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Screening for Falls in Community-Dwelling Elderly

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Fifty community-dwelling elders were screened and followed for 14 months. Sixteen experienced falls and 34 did not. The screening variables consisted of age, the Clinical Test of Sensory Interaction on Balance, the Performance-Oriented Mobility Assessment for Balance, functional reach, the Physical Performance Test, and the following timed tests: floor transfer; 5-step test; 5 chair stands; tandem, semitandem, and side-by-side stance; penny pick-up; 360° turn; 50-ft walk; and 5-min walk. Data analysis and chi-squared or *t* tests were performed for each variable to determine significant differences between groups. Correlations, sensitivity, and specificity were calculated, and a stepwise discriminant analysis conducted to determine which significant variables best predicted falls. Discriminant analysis determined that the floor transfer and the 50-ft walk predicted falls in community-dwelling elders, correctly classifying 95.5% of participants. Prediction for falls was 81.8%, and for no falls, 100%. The timed floor transfer and 50-ft walk were the most discriminating measures to identify potential fallers.■

***Key Words*:** ■

Falls are a leading cause of injury, immobility, disability, psychosocial dysfunction, nursing-home placement, and premature death in the elderly (Hoyert, Kochanek, & Murphy, 1999). Approximately 30% of the community-based population over the age of 65 and 40% of the community-based population over the age of 80 will fall at least one time per year (Tinetti, Speechley, & Ginter, 1988; Tinetti & Williams, 1997). Falls are associated with more than 300,000 hip fractures annually, resulting in a 20% mortality rate after 1 year (American Academy of Orthopaedic Surgeons [AAOS], 1998). Accidents and fall-related injury are the seventh leading cause of death in the elderly (Centers for Disease Control and Prevention, 1999■). The direct care costs for elderly fall-related injuries were $20.2 billion in 1994 (AGS Ethnogeriatrics Advisory Committee, 1996). By 2020, the cost of fall injuries is projected to reach $32.4 billion (Englander, Hodson, & Terregrossa, 1996). Falling and instability are reported as the leading contributing

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factors in 40% of nursing-home admissions (Bezon, Echevarria, & Smith, 1999). Falls that do not result in injury might[redacted] lead to decreased mobility because of increased fear of future falls (American Geriatrics Society, British Geriatrics Society, & AAOS, 2001).

Fifty percent of elderly recurrent fallers admit to restricting their activities to avoid falls (Nevitt, Cummings, Kidd, & Black, 1989). Therefore, programs aimed at fall prevention are needed. To identify those who have the greatest fall risk, a quick, simple screening test for elders would be useful (Studenski et al., 1994). There are several measures that can be used for determining fall risk, but implementing the entire spectrum of available instruments is not practical for screening purposes because of time constraints (Berg, Wood-Dauphinee, Williams, & Gayton, 1989; Di Fabio & Seay, 1997; Shumway-Cook, Baldwin, Polissar, & Gruber, 1997). Quick identification of fall risk, using a minimum number of tests, is essential.

Studies have shown that falls might be attributed to one primary factor but are most likely the result of multiple factors (Baker & Harvey, 1985; Havlik et al., 1987[redacted]; Tinetti et al., 1988). Tinetti et al. (1988) reported that the chance of falling increases linearly with the number of risk factors observed in the elderly. Individuals with no risk factors have an 8% chance of falling; four or more risk factors increase the chance of falling to 78%.

The ability of a single measure to identify potential fallers is limited, but functional-mobility status is a strong predictor of falls (Tinetti et al., 1988). Gunter, White, Hayes, and Snow (2000) compared laboratory measures of lower extremity strength and power with measures of functional mobility, which incorporated lower extremity strength and power, and found that measures of functional mobility better discriminated between fallers and nonfallers. Performance of a functional task can be an appropriate alternative technique to screen flexibility, strength, balance, and endurance in elders (Bonder & Wagner, 1994). Therefore, it is important to choose functional tasks that will encompass these impairments. Recently, the American Geriatrics Society Panel on Falls in Older Persons outlined specific recommendations for routine care assessment of older adults (American Geriatrics Society et al., 2001). They recommended asking about falls and if an older adult reported a single fall, a quick screen for difficulty or unsteadiness with a simple functional task (standing up from a chair without using the arms, walking several paces, and returning to the chair) should be completed. Those who demonstrate difficulty or unsteadiness with this task or report recurrent falls would then require a detailed fall assessment including assessment of fall circumstances, medications, risk factors and environmental risks, medical and mobility problems, neurologic function, and cardiovascular status.

Unfortunately, there has been little research documenting the sensitivity and specificity of physical-performance measures that predict falling in elderly populations (Harada et al., 1995; Lord & Clark, 1996; Shumway-Cook et al., 1997). To develop an appropriate screening battery for fall risk that can be completed in a short time, a minimum set of measures that have high prediction of fall risk should be selected. The purpose of this study was to identify performance measures that have the greatest potential to predict falls in community-dwelling elderly adults.

Methods

PARTICIPANTS

Participants were recruited from a community-based senior citizens' center that serves a predominantly Hispanic population. Before the initial screening, all participants were told about the study and asked to sign an institutionally approved informed-consent form. There were 50 participants, 13 men (26%) and 37 women (74%). The mean age of the group was 72.3 (± 8.6) years. Twenty-seven participants were Hispanic, 3 were African American, and 15 were Caucasian. The inclusion criteria for this study were that the participant be over the age of 60 and function as an independent, community-dwelling person. No participants were excluded based on disease or dysfunction, but a brief medical history was obtained to determine the number and types of problems present. Twenty-five of the participants were diagnosed with diabetes, 21 reported hypertension, and 16 had arthritis of the lower extremities. Eleven participants reported some form of cardiopulmonary disorder including previous cardiac-bypass surgery, stroke, transient ischemic attack, and peripheral vascular disease.

After the initial screening, participants were closely followed on a regular basis for 14 months by case managers from the senior citizens' center. Before the assessment period, the investigators met with the case managers and instructed them to ask the participants during each visit if they had fallen since their last visit. If a participant reported a fall, the case managers were to inquire about fall frequency, location, cause, and any injuries suffered. They were instructed to contact the researchers immediately with this information. Then one researcher contacted the participant by telephone within 1–2 weeks to verify the reported fall and confirm the previously provided answers to the fall questions. A positive fall history was defined as an event that resulted in a person coming to rest inadvertently on the floor, ground, or an object below knee level but that was not a consequence of a violent blow, loss of consciousness, sudden onset of paralysis, or epileptic seizure (Gibson, Andres, Isaacs, Radebaugh, & Worm-Peterson 1987; Lach et al., 1991). Therefore, the falls did not include major intrinsic events such as stroke or extrinsic events such as violence (Gibson et al.). If a positive fall history was reported, these falls were further categorized into occasional accidental falls or pattern/intrinsic falls. This distinction was based on criteria established by Lord, Ward, Williams, and Strudwick (1995). An accidental faller was defined as a participant who reported all of the following: fell one time only in the follow-up period; fell as a result of a trip or a slip, but not because of poor balance or legs giving way, or if they were not sure what caused the fall; and would have fallen in the same circumstances if they were 30 years younger.

SCREENING PROCEDURES

The measurements that were collected during the screening process included the following: a timed floor transfer; a 5-step test; five timed chair stands; timed tandem, semitandem, and side-by-side stances; the Clinical Test of Sensory Interaction on Balance (CTSIB); the Performance-Oriented Assessment of Mobility—Balance subscale (POAM-B); functional reach (FR); the Physical Performance Test (PPT); and a 5-min walk for distance. Performance-based measures for

Table 1 Performance-Based Measures for Screening

Measure	Description	Unit of measure
Floor transfer	Move from standing to sitting on a floor mat and back to standing.	Time in seconds
5 steps	Step onto and back off a 4-in. step 5 times.	Time in seconds
5 chair stands	Sit to stand to sit five times without using arms.	Time in seconds
Tandem stance	Stand in tandem without shoes for 10 s.	Average time of 3 trials
Semitandem stance	Stand with first metatarsal head to heel without shoes for 10 s.	Average time of 3 trials
Side-by-side stance	Stand with feet together without shoes for 10 s.	Average time of 3 trials
CTSIB	Stand with feet together with eyes open and closed on floor and foam.	Time, 30 s maximum
POAM-B	9 tasks involving sitting/standing balance and transfers, a nudge, and a turn.	Rank 0 to 1 or 2, maximum score 16
FR	Reach forward as far as possible without losing balance or stepping.	Average distance moved in inches for 2 trials
PPT	7 tasks including eating, writing, putting on/off a jacket, lifting a book onto a shelf, picking up a penny from the floor, turning, and walking 50 ft.	Rank 0 to 2 or 4, maximum score 28, and time in seconds
5-min walk	Walk for 5 min as quickly as possible.	Distance in feet

Note. CTSIB = Clinical Test of Sensory Interaction on Balance; POAM-B = Performance-Oriented Mobility Assessment for Balance; FR = functional reach; PPT = Physical Performance Test.

the screening are listed in Table 1. These tests were performed by several researchers, who were trained in the screening procedures, in random order with rests provided when necessary.

A timed floor transfer is a clinical test of strength, flexibility, function, and problem solving; it measures the time necessary to transfer from standing to the floor and return to standing in any way that participants are able. Some elders overestimate their ability to perform this task (Tinetti, Lui, & Claus, 1993). Brandon, Boyette, Gaasch, and Lloyd (2000) included a timed floor-transfer task to increase the challenge of their functional-mobility test battery in a group of healthy older adults who received exercise intervention. Tinetti et al. (1993) recommended that the ability to perform floor transfers be assessed because they found that 47% (148/220) of elders who fell but were not injured reported an inability to get up from the floor without help after falling. They also noted that these elders were more likely to suffer functional decline or expire in the following year than were the nonfallers or fallers who were able to get up independently from the floor. These findings suggest that inability to perform a floor transfer might indicate increased frailty. Because this is a novel performance measure, we calculated the intraclass correlation coefficients (ICCs) on the timed data from 13 of the participants in this study to determine test–retest reliability, and the results were moderately high ($ICC_{2,1}$ = .79, p = .0001).

Tinetti and Speechley (1989) have reported that approximately 10% of falls occur on stairs, with descent being more hazardous than ascent. Therefore, stair climbing is an important functional task to assess, but stairs are not always available in testing environments. The timed 5-step test is a novel clinical test that measures the length of time it takes to step forward and up and backward and down from a 4-in. step five times as fast as possible. We found this test to have excellent test–retest reliability (r = .97, $p < .001$) in a pilot study conducted with 30 elders.

Participants were also asked to fold their arms across their chest and stand and sit five times from a standard chair while an investigator timed the activity (Guralnik et al., 1994). These chair stands assess bilateral lower extremity strength and function. This functional task has been documented to be difficult for 42% of the elderly (Brown, 1997), and its test–retest reliability is high (r =.89; Nevitt et al., 1989).

Balance was tested with timed stance tests, CTSIB, POAM-B, and FR. Stance tests including tandem, semitandem, and side-by-side standing were repeated three times and averaged. Participants were asked to stand with feet positioned heel to toe, first metatarsal head to heel, and side by side for 10 s each. Excellent test–retest reliability (r = .97) and interrater reliability (kappa = .92) have been reported for these tests (Winograd et al., 1994).

Balance was also tested with the CTSIB, a timed balance test that evaluates somatosensory, visual, and vestibular function for upright posture (Shumway-Cook & Horak, 1986). It was modified by using four of the possible six conditions, which consisted of standing without shoes both on the floor and on foam for a period of 30 s with eyes open and closed. Test–retest reliability of the CTSIB has been reported to be moderately high (r = .75) in community-dwelling elders (Anacher■ & DiFabio, 1992).

The POAM-B, developed by Tinetti (1986), is a reliable task-performance exam (90% agreement) consisting of a nine-item ordinal scale with ranks of 0 to 1 or 2 for each item. The tasks include the following: sitting balance, rising from an armless chair, immediate standing balance, static standing balance, tolerating a nudge on the sternum, standing with eyes closed, turning 360°, and sitting down in a chair. This test has been shown to be highly predictive of falls and fall-related injuries in community-dwelling elders (Tinetti et al., 1988).

The FR test was designed by Duncan, Weiner, Chandler, and Studenski (1990) to measure the forward limit of dynamic postural control. Volitional arm movements are coupled with stabilizing postural control of the trunk and lower extremity muscles. In the standing position with the shoulder adjacent to a yardstick and the upper extremity flexed to 90°, the participant is asked to reach forward as far as possible without stepping or falling. This test was repeated twice, and the distance reached in inches was averaged. FR has good test–retest ($ICC_{3,1}$ = .98) and interrater reliability ($ICC_{3,1}$ = .92) and predictive, criterion, and concurrent validity (Duncan et al., 1990; Duncan, Studenski, Chandler, & Prescott, 1992; Duncan, Weiner, Chandler, & Studenski, 1992; Weiner, Bongiorni, Studenski, Duncan, & Kochersberger, 1993).

The PPT is used to assess upper limb fine motor and overall gross motor function with seven tasks that simulate activities of daily living of various degrees of difficulty (Reuben & Siu, 1990). The tasks include simulated eating, writing a specified sentence, putting on and removing a jacket while standing, lifting a book and putting it on a shelf, picking up a penny from the floor, turning 360°, and walking 50 ft (Reuben & Siu). The 50-ft-walk test requires the participant to walk 25 ft, turn around, and walk 25 ft back to the starting point as quickly as possible. The PPT was reported by Reuben and Siu to have high reliability (r = .93), good internal consistency (Cronbach's alpha = .79), and good construct and concurrent validity when compared with self-reported measures of physical function. A separate ICC was calculated for the 50-ft-walk test using data from 16 of the participants in this study. Test–retest reliability was high ($ICC_{2,1}$ = .98, $p < .0001$).

The 5-min-walk test is used to assess cardiovascular endurance by recording the distance walked as quickly as possible in 5 min (Protas, 1997). Stanley and Protas (1991) have reported that in elderly women, the 5-min walk was moderately correlated with peak oxygen consumption, and they concluded that a 5-min walk would provide moderately better estimates of maximal exercise performance than would a 3-min walk. The 5-min-walk test has excellent test–retest reliability (r = .92; Peloquin, Gauthier, Bravo, Lacombe, & Billiare, 1998) and responsiveness (Peterson et al., 1993; Price, Hewett, Kay, & Minor, 1988).

Data Analysis

We performed exploratory data analysis on the scores taken from all the screening tests. Descriptive statistics included means, standard deviations, and frequency distributions. The data were screened with tests of collinearity, Studentized residuals, Cook's distance, leverage, and residual analysis with an alpha level of .05. Chi-squared tests for cross-tabulation tables and t tests were conducted to find which performance variables differed significantly (p A .05) between groups. Phi, point-biserial, and Pearson correlations were calculated among the selected screening variables to determine similarities and variables with minimal overlap. Cut-off values were based on the highest combined levels of sensitivity and specificity and established for each of the chosen variables through mathematical calculations and the receiver operating characteristic curve construction outlined by Portney and Watkins (2000). Sensitivity was defined as the percentage of people correctly classified into the falls group, and specificity, as the percentage of people correctly classified into the no-falls group.

The physical-performance measures for which there were significant differences were used in the final stepwise discriminant-function analysis. Age was included as a possible predictor variable because there were significant differences between groups, and it has been reported to be a predictor of fall risk (Guralnik et al., 1994; Shumway-Cook et al., 1997; Tinetti et al., 1988). The nine physical-performance measures were floor transfer, 5-step test, tandem stance, POAM-B, functional reach, 5-min walk, and three timed components of the PPT: the penny pick-up, turn, and 50-ft walk. The total PPT score was not used in the discriminant-function analysis because the scores appeared to be greatly affected by the educational limitations of our participants, not cognitive or physical impairments. The discriminant-function analysis revealed the linear combination of these variables that maximally separated the two groups (Tabachnick & Fidell, 1989). All data analysis was performed with SPSS 11.0 PC statistical software (SPSS Inc., Chicago).

Results

Of the 50 participants included in this study, 34 (68%) reported a negative fall history and were classified as the no-falls group. There were 16 (32%) who reported a positive fall history. Five of those participants were classified as accidental fallers, and therefore their data were eliminated from the sample used for statistical analysis. The causes for falls in the accidental-fall group were unusual activities in which a younger person would also fall (because of a ladder or chair collapsing while one was standing on it, a large dog unexpectedly jumping up from behind and knocking one down, or shoes getting caught between the edges of an uneven sidewalk). The 11 (22%) who were "true fallers" were classified as the falls group. The average number of reported falls was 2.8, and the number of falls ranged from one to six.

The mean age of the final sample of 45 was 73.2 ± 7.9 years. In the no-falls group there were 10 men and 24 women with a mean age of 71.2 ± 7.3 years (range 60–87). In the falls group there were 2 men and 9 women with a mean age of 79.6 ± 6.5 years (range 69–88). Three of the 11 fallers were diagnosed with diabetes, 1 reported hypertension, 2 reported having arthritis of the lower extremities, 2 reported having cancer, 1 had had a stroke, and 1 reported a history of peripheral vascular disease.

While screening the histograms and the frequency distributions for normality, we found extreme scores that produced either floor or ceiling effects with some of the timed data. Each extreme score was examined but did not consistently identify any one faller as an outlier. Three variables were recoded, however, because of distributions with floor effects and one variable with floor and ceiling effects, demonstrated by zero scores and maximum timed scores, respectively. These variables were the floor transfer, the 5-step test, tandem stance, and penny pick-up. For the two timed variables, the 5-step test and penny pick-up, a different participant was unable to perform each task. To minimize data loss, their scores were recoded to values 1 s higher than the highest recorded time for each of these measures.

Another recoding procedure involved changing certain ratio measures to dichotomous nominal measures, with time in seconds converted to "able" or "unable." Two variables were recoded with this technique because of a large number of zero scores for each. The floor transfer had 7 zero scores for participants unable to perform the task. Tandem stance resulted in 8 zero scores with 20 maximum scores (10 out of 10 s). The latter produced both floor and ceiling effects.

The bimodal distributions could only be improved by recoding the data into dichotomous nominal data.

The groups differed significantly on 10 of the 17 variables, as shown in Table 2. The variables that were selected for analysis based on significant differences include the following: age, floor transfer, 5-step test, tandem stance, POAM-B, FR, penny pick-up, 360° turn, 50-ft walk, and 5-min walk. The turn, 5-step test,

Table 2 Descriptive Characteristics and Probability Values Indicating Differences Between Fallers and Nonfallers

Variable	Fallers	Nonfallers	*p*
Age (years), *M* ± *SD*	79.0 ± 6.6	71.4 ± 7.5	.01[a]
Floor transfer			
unable	63.6% (7/11)	0% (0/33)	<.001[b]
able	10.5% (4/11)	100% (33/33)	
5-step test (s), *M* ± *SD*	29.2 ± 10.8	16.2 ± 6.1	.002[a]
5 chair stands (s), *M* ± *SD*	27.5 ± 17.4	16.8 ± 5.1	.09
Tandem stance			
unable	54.4% (6/11)	5.90% (2/34)	.01[b]
able	45.5% (5/11)	94.1% (32/34)	
Semitandem (0–10 s), *M* ± *SD*	7.9 ± 4.0	9.7 ± 1.0	.16
Side-by-side stance (0–10 s), *M* ± *SD*	10.0 ± 0.0	10.0 ± 0.0	No difference between groups
CTSIB (0–30 s)			
eyes open, floor, *M* ± *SD*	30.0 ± 0.0	30.0 ± 0.0	No difference between groups
eyes closed, floor, *M* ± *SD*	28.6 ± 4.7	30.0 ± 0.0	.34
eyes open, foam, *M* ± *SD*	19.1 ± 13.8	29.0 ± 3.12	.08
eyes closed, foam, *M* ± *SD*	13.7 ± 14.1	24.2 ± 9.2	.08
POAM-B (0–16 score), *M* ± *SD*	12.2 ± 3.6	15.4 ± 1.2	.02
FR (in.), *M* ± *SD*	7.0 ± 2.5	10.8 ± 2.8	<.001[a]
PPT			
penny pick-up (s), *M* ± *SD*	7.7 ± 3.7	3.6 ± 1.2	.004[a]
turn (s), *M* ± *SD*	10.1 ± 5.3	4.8 ± 1.9	.008[a]
50-ft walk (s), *M* ± *SD*	33.2 ± 14.7	15.7 ± 3.2	.003[a]
5-min walk (ft), *M* ± *SD*	684.3 ± 307.1	1,136.8 ± 232.7	.001[a]

Note. CTSIB = Clinical Test of Sensory Interaction on Balance; POAM-B = Performance-Oriented Mobility Assessment for Balance; FR = functional reach; PPT = Physical Performance Test.

[a]*t* test. [b]χ^2 test.

Table 3 Pearson Correlation Coefficients Among Significant Screening Variables Used to Predict Falls

	Variable									
Variable	Age	Floor transfer	5-Step	Tandem	POAM-B	FR	Penny pick-up	Turn	50-ft walk	5-min walk
Age										
Floor transfer	–.38*									
5-step	.43*	–.57**								
Tandem	–.61**	.44*	.44*							
POAM-B	–.31	.44*	–.72**	.50**						
FR	–.52**	–.49**	–.57**	.36	.40*					
Penny pick-up	.18	–.51**	.64**	–.40*	–.73**	–.51**				
Turns	.37	–.45*	.83**	–.53**	–.81**	–.47*	.74**			
50-ft walk	.48**	–.52**	.83**	–.64**	–.84**	–.54**	.72**	.86**		
5-min walk	–.58**	.51**	–.75**	.49**	.66**	.65**	–.58**	–.61**	–.82**	
Falls	.46**	–.76**	.61**	–.55**	–.57**	–.52**	.65**	.61**	.71**	–.62**

Note. POAM-B = Performance-Oriented Mobility Assessment for Balance; FR = functional reach.
**p* A.01. ***p* A.001.

Table 4 Sensitivity and Specificity for Significant Screening Variables Based on Fall History

Variable	Scale cut-off score	Sensitivity	Specificity
Age	74 years	82% (9/11)	71% (24/34)
Floor transfer	unable/able	64% (7/11)	100% (33/33)
5-step test	21 s	82% (9/11)	82% (28/34)
Tandem stance	unable/able	55% (6/11)	94% (32/34)
POAM-B	score of 12	55% (6/11)	97% (33/34)
FR	8 in.	73% (8/11)	88% (30/34)
Penny pick-up	4 s	100% (11/11)	82% (28/34)
Turn	6 s	82% (9/11)	78% (25/32)
50-ft walk	18 s	91% (10/11)	70% (23/33)
5-min walk	1,000 ft	82% (9/11)	79% (27/34)

Note. POAM-B = Performance-Oriented Mobility Assessment for Balance; FR = functional reach.

POAM-B, and 5-min walk were all highly correlated with the 50-ft walk (*r* B .80, $p < .001$), and the 5-step test correlated highly with the POAM-B and turn (*r* B .80, $p < .001$). Several variables were moderately correlated with one another (Table 3). Cut-off scores based on optimal sensitivity and specificity for each variable are listed in Table 4.

The canonical discriminant function resulted in a canonical correlation of $r = .838$ and the equation $Y = –0.766 + 3.004$ (floor transfer) – 0.086 (50-ft walk). *Y* is the score used to classify the participant into the correct group, falls (negative number) or no falls (positive number). The timed floor transfer and the timed 50-ft walk were the only significant variables ($p < .001$) that correctly classified the participants, with 42 out of the 44 grouped cases correctly classified (95.5%). Falls were predicted correctly for 9 of 11 participants (81.8%). No-falls group membership was predicted correctly for 33 of 33 participants (100%). The combination of these two measures indicates excellent specificity for predicting the no-falls group and good sensitivity for predicting the falls group. The effect size for the floor transfer was 1.92, with the added effect size of 0.46 for the 50-ft walk. The effect size for the two measures was 2.38. The power was 1.00 for the floor transfer and .99 for the 50-ft walk, based on 44 participants. Power analysis resulted in a very large effect size and indicated that 22 participants are required to detect a significant difference with an alpha level of .05 and a power of .80.

Discussion

The results indicate that two of the nine variables best predicted group membership. The two falls-group members who were incorrectly classified were able to perform the tandem task, but only for 1.5 s and 6.5 s, not the entire 10-s time interval. Because those timed data had to be recoded to able or unable because of floor and ceiling effects, the ratio-level information was lost. Those 2 people had difficulty with tandem stance and might have been classified differently were that measure included as ratio-level data in the analysis. The dichotomous distribution could be avoided in future studies if the timed tandem-stance data were collected beyond the 10-s limit. Timing tandem stance for 60 s or until a loss of balance is exhibited would eliminate the ceiling effects found and might result in improved sensitivity.

The POAM-B has been reported to be highly predictive of falls and fall-related injuries in elderly community-dwelling adults (Tinetti et al., 1988). It did not discriminate between fallers and nonfallers, however, which might be a result of the significantly high correlations with the 50-ft-walk test. Topper, Maki, and Holliday (1993) reported similar findings and attributed insufficient resolution and poor specificity to scores clustering at the high end of the scale.

It was surprising that FR, a test shown to be a good predictor of falls in other studies (Duncan et al., 1990; Duncan, Studenski et al., 1992; Duncan, Weiner, et al., 1992; Weiner et al., 1993), did not serve as a discriminator in the current study. This finding is consistent with those of Cho and Kamen (1998), however, who also reported no significant differences in functional reach between elderly frequent fallers and nonfallers. Means of 7.2 for the falls group and 10.7 for the no-falls group were close to the limits of 6 and 10 in. defined by Duncan■ et al. (1992). The FR cut-off score of 8 in. determined in this study supports the limits reported by Duncan■ et al. (1992). Nonetheless, members of each group in the current study had scores opposite those that were expected based on the literature. There were 3 participants with fall history who were able to reach more than 10 in. and 3 with no history of falls who were not able to reach more than 6 in. The impaired reach for the latter participants might be related to limited shoulder and spinal range of motion, skeletal deformities, or postural dysfunction, and these factors might need to be considered when using FR. The unexpected scores in each group might have sufficiently reduced the predictive potential of the FR because of the small population used for the discriminant-function analysis.

The ability of the floor transfer to predict falls confirms the importance of this task as an indicator of frailty (Tinetti et al., 1993). Tinetti et al. (1993) reported that 47% of their population of elders who had fallen were unable to get up from the floor independently, and 7 of 11 (64%) of our population who experienced falls failed to perform a similar task. This floor transfer appears to be a unique indicator of fall risk because no other screening variable correlated highly with it.

The 50-ft walk, the second significant predictor, was found to be highly correlated with the turn, 5-step test, POAM-B, and 5-min walk. These correlations might explain to some extent why only two variables were found to be predictive, because these highly correlated tests would not significantly add to the discriminant function. The correlations also suggest that the tests might be measuring similar constructs and be redundant. Therefore, to increase efficiency of the screen, most of those tests could be eliminated.

Many participants scored lower on the PPT because of the writing segment of the test. The participants were required to read and write the sentence “Whales live in the blue ocean” (Reuben & Siu, 1990) in either English or Spanish. Difficulty in reading and writing this sentence in their primary language resulted in a lower score. Many of the participants screened had minimal formal education and were limited in their ability to read or write. Even so, they performed well on the other fine-motor-control test—simulated eating. It is interesting that the correlations between the PPT total score and timed turn ($r = -.10$, $p = .53$) and penny pick-up ($r = -.05$, $p = .77$), which are tests from the PPT, were very low and nonsignificant. Conversely, the correlation between the PPT and the 50-ft-walk test, which is also included in the PPT, was very high and significant ($r = -.81$, $p < .001$). The low writing score and inconsistent correlation results led us to question the validity of the PPT, and the total PPT score was not included in the discriminant function. Therefore, the three most difficult timed tasks from the PPT (penny pick-up, turn, and 50-ft walk) were used. The validity and utility of the PPT for assessing function in the elderly should be considered carefully, because it might depend on an individual's educational background.

Elders' ability to recall and self-report falls retrospectively is imperfect and problematic (Cummings, Nevitt, & Kidd, 1988) and can affect the ability to accurately record falls. Therefore, we chose a prospective study design and used caseworkers who regularly and closely interact with these participants to minimize recall bias and improve the accuracy of fall reporting. Nonetheless, the accuracy of fall categorization and fall-reporting errors must be considered, because they could affect this study. Data from accidental fallers as defined by Lord et al. (1995) were eliminated to more conservatively and clearly differentiate the two groups and the potential differences in physical performance. Similar exclusion criteria have been implemented by other researchers (Anacker & DiFabio, 1992; Tinetti, 1986; Nevitt et al., 1989; Shumway-Cook et al., 1997; Studenski et al., 1994), but the validity of the accidental-faller classification needs to be investigated. Alternative fall categorization could be implemented with recurrent or injurious falls (O'Loughlin, Robitaille, Boivin, & Suissa, 1993) but might result in missing individuals at high risk for falling. Four of the 11 elders classified as "true fallers" fell only one time in the follow-up period and would have been eliminated based on a recurrent-fall classification. Two of these 4 exhibited multiple physical impairments based on examination after the follow-up period, and 1 was admitted to a nursing home and died after the follow-up period. Four of the 5 accidental fallers were available for further testing after the follow-up period and demonstrated no major cognitive impairments, physical impairments, or functional limitations. An injurious fall is difficult to define, but no fractures caused by falls were reported, and only 1 faller was admitted to a nursing home during the follow-up period.

A limitation of the current preliminary study is the small sample size, which can affect the outcome of the discriminant-function analysis. Future studies on larger populations are necessary to confirm these results and to generalize them to elders as a whole. Although many of the measures tested are able to differentiate groups, the responsiveness of these measures has yet to be determined. Nonetheless, the results of this study support the feasibility of using performance tests in screening for fall risk.

Conclusions

In summary, several performance tests can discriminate between people who fall and those who do not. The best predictors of falls found in this study were the timed floor transfer and the 50-ft walk. These tests can form a basis for a quick screening battery to identify elders at risk of falling so that further assessment and appropriate interventions to decrease fall risk can be implemented.

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