 0.76)	0.5 (0.36, 0.64)	0.58 (0.45, 0.7)

NOTE: Values expressed as A-sensitivity (confidence interval) and B-specificity (confidence interval

[*] Entry Falls-status - classification as Non-faller or Faller based on self-reported history of ≥1 injury fall or ≥2 falls[14];

[†] Tinetti POMA- total of Balance and Gait subscales, where ≤26/28 indicated problems[22];

[‡] EquiTest SOT- total score for six conditions ≤729 (70–79 year old mean) was abnormal[23].

Anterior-Posterior- A-P, Medial-Lateral- M-L.