Research Report

Predicting the Probability for Falls in Community-Dwelling Older Adults Using the Timed Up & Go Test

Background and Purpose. This study examined the sensitivity and specificity of the Timed Up & Go Test (TUG) under single-task versus dual-task conditions for identifying elderly individuals who are prone to falling. Subjects. Fifteen older adults with no history of falls (mean age=78 years, SD=6, range=65–85) and 15 older adults with a history of 2 or more falls in the previous 6 months (mean age=86.2 years, SD=6, range=76–95) participated. Methods. Time taken to complete the TUG under 3 conditions (TUG, TUG with a subtraction task [$TUG_{cognitive}$], and TUG while carrying a full cup of water [TUG_{manual}]) was measured. A multivariate analysis of variance and discriminant function and logistic regression analyses were performed. Results. The TUG was found to be a sensitive (sensitivity=87%) and specific (specificity=87%) measure for identifying elderly individuals who are prone to falls. For both groups of older adults, simultaneous performance of an additional task increased the time taken to complete the TUG, with the greatest effect in the older adults with a history of falls. The TUG scores with or without an additional task (cognitive or manual) were equivalent with respect to identifying fallers and nonfallers. Conclusions and Discussion. The results suggest that the TUG is a sensitive and specific measure for identifying community-dwelling adults who are at risk for falls. The ability to predict falls is not enhanced by adding a secondary task when performing the TUG. [Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Phys Ther.* 2000;80:896–903.]

Key Words: *Balance, Fall prevention.*

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The Timed Up & Go Test (TUG) is a test of balance that is commonly used to examine functional mobility in community-dwelling, frail older adults (aged 70–84 years).[1] The test requires a subject to stand up, walk 3 m (10 ft), turn, walk back, and sit down. Time taken to complete the test is strongly correlated to level of functional mobility.[1] Older adults who are able to complete the task in less than 20 seconds have been shown to be independent in transfer tasks involved in activities of daily living, have high scores on the Berg Balance Scale, and walk at gait speeds that should be sufficient for community mobility (0.5 m/s).[1] In contrast, older adults requiring 30 seconds or longer to complete the task tend to be more dependent in activities of daily living, require assistive devices for ambulation, and score lower on the Berg Balance Scale.[1]

Although the TUG has been shown to be useful for predicting level of functional mobility, its validity for identifying community-dwelling older adults who are at risk for falls is unknown. *Functional mobility* is a term used to reflect the balance and gait maneuvers used in everyday life (eg, getting in and out of a chair, walking, turning).[1] Thus, one goal of our research was to determine the sensitivity and specificity of the TUG for predicting falls in community-dwelling older adults.

Recent research has suggested that assessment of balance under multi-task conditions may be a more sensitive indicator of balance problems and falls than assessment of balance in a single-task context.[2–5] Researchers using laboratory tests of balance under dual-task conditions have found that the ability to maintain stability can be affected by performance of concurrent cognitive tasks,[2–4] and this effect is enhanced in older adults with balance impairments and a recent history of falls.[5]

Lundin-Olsson and colleagues[6] investigated the effect of performing multiple tasks on balance, mobility, and falls in frail older adults who lived in an institutional setting. Physical frailty is defined by severely impaired strength, mobility, balance, and endurance. They modified the TUG to add a manual task (TUG_{manual}) (ie, carrying a glass of water) and found that frail older adults who had a time difference of greater than 4.5 seconds between the TUG_{manual} and the TUG were more prone to falls during the following 6 months. They concluded that the

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The study was approved by the Institutional Review Board of Northwest Hospital, Seattle, Wash.

This investigation was supported by a grant from the Foundation for Physical Therapy to Dr Shumway-Cook and by National Institute on Aging grant AG-05317 to Dr Woollacott.

This article was submitted May 12, 1999, and was accepted May 30, 2000.

Foundation for Physical Therapy

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difference in time between the TUG and TUG_{manual} is useful for identifying institutionalized elderly people who are prone to falls.[6] Whether performance on the TUG in a dual-task condition is a useful measure for identifying community-dwelling older adults who are prone to falls is not known. Thus, another goal of our study was to determine whether, in community-dwelling older adults, the TUG performed under dual-task conditions was a more sensitive and specific predictor of falls than the TUG measure alone.

In a previous study using a simultaneous task paradigm, we studied the effects of 2 types of secondary tasks (a spatial orientation task versus a language task) on postural control during stance under 2 surface conditions (firm versus compliant).[5] We compared the effects of these tasks on balance between a group of young adults (aged 24–44 years) and 2 groups of older adults (ie, those with a history of falls [aged 65–86 years] and those without a history of falls [aged 65–94 years]).[5] In young adults, neither secondary task affected stability in stance. In contrast, in the older nonfallers, the effect of a secondary task was dependent on the difficulty of the postural task. In the less challenging postural condition (standing on a firm surface), neither cognitive task affected balance; however, there was a significant increase in postural sway when cognitive tasks were performed in the more challenging postural condition (standing on a compliant foam surface). Finally, the older adults with balance problems and a history of recurrent falls swayed more when performing either secondary task even in the less challenging postural condition. Results from that study suggest that the effect of a secondary task on postural control was dependent on the balance abilities of the subject, the difficulty of the balance task, and the type of secondary task being performed.[5] The effects of different types of secondary tasks on functional mobility have not been determined. Certain types of secondary tasks performed in conjunction with the TUG may be more sensitive predictors of falls than others. Therefore, another goal of this study was to compare the sensitivity and specificity of 2 conditions of TUG performance (cognitive versus manual) in identifying community-dwelling older adults who are at risk for falls.

Our hypotheses were (1) that, although the TUG itself would be a sensitive predictor of falls, the dual-task TUG would be a more sensitive predictor of falls than the TUG alone and (2) that the TUG with the addition of a cognitive task ($TUG_{cognitive}$) would be a more specific and sensitive predictor of falls than the TUG_{manual}.

Method

Subjects

Thirty community-dwelling older adults living in the greater Seattle area were enrolled in the study after giving informed consent. The participants were volunteers recruited from subjects involved in previous aging studies that were carried out by the first author. The participants were 15 older adults with no history of falls (mean age=78 years, SD=6, range=65–85) and 15 older adults with a history of 2 or more falls in the previous 6 months (mean age=86.2 years, SD=6, range=76–95). The inclusion criteria were that the subjects had to be aged 65 years or older, living independently in the community, able to walk 9.1 m (30 ft) with or without an assistive device but without the assistance of another person, able to follow simple instructions, and able to carry a cup by a handle.

Criteria for inclusion in the group of older adults with a history of falls included a self-report of 2 or more falls within the past 6 months. A *fall* was defined as any event that led to an unplanned, unexpected contact with a supporting surface. We excluded falls resulting from unavoidable environmental hazards such as a chair collapsing. In addition, we excluded people who had only 1 fall within 6 months in order to maximize the possibility of selecting a sample of older adults with recurrent fall problems. Further criteria for the older adults in the faller category included an absence of known neurological or musculoskeletal diagnosis that could account for possible imbalance and falls, such as cerebrovascular accident, Parkinson disease, cardiac problems, transient ischemic attacks, or lower-extremity joint replacements.

Procedure

After informed consent was obtained, subjects completed a health status questionnaire providing information on age, residential status, marital status, medical history, current coexisting medical conditions, self-reported history of imbalance, type of assistive device used for ambulation, and use of prescription medications. This information was used to characterize the demographics and health status of subjects participating in the study. In order to verify our classification of the 2 groups based on balance abilities, balance was measured using 1 self-report instrument and 2 performance-based measures. The Activities-specific Balance Confidence Scale (ABC) is a self-report measure of balance that people can use to rate their perceived confidence related to balance when performing common activities of daily living.[7] We asked our subjects to use the ABC to rate their degree of confidence (1=no confidence to 10=full confidence) in performing 10 basic activities of daily living and instrumental activities of daily living

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without fear of loss of balance. The result was a score ranging from 10 to 100. In a previous study examining the psychometric properties of the ABC on 102 older adults living in the community, the ABC test-retest correlation (r) was .92 ($P<.001$), indicating good test-retest reliability; the Cronbach alpha was .96, indicating high internal consistency.[7] The test did not discriminate fall status among community-dwelling older adults.[7]

Subjects then underwent a 45-minute performance-based evaluation of balance and mobility function. Balance was evaluated using the Berg Balance Scale, which rates performance from 0 (cannot perform) to 4 (normal performance) on 14 different tasks, including ability to sit, stand, reach, lean over, turn and look over each shoulder, turn in a complete circle, and step.[8] The total possible score on the Berg Balance Scale is 56, which is supposed to indicate excellent balance. The Berg Balance Scale has been shown to yield measurements with excellent interrater and test-retest reliability (intraclass correlation coefficient [ICC]=.98 and .97, respectively) and good internal consistency (Cronbach alpha=.96).[8] Scores obtained from the Berg Balance Scale been shown to be correlated with scores obtained from other tests of balance and mobility, including the Tinetti Mobility Index ($r=-.91$) and the Get Up & Go Test ($r=-.76$).[9]

Mobility was evaluated by asking subjects to walk for 3 minutes at their preferred speed. Distance walked was measured, and speed for self-paced gait was determined. Subject demographics and clinical test results are summarized in Table 1.

Experimental Protocol

Subjects were asked to complete 3 trials of the TUG under 3 conditions: performance of the TUG alone, performance of the TUG with the addition of a cognitive task ($TUG_{cognitive}$), and performance of the TUG with the addition of an upper-extremity motor task (TUG_{manual}). The tasks were presented in random order. When performing the TUG, subjects were given verbal instructions to stand up from a chair, walk 3 m as quickly and as safely as possible, cross a line marked on the floor, turn around, walk back, and sit down. Those subjects who used an assistive device when walking in the community were requested to use that device. In the $TUG_{cognitive}$, subjects were asked to complete the test while counting backward by threes from a randomly selected number between 20 and 100. In the TUG_{manual}, subjects were asked to complete the test while carrying a full cup of water. Subjects who used a walker for ambulation (n=5) were excluded from this condition. Subjects were given one TUG practice trial to familiarize themselves with the task.

Table 1.
Demographics of Older Adults Without a History of Falls (n=15) and Older Adults With a History of Falls (n=15)

	Nonfallers	Fallers
Age[a] (y)		
$\bar{X}$	78.4	86.2
SD	5.8	6.4
Range	65–85	76–95
Sex		
Female	10 (67%)	8 (53%)
Assistive device		
None	15 (100%)	3 (20%)
Cane		7 (47%)
Walker		5 (33%)
No. of prescriptions		
0–1	50%	42%
2–3	50%	42%
≥4		16%
No. of comorbidities		
0–1	82%	33%
2–3	18%	59%
≥4		8%
Self-paced gait speed (m/s)[a]	1.2 (0.1)	0.47 (0.2)
Berg Balance Test[a] (range 0–56)	55.5 (1)	32.7 (7.5)
Activities-specific Balance Confidence Scale[a] (range 0–100)	93.2 (7)	53.0 (17)

[a] Significant difference ($P<.05$) between groups.

Data Analysis

Two raters measured performance by timing the TUG in all 3 conditions. Interrater reliability as measured with an ICC (3,3) was high, with r_i=.98, .99, and .99 for the TUG, TUG_{manual}, and $TUG_{cognitive}$, respectively.[10] As a result, further analyses were performed on the data obtained from one rater only. Histograms and descriptive statistics were calculated to determine distributions, detect outliers, and consider the need for transformations. A logarithmic transformation was performed on time data due to nonnormality, the result of positively skewed data.

A multivariate analysis of variance (MANOVA) was then performed to determine whether group differences existed on the transformed time measures. Scores were averaged over the 3 trials. In cases where the MANOVA demonstrated a difference ($P<.05$), a *post hoc* within-subject analysis was performed. To determine the ability of the TUG performed under the 3 conditions to predict faller versus nonfaller group membership, cross-validated discriminant function analyses were performed on 5 variables: the 3 transformed timed measures and 2 difference measures ($TUG_{manual}-TUG$ and $TUG_{cognitive}-TUG$). A prior probability of classifying an older adult as a faller was set at 35%, based on falls rate literature.[11,12]

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Table 2.
Comparison of Time Taken (in Seconds) to Complete the TUG, TUG_{manual}, and $TUG_{cognitive}$ in Older Adults Without a History of Falls (n=15) and Older Adults With a History of Falls (n=15)[a]

	TUG		TUG_{manual}		$TUG_{cognitive}$	
	Nonfallers	**Fallers**	**Nonfallers**	**Fallers**	**Nonfallers**	**Fallers**
$\bar{X}$	8.4	22.2	9.7	27.2	9.7	27.7
SD	1.7	9.3	1.6	11	2.3	11.6
Range	6.4–12.6	10.3–39.2	6.9–12.6	14–48.7	6.2–14.6	11–49.6

[a] TUG=Timed Up & Go Test, TUG_{manual}=Timed Up & Go Test with addition of a manual task, $TUG_{cognitive}$=Timed Up & Go Test with addition of a cognitive task.

A logistic regression procedure was used to determine the cutoff value for each timed test that maximized sensitivity and specificity and predicted the probability of fallers at .5 or greater. All of these analyses were performed with SAS 6.12.[13,*] The Pearson product moment correlation coefficient (r) was used in bivariate correlations, and a 3-way analysis of variance was performed to compare demographics across the 2 groups. These analyses were performed using SPSS 8.0.[14,†]

Results

Results from the MANOVA showed that the older adults with a history of falls were slower ($F=22.97$, $P<.001$) than the older adults without a history of falls in all 3 conditions (TUG, $TUG_{cognitive}$, and TUG_{manual}). Table 2 compares the time taken to complete the TUG in all 3 conditions for both groups of subjects.

Because there was a difference in age ($t=-3.5$, $P=.002$) between the older adults with a history of falls and the older adults without a history of falls, a MANCOVA was used to reanalyze the TUG data using age as a covariate. Using this analysis, there was still a difference in time taken to complete the TUG between the 2 groups, suggesting that the differences found in older subjects were not due to age alone, but rather due to balance status. In addition, the time taken to complete the TUG by the older adults with a history of falls was highly correlated ($r=.95$) with the type of assistive device used for ambulation. The time taken to complete the TUG with no device was 9.0 seconds (range=6.4–13.4), the time taken to complete the TUG with a cane was 18.1 seconds (range=14.6–22.3), and the time taken to complete the TUG with a front-wheeled walker was 33.8 seconds (range=28.3–39.2). These results are illustrated in Figure 1.

The addition of either a cognitive task or a manual task increased the time taken to complete the TUG in both groups of older adults (older adults with a history of falls: $F=79.3$, $P<.001$; older adults without a history of falls: $F=21.9$, $P<.001$). Figure 2 compares the performance of individuals within each of the 2 groups on the 3 tasks. Table 3 displays the increase in time taken to complete the TUG in the 2 secondary task conditions for each of the 2 groups. In the older adults with a history of falls, the time taken to complete the $TUG_{cognitive}$ increased on average 25% compared with 16% in the older adults without a history of falls. The TUG_{manual} increased 22% in the older adults with a history of falls compared with 15% in the older adus without a history of falls.

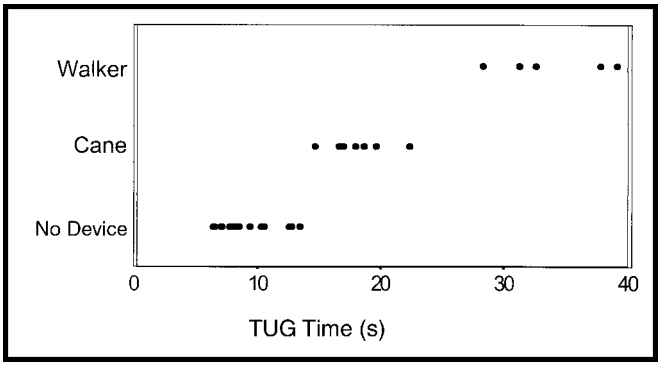

Figure 1.
Comparison of the time taken to complete the Timed Up & Go Test (TUG) as a function of the assistive device used for ambulation.

Discriminate analysis indicated that the 3 measures (TUG, TUG_{manual}, and $TUG_{cognitive}$) were equivalent with respect to classifying fallers and nonfallers, suggesting that all 3 tests were comparable for identifying community-dwelling older adults who are prone to falls. In Table 4, we compare the sensitivity and specificity for each of the 3 tests in predicting falls in community-dwelling older adults. The TUG alone correctly classified 13/15 fallers (87% sensitivity) and 13/15 nonfallers (87% specificity). Compared with the TUG under single-task conditions, use of the dual-task TUG (either cognitive or manual) to identify fall status decreased sensitivity to 80% while increasing specificity to 93%, thus maintaining a comparable overall prediction rate (87%). Using difference scores between the dual-task TUG and the single-task TUG to determine probability for falls

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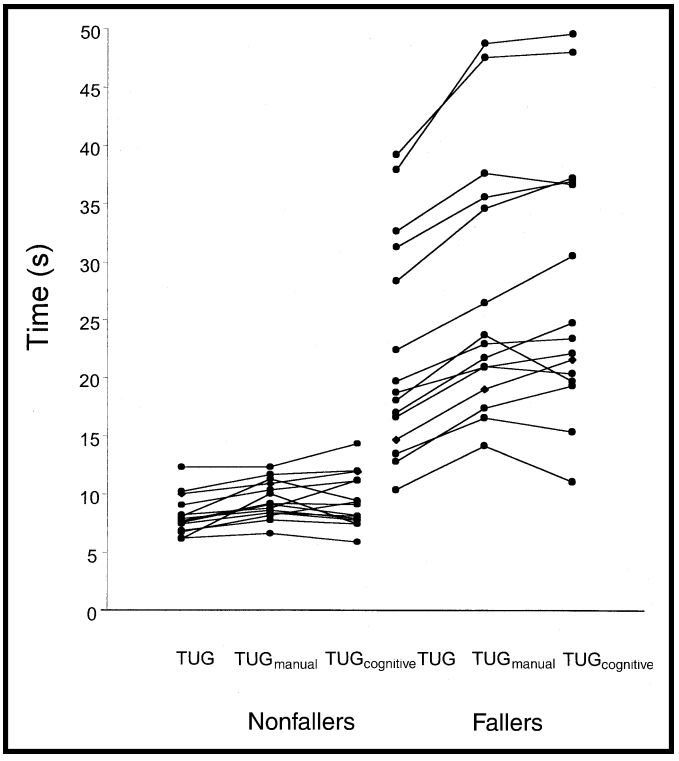

Figure 2.
Comparison of the performance of individuals within the group of older adults without a history of falls and the group of older adults with a history of falls on the 3 tasks (Timed Up & Go Test [TUG] alone, TUG with addition of a cognitive task [$TUG_{cognitive}$], and TUG with addition of a manual task [TUG_{manual}]).

Table 3.
Difference in Time Taken to (in Seconds) Complete the TUG_{manual} and $TUG_{cognitive}$ Compared With the TUG in Older Adults Without a History of Falls (n=15) and Older Adults With a History of Falls (n=15)[a]

	$TUG_{cognitive}$		TUG_{manual}	
	Nonfallers	**Fallers**	**Nonfallers**	**Fallers**
$\bar{X}$	1.28	5.56	1.32	4.98
SD	1.0	3.2	1.0	2.2
Range	−0.3–3.0	0.7–11.7	0.01–3.9	2.2–10.9

[a] TUG=Timed Up & Go Test, TUG_{manual}=Timed Up & Go Test with addition of a manual task, $TUG_{cognitive}$=Timed Up & Go Test with addition of a cognitive task.

resulted in lower prediction rates than when the actual test scores were used.

Logistic regression analysis was used to determine cutoff levels for the TUG, the TUG_{manual}, and the $TUG_{cognitive}$. Cutoff levels that maximized both sensitivity and specificity and had a predicted probability of .5 or larger were determined to identify the specific time score that best classified fallers and nonfallers. As shown in Table 5, older adults who took 13.5 seconds or longer to perform the TUG were classified as fallers with an overall correct prediction rate of 90%. On the TUG_{manual}, classification of older adults as fallers using the time score of 14.5 seconds or longer resulted in a 90% correct prediction rate. Finally, elderly subjects who completed the $TUG_{cognitive}$ in 15 seconds or longer were classified as fallers with an overall correct prediction rate of 87%.

Table 4.
Comparison of the Sensitivity and Specificity for Identifying Older Adults With and Without a History of Falls[a]

	Sensitivity (% Fallers)	**Specificity (% Nonfallers)**	**Overall Prediction**
TUG	13/15 (87%)	13/15 (87%)	26/30 (87%)
TUG_{manual}	12/15 (80%)	14/15 (93%)	26/30 (87%)
$TUG_{cognitive}$	12/15 (80%)	14/15 (93%)	26/30 (87%)
TUG_{manual}−TUG	10/15 (67%)	13/15 (87%)	23/30 (76%)
$TUG_{cognitive}$−TUG	7/15 (47%)	14/15 (93%)	21/30 (70%)

[a] TUG=Timed Up & Go Test, TUG_{manual}=Timed Up & Go Test with addition of a manual task, $TUG_{cognitive}$=Timed Up & Go Test with addition of a cognitive task.

The relationship between fall status and time taken to perform the TUG in the 3 conditions is shown in Figure 3. In all 3 conditions, this relationship was nonlinear. For example, an individual who took 13 seconds to complete the TUG had a 69% probability of being a faller. An individual who took 14 seconds to complete the TUG had an 83% probability of being a faller. This nonlinearity could also be seen in the TUG_{manual}, where a 16-second score was associated with a 70% probability of being a faller, whereas the probability rose to 81% with a score of 17 seconds.

Discussion and Conclusions

We investigated the sensitivity and specificity of the TUG under both single and dual task conditions in identifying fall prone older adults living in the community. Our results indicate that the TUG itself is a sensitive and specific indicator of whether falls occur in community-dwelling older adults. Thus, we believe the TUG is a relatively simple screening test that takes only minutes to complete, and we contend that it appears to be a valid method for screening for both level of functional mobility and risk for falls in community-dwelling elderly people. Results from the discriminate analysis suggest that older adults who take longer than 14 seconds to complete the TUG have a high risk for falls. Our cutoff value of 14 seconds is different from that of Podsiadlo and Richardson,[1] who found that a cutoff value of greater than 30 seconds was best for predicting functional dependence among older adults. The differences in time values may reflect the differences in subjects used in the 2 studies. Podsiadlo and Richardson's study included older adults with a wide range of neurologic pathologies. In contrast, we studied community-

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Table 5.
Balance Test Cutoff Scores to Maximize Sensitivity, Specificity, and Predicted Probability[a]

	Cutoff Score (s)	Sensitivity (% Fallers)	Specificity (% Nonfallers)	Overall Prediction	Predicted Probability
TUG	≥13.5	80%	100%	90%	.77
TUG_{manual}	≥14.5	86.7%	93.3%	90%	.5
$TUG_{cognitive}$	≥15	80%	93.3%	86.7%	.5

[a] TUG=Timed Up & Go Test, TUG_{manual}=Timed Up & Go Test with addition of a manual task, $TUG_{cognitive}$=Timed Up & Go Test with addition of a cognitive task.

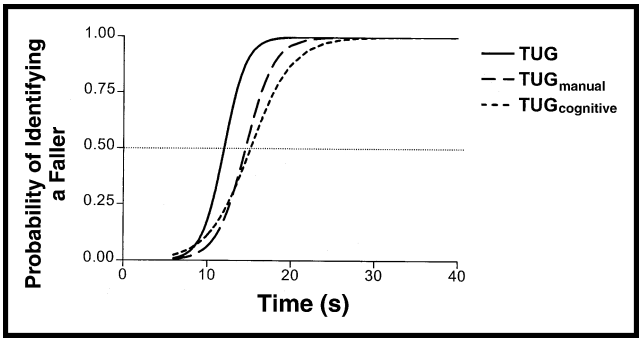

Figure 3.
The time taken to perform the Timed Up & Go Test (TUG), TUG with addition of a manual task (TUG_{manual}), and TUG with addition of a cognitive task ($TUG_{cognitive}$) as a function of probability of predicting elderly individuals who are prone to falls.

dwelling, frail older adults, but we excluded older adults with known neurologic diseases.

Our finding that all 3 tests (TUG, TUG_{manual}, and $TUG_{cognitive}$) were comparable in determining the likelihood of falling in community-dwelling older adults did not support our hypothesis that measurement of mobility under multi-task conditions would be a more sensitive indicator of likelihood for falls. In addition, difference scores (eg, $TUG_{manual}-TUG$) did not increase the ability to identify community-dwelling older adults who are prone to falls. This finding is not consistent with Lundin-Olsson and colleagues'[6] finding that comparing mobility performance between single-task and dual-task conditions was a more useful way of predicting future falls in institutionalized elderly people. There are 2 dissimilarities between these studies that could explain these differences. First, Lundin-Olsson and colleagues studied a population of frail older adults living in an assisted-living environment. We examined older adults who, despite having balance impairments, were living independently within the community. Second, in Lundin-Olsson and colleagues' study, predictors of future falls were sought. In contrast, we were looking for measures that are useful for identifying individuals with a likelihood of falling. It may be that, although difference scores are not useful in a discriminate function, they may remain useful as predictors of future falls in some populations of elderly individuals.

Effect of Multiple Tasks on Mobility in Elderly People Who Are Prone to Falls

Results from this study confirm that simultaneous performance of a secondary task had a deleterious effect on functional mobility. The addition of a secondary task increased the time taken to complete the TUG by 22% to 25%. This effect was independent of the type of secondary task performed (either manual or cognitive). These findings do not support our hypothesis that cognitive tasks would affect mobility more than manual tasks.

Clinical Implications

Given the incidence and consequences of falls among older adults, screening methods that identify elderly individuals who are prone to falls and who may benefit from interventions designed to improve balance and decrease falls and risk for falls are critical. Results from our study suggest that the TUG is a simple screening test that is a sensitive and specific measure of probability for falls among older adults.

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