Are Scores on Balance Screening Tests Associated with Mobility in Older Adults?

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ABSTRACT

Purpose: To examine associations between measures of static and dynamic balance and performance of mobility tasks in older adults. **Methods:** A cross-sectional analysis from 195 community dwelling participants (mean age 80.9 years, range 65 -103 years). Participants performed tests of static (tandem stance) and dynamic (360° turn) balance and mobility (walking speed and timed chair rise). Associations among balance and mobility measures were examined using correlation and logistic regression. **Results:** Static and dynamic balance were moderately associated (r = -.462). Relationships between dynamic balance and mobility were stronger than those between static balance and mobility. The association between dynamic balance and walking speed was particularly strong (r = -.701). Using logistic regression, age, and balance performance were significant predictors for outcomes of walking speed (dichotomized to < 1.0 m/s, ≥ 1.0 m/s), and timed chair rise (dichotomized to ≤ 13.6 s, > 13.6 s). Faster 360° turn times were independently associated with faster walking speed and chair rise time. **Conclusion:** Mobility tasks require both dynamic and static balance. As falls are a major health risk for older adults, including brief assessments of dynamic and static balance in the examination of older adults provides valuable information about physical function and mobility.

Key Words: functional performance, aging, balance

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INTRODUCTION

For older adults, maintaining mobility and balance is critical for remaining independent and for decreasing the risk of morbidity and mortality. Physical therapists have a unique opportunity to screen older patients for declines in mobility and balance, regardless of the referral diagnosis. A simple clinical assessment to identify these deficits in mobility and balance can result in implementing interventions to decrease the risk of falls and limit functional decline. Several physical performance test batteries using assessments such as walking speed and the timed chair rise task have been developed to identify individuals at risk of functional decline.[1-3] Other performance batteries have been developed specifically to identify balance impairments and falls risk.[4,5]

The ability to maintain one's balance both statically and dynamically is a key predictor of falls and indicator of function for older adults.[6-8] Balance is a multifaceted skill that requires constant processing of sensorimotor information, choosing appropriate motor responses, and executing these responses to maintain an upright position.[9] Brief clinical assessments of balance often focus solely on static balance skills such as the Rhomberg or tandem stance series,[10] or on dynamic balance skills such as the Timed Up and Go.[11] While the Timed Up and Go is a brief, sensitive, and specific measure to identify individuals at risk of a fall,[5] it does not specifically identify impairments in static or dynamic balance skills. Comprehensive clinical assessments of balance, such as the Berg Balance Scale, include tasks measuring both static and dynamic balance skills and are predictive of falls,[4] but they often require too much time for a clinical screen. A brief balance assessment, targeting both static and dynamic components of balance, could determine if an intervention specific to the area of impairment is necessary.

We chose 2 brief measures of static and dynamic balance, the tandem stance test (TST) and the timed 360° turn (360° turn), respectively, to examine the relationships between balance measures and mobility. The TST is a short assessment of static balance used in several physical performance batteries including the Established Populations for Epidemiologic Studies of the Elderly (EPESE) short performance battery[3] and the Berg Balance Scale.[4] The 360° turn is a brief assessment of dynamic balance that is scored on qualitative characteristics in the Physical Performance Test[1] and as a timed quantitative item on the Berg Balance Scale.[4] These tests were chosen because we believe they measure different components of balance, require only a stopwatch, and take only minutes to administer. Considering the very brief period of time, minimal equipment, and small space required, these measures could be applied easily in almost any clinical or home environment. However, the association of performance on these brief tests to each other and to functional mobility has not been reported. The aim of this study was to examine associations among these brief assessments of static and dynamic balance and the functional mobility tasks of walking and rising from a chair.

METHODS

Study Participants

This was a cross-sectional investigation using baseline data from an ongoing longitudinal study of older adults. Members of a senior center and residents of a continuing care retirement facility were invited to participate in on-site health promotion and wellness assessments advertised on community bulletin boards and in newsletters. All participants provided informed consent approved by the University of North Carolina at Chapel Hill Institutional Review Board. Eligible participants were 65 years of age or older, living independently or in an assisted living residence, and able to walk independently with or without an assistive device. Prior to participation in physical performance testing, individuals completed a health status screen to identify symptoms or signs contraindicative of testing, such as new onset of pain, dizziness, problems with glycemic control, or major surgeries within the last 6 months. One hundred ninety-five participants volunteered for the assessment.

Measurements

Participants first self-reported information on health history, medication use, and independence in activities of daily living; they then completed physical performance testing. All performance measures were timed and recorded to the nearest tenth of a second.

Balance

Static balance

The tandem stance test (TST) is an assessment of static balance ability[4,12] included in the EPESE short performance battery[3] and the Berg Balance Scale.[4] The task requires individuals to maintain upright balance with a narrow base of support without assistance or taking a step. Individuals who are unable to hold this position for at least 10 seconds are at a higher risk of falls and functional decline.[10,13] Using a standard protocol, the tester demonstrated the tandem stance position (heel-toe), and then instructed the participant to assume and maintain the TST position without taking a step or using support for at least 10 seconds.[10] No practice trials were allowed. Participants were allowed to support themselves while assuming the tandem-stance position, and were guarded by the tester during the testing period to prevent falls. Participants were instructed to release their support when they felt stable, and to hold the position until the tester said 'stop.' Timing began once the participant assumed the correct position and released his support; timing stopped at 10 seconds, when a foot was moved out of position or when a hand was placed on the support. Participants who could not assume the heel-toe position were not included in analyses.

Dynamic balance

The timed 360° turn (360° turn) assesses dynamic balance, requiring individuals to turn in a circle while taking steps (ie, the base of support is changing during the task). Individuals who take longer than 3.8 seconds to turn 360° are at a higher risk of falls[14] and loss of independence in activities of daily living (ADLS).[15] This study used the timed version of the test described by Gill et al.[15] Subjects were asked to turn in a circle as quickly as possible in the direction of their choice. The tester first demonstrated the task and then instructed the subject to start. Timing started on the word 'go' and stopped when the participant faced the tester with both feet forward. No practice trials were allowed. Participants performed 2 trials in the direction of their choice, and the average of 2 trials was used for analysis.

Mobility

Considerable evidence suggests that performance of functional mobility tasks, such as walking and rising from a chair predicts disability, morbidity, and mortality.[3,15-18] Individuals who walk slower than 1.0 m/s have poor self-perception of physical function,[18] increased fear of falling,[19] and are at a higher risk of falls,[20] loss of independence in activities of daily living, and morbidity.[3] Walking is a dynamic activity requiring muscle strength,[19] balance,[20] endurance,[21] and attention.[22]

Self-selected walking speed was assessed using a conventional 10-meter walk course including acceleration and deceleration zones at each end.[23,24] Participants were instructed to walk at their usual pace at the beginning of the acceleration zone. Timing started when the participant's foot crossed the tape at the start of the 10-meter course, and stopped when the foot crossed the line at the end of the course.[8] Two trials were conducted and average walking speed was calculated in meters/second (m/s).

The ability to rise from a chair without using one's arms is a physical performance measure requiring primarily lower limb strength. The ability to rise from a chair multiple times also requires vision, proprioception, balance, and sensorimotor skills.[25,26] Several screening batteries use a chair rise measure as an indicator of function and predictor of decline.[10,27] The inability to rise from a chair 5 times in less than 13.6 seconds is associated with increased disability and morbidity.[3]

Using a standard protocol, the timed chair rise task (TCR) requires participants to rise from a standard height (43.2 cm), armless chair with arms folded across the chest.[3] The tester demonstrated the task and then subjects were instructed to stand. Participants who could successfully rise 1 time were then instructed to stand up and sit down 5 times as quickly as possible, keeping their arms folded across their chest.[10] Timing began at the word go and stopped when the participant stood for the fifth repetition. If participants used their arms during the TCR task, they were asked to repeat the task. If unable to rise 5 times without using their arms, they were excluded from analyses.

Analysis

Data were analyzed using SAS software, version 8.02 (SAS Institute, Inc., Cary, NC). Descriptive statistics were generated from 195 subjects including demographics, ADL, and medical conditions (Table 1). Descriptive statistics for the physical performance measures and Pearson correlation analysis were generated from the 179 subjects who completed all physical performance testing. The TST had a bimodal distribution with the majority of participants able to hold the position for the full 10 seconds or 1 to 2 seconds; therefore, the data were dichotomized (Table 2). The 16 subjects excluded from this analysis either could not complete 5 repetitions of the chair rise task or did not attempt the tandem stance position. Pearson correlation analyses were used to assess associations among performance on balance (TST and 360° turn) and mobility measures (walking speed and TCR) (Table 3).

To further examine the association between balance (360° turn and TST) and mobility we used logistic regression modeling to determine the probability of performing well on tasks of functional mobility based on balance performance. For this analysis, performance variables were dichotomized based upon established cut points in the literature. The balance measures were categorized as follows: TST was coded as 0 if unable to maintain the position for at least 10 seconds, and 1 if able to maintain the position for 10 seconds;[16] 360° turn, was coded as 0 if longer than 3.8 seconds, and as 1 if less than or equal to 3.8 seconds.[15] For the outcome measures, subjects who could not complete 5 repetitions of the chair rise task, or took longer than 13.6 seconds were given a score of 0 and those with a time of 13.6 seconds or less were given a score of 1.3 Seven subjects were not tested on the TST for various reasons such as recent hip surgery or pain, so only 188 subjects were included for this measure in the logistic regression analysis. Walking speed was originally divided into 3 categories of performance: 0 (< .6 m/s), 1 (.6 -1.0 m/s), and 2 (> 1.0 m/s).[17,28] However, because only 11 participants walked slower than .6 m/s, the slow and intermediate categories were collapsed, leaving dichotomous scores of 0 (< 1.0 m/s) and 1 (≥ 1.0 m/s). Collapsing the slow and intermediate groups is supported by prior reports that suggest individuals who walk slower then 1.0 m/s have a higher risk of morbidity and functional decline compared to individuals who walk at 1.0 m/s or faster.[17]

Table 1. Participant Characteristics

Demographic and health status variables (N=195)	% Participants or Mean (SD)
Age (years)	80.9 (5.9)
> 85	28.2 %
Gender (female)	70 %
Race (white)	99 %
Education level (Bachelors Degree or higher)	61 %
Married	58 %
Use assistive device	26 %
Activities of Daily Living (Katz)	
Independent in all ADLs	99%
Independence in Activities of Daily Living (OARS)	
Independent in all IADLS	62.2 %
Dependent in 1 IADL	22.0 %
Dependent in more than 1 IADL	15.8%
Medical conditions (number)	3.3 (2.1)
Prescription medications (number)	3.2 (2.6)

Four logistic regression models were generated to determine the odds of performing well on the outcomes of TCR and walking speed based on balance, controlling for age and gender. Odds ratios (OR) for mobility outcomes were generated for each balance test in the first three models. The last model was used to generate odds ratios for the mobility outcomes when both balance assessments were in the model.

RESULTS

Study Participants and Performance Measures

This sample of independent community dwelling older adults and CCRC residents was predominantly female (70%), married (58%), and well educated (61% bachelors degree or higher), with a mean age of 80.9 years, 3.2 medical conditions, and 3.3 prescription medications. Thirty-one participants (17%) reported dependence in one or more instrumental activities of daily living (IADL) (Table 1). The sample was relatively high functioning with approximately 70% of participants walking at 1.0 m/s or faster and 58% completing 5 chair rises in less than 13.6 seconds. Seventy-four percent could turn in a circle in less than 3.8 seconds, and 46% could maintain tandem stance for at least 10 seconds (Table 2).

Relationships Between Balance and Mobility

The 2 balance measures were moderately correlated (r = .46). The TST was moderately correlated to walking speed (r = .49), but not related to TCR (r = -.08). The 360° turn was strongly related to walking speed (r = .70), and weakly related to TCR (r = .26) (Table 3). The TST and the 360° turn were significantly associated with the outcome variables of walking speed and TCR when entered individually into the logistic regression model. However, individuals who performed the 360° turn in less than 3.8 seconds were much more likely to perform well on tasks of walking speed (OR = 20.7) and TCR (OR = 8.5) than individuals who performed well on the TST. When both balance variables were entered into the model, TST and 360° turn were significantly associated with the outcome of walking speed, but only the 360° turn was a significant predictor of TCR performance. The covariate of gender was not associated with either mobility outcome, and age was only significant in models with one performance variable (Table 4).

DISCUSSION

Results of this study suggest that these brief measures of static and dynamic balance are weakly associated, and assess different components of balance. In addition, results from logistic regression indicate performance of the 360° turn was significantly associated with both mobility measures. Individuals who can turn in a circle in less than 3.8 seconds are 8.5 times as likely to rise from a chair 5 times in less than 13.6

Table 2. Physical Performance Measures (N = 179)

Balance and Mobility Measures	Mean Score [95% CI]	Time	N (%)
Tandem Stance (s)	Not Applicable*	0 - <10	102 (54)
		≥ 10	86 (46)
360° Turn (s)	3.3 [3.1, 3.6]	≤ 3.8	149 (76)
		> 3.8	46 (24)
Timed Chair Rise (s)	14.4 [13.5, 15.3]	≤ 13.6	103 (58)
		> 13.6	76 (42)
Self Selected Walking (m/s)	1.1 [1.1, 1.2]	< 1.0	58 (30)
		≥ 1.0	137 (70)

* Times for the tandem stance were not normally distributed. Participants could either hold the position for the full 10 seconds or 1-2 seconds; therefore, the data were dichotomized.

Table 3. Pearson Correlations Between Balance and Mobility Measures (N = 179)

Measures	Tandem Stance Test	Walking Speed	Timed Chair Rise
360° Turn	-.462*	- .701*	.260*
Tandem Stance Test		.495*	- .083
Walking Speed			- .231*

* Significant at $P < .001$

seconds and 20.7 times as likely to walk at 1.0 m/s or faster. Turning around involves sequential steps and shifting body weight from one foot to the other while maintaining upright balance. Walking also requires shifting body weight between limbs as one takes sequential steps for forward or backward progression.[29] Rising from a chair is a multidimensional skill, requiring dynamic transfer of the body's center of mass and then stabilization over a fixed base of support. In the tandem stance task, the body weight must be maintained in a static position with feet fixed on the floor. A surprising finding is the lack of association between performance of the tandem stance and the TCR. Turning performance was associated with chair rise times, suggesting that dynamic balance skills are key for walking and rising from a chair, and that static skills make a smaller contribution to performance of these tasks.

Our study confirms the importance of including a measure of dynamic balance, such as the timed 360° turn, for screening balance and for falls risk assessments.[4,30] Other researchers report associations between poor turning performance and an increased risk of ADL disability,[15] functional decline, and hip fracture.[31-33] Turning safely is a key component for daily tasks such as getting in and out of a car or maneuvering in the bathroom, and thus plays an important role in maintaining functional independence.

The significant odds ratio for dynamic balance performance and chair rise is a novel finding, and suggests that dynamic balance skills are an important component of the TCR task. Several studies suggest leg strength is a primary component of the TCR task. Jones et al reported strong correlations (r = .77) between the number of chair rises performed in 30 seconds and leg strength as measured by the maximum weight a participant could leg press for one repetition.[34] However, McCarthy and colleagues using regression analyses reported that only a moderate proportion of the variance of TCR performance was explained by isokinetic lower extremity strength (R^2 = .43), suggesting that chair rise is not an exact proxy for lower extremity strength, but is a multicomponent task requiring other physical skills.[35] This finding is further supported by Lord et al who demonstrated significant but weak associations between measures of static balance as measured by postural sway and chair rise.[25] We are aware of no study to date that has examined the association between dynamic balance performance and chair rise.

Overall, our study sample had similar demographic and functional characteristics compared to other large cohort studies assessing physical performance measures in older adults.[8,10,25] Functionally, our sample demonstrated a similar distribution of 360° turn times as the 664 older adults studied by Gill et al,[8] similar walking speeds as the 4,588 older adults studied by Guralnik et al,[3] and similar mean times for 5 chair rises as the 664 older adults studied by Lord et al.[25] The similarity of our sample to other large study samples suggests that our findings on the importance of dynamic balance abilities in relation to

Table 4. Logistic Regression Analysis (N = 188)

Independent Variable	Dependent Variables					
	Walking Speed (≥ 1.0 m/s)			Timed Chair Rise (≤ 13.6 s)		
	Odds Ratio	(95% CI)	*P*-Value	Odds Ratio	(95% CI)	*P*-Value
Age	.86	(.80 - .92)	< .01	.92	(.87 – .97)	.01
Gender	.86	(.42 - 1.75)	.67	1.2	(.68 – 2.37)	.49
Age	.90	(.84 - .97)	< .01	.94	(.89 – .99)	.03
Gender	1.31	(.58 - 2.94)	.52	1.47	(.77 – 2.82)	.24
Tandem Stance	7.32	(3.32 – 16.1)	< .01	2.23	(1.78 – 4.22)	.01
Age	.88	(.82 - .95)	< .01	.95	(.90 – 1.03)	.05
Gender	1.12	(.48 – 2.64)	.78	1.46	(.75 – 2.85)	.25
360° Turn	20.72	(7.90 – 54.32)	< .01	8.54	(3.26 – 21.96)	.01
Age	.92	(.85 - .99)	.04	.95	(.91 – 1.01)	.10
Gender	1.71	(.67 – 4.35)	.26	1.54	(.78 – 3.02)	.21
360° Turn	13.00	(4.76 – 35.52)	< .01	7.56	(2.81 – 20.36)	.01
Tandem Stance	1.07	(1.03 – 1.11)	< .01	1.33	(.67 – 2.70)	.43

functional mobility should be applicable to a larger population of community dwelling older adults.

As the population ages, early identification of mobility and balance problems will play a major role in falls prevention and promoting independence in the elderly. Physical therapists treat older adults for a variety of diagnoses that are not associated with specific balance impairments, and clinic time constraints usually do not allow for comprehensive balance assessments of all patients. However, this study suggests strong relationships between performance of the TST, timed 360° turn, and mobility skills. These specific balance screens require minimal time, and provide an opportunity to identify individuals at risk for falls, and potentially to reverse declines in function by use of appropriate interventions. If a physical therapist identifies a deficit in static or dynamic balance during a standard evaluation, the patient's physician and health care providers can be notified, and a thorough multidisciplinary assessment can be performed to determine the cause of the balance impairment and decrease the risk of future falls.

Participants in this study were predominantly white, high functioning, well-educated older adults living in the community and CCRC settings. These demographic characteristics may limit the generalization of our results to a more racially diverse group of older adults.

CONCLUSION

Mobility requires both static and dynamic balance abilities. Our data suggest that dynamic balance, as measured by the 360° turn, has a stronger association with self-selected walking speed and chair rise ability than the more commonly used static measure of TST. Incorporating the 360° turn and the TST in a brief screening battery may provide additional insight on potential balance impairments and functional mobility. Due to the high prevalence of mobility dysfunction and injurious falls in older adults, clinicians should consider using both of these brief balance assessments as part of a standard physical therapy evaluation to screen for potential balance and mobility impairments in the older adult population.

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