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Use of the walking and turning test to accurately discriminate between independently ambulatory community-dwelling older Thai adults with and without a history of falls: a retrospective diagnostic study

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ABSTRACT

Objectives This study developed and investigated the possibility of using the walking and turning test (WTT) to indicate fall risk in community-dwelling older adults.

Design Retrospective diagnostic study.

Setting The study was carried out in a community setting.

Participants The study focused on community-dwelling older Thai adults.

Primary and secondary outcome measures The participants were assessed based on demographics, fear of falls using a 'yes/no' question and the Short Falls Efficacy Scale International, as well as fall data in the previous 6 months. The participants then performed the WTT, timed up and go test, five times sit-to-stand test and handgrip strength test (HG) in random order.

Results There were a total of 86 participants with an average age of 69.95±6.10 years (range from 60 to 88 years), most of whom were female (67.44%). 40 participants (46.51%) reported that they had fallen at least once in the previous 6 months. A comparison of various physical ability tests revealed significant differences between faller and non-faller participants (p<0.001). The outcomes of the WTT showed significant correlations with fall variables, balance and muscle strength (0.394 to 0.853, p<0.001). Based on sensitivity, specificity and area under the curve, the cut-off score of 6.40 s showed the highest level of ability to indicate falls among community-dwelling older adults, with a sensitivity of 92.50% and a specificity of 78.26%.

Conclusions The study suggests the clinical usefulness of the WTT in determining falls in older individuals. WTT is a physical ability measurement that indicates balance ability and muscle strength. The test is practical, requires little space and equipment and can be used in large populations.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The walking and turning test was designed based on easy-to-administer measurement, simplicity and convenience, and the ability to be used in communities with large populations.
⇒ The walking and turning test evaluates the time needed to turn left and right during walking, which is consistent with basic human movement and the daily activities of older individuals.
⇒ The retrospective study used 6 months of fall data in older participants may not be representative of the ability to identify future fall risk.
⇒ The number of older participants at the old, older and oldest levels should be equal for optimal clinical applicability.

INTRODUCTION

Increasing age is associated with worsening gait, impaired balance and muscle weakness, all of which can contribute to the risk of falls.[1] Approximately 30% of community-dwelling older individuals report falls each year.[2] Falls among older adults are a major contributor to loss of independence, hospitalisation from trauma and injury-related fractures, as well as decreases in quality of life, associated healthcare costs and death rates.[3] Approximately 95% of hip fractures are caused by falls, and 10%–20% of patients with hip fractures are admitted to nursing homes, with 20% dying within 12 months.[4–6] Therefore, simple, feasible and practical screening assessment tools based on easy-to-administer measurements that can be carried out in almost any setting may be beneficial to these individuals.

Numerous tests have been suggested as fall risk indicators, and many studies have recommended functional field-based balance assessments that can approximately indicate levels of functioning among individuals.[7–9] However, the validity of these assessments has not been demonstrated in large representative samples of community-dwelling older people.[4] Moreover, most existing mobility and balance measures for older individuals commonly require specific equipment and area testing. There remains the possibility of encountering issues related to floor effects. For example, tests such as the time up and go test (TUG) or the sit-to-stand test (STS) require participants to rise independently, which may present limitations for community-dwelling older adults who experience knee or hip pain. The study by Tiedemann *et al*[10] examined the comparative ability and clinical utility of eight mobility tests for predicting multiple falls in community-dwelling older people. The study evaluated feasibility based on the equipment required, as well as the space and setting for administering the tests. Results indicated that the alternate step test, sit-to-stand five times test (STS-5) and 6-me walk test were the most effective, considering feasibility, reliability and predictive validity for falls. However, despite the favourable ratings for predictive validity, the sensitivity and specificity of the mobility tests as predictors of multiple falls remained low when considering the cut-off points for each test.[10] Therefore, the consideration of feasibility is also important apart from the reliability and accuracy of fall indications.

For the activities of daily living, turning of the body is ubiquitous. Nearly every task performed during the day requires some amount of turning.[11] Turning is more complex and demanding than a linear gait as it requires complex interplay among various neural resources that coordinate motor control, spatial awareness and sensory integration to plan and coordinate postural transitions, as well as more coupling between the balance and gait control systems and more spatial coordination between limbs.[12–14] The inherently unstable bipedal gait becomes critical during curved walking or turning, as shown by turning difficulties in older people.[15] During walking combined with turning, trunk movements adapt to maintain balance against inertial forces. These gait adaptations are reflected in strong muscle activity and finely tuned leg movement mechanics.[15] Furthermore, it has been determined that turning can indicate a higher level of physical ability than straight-ahead walking.[16] In addition, it has been reported that turning is considered a daily activity that can account for up to 50% of daily walking volume.[11 15] The capacity to move the body to walk while turning efficiently is necessary for actions such as walking around immovable objects, shifting directions while walking and making turns in crowded environments with various obstructions.[15] Moreover, difficulty turning is a major contributor to mobility disability, falls and reduced quality of life in older people because it requires dynamic balance control that worsens with age.[16] Previous studies demonstrated that turning was reported as the primary activity involved in falls[17] and that falls during turning resulted in eight times more hip fractures than falls during straight-line walking.[18 19] However, most gait research has focused on straight-ahead walking. Research on turning has primarily been limited to laboratory or clinical settings, and little is known about turning in home or community environments.[11] Although several studies have been conducted on turning tests, most have involved half-turn (180-degree) and full-turn (360-degree) movements.[20–22] Most studies on 90-degree turns have primarily focused on the biomechanics and physiological responses of the body whileph turning in general populations, older people and patients with neurological conditions.[23–28] These studies highlight the potential benefits of using 90-degree turn walking patterns as a tool for assessing various issues related to mobility. A comprehensive review of the literature has identified the development of the L-test, an adaptation of the TUG, designed to evaluate functional mobility in individuals with lower-limb amputations and patients with chronic stroke.[29–31] The L-test, however, necessitates a testing area of 3× 7 m, along with the use of a standard-height chair and incorporates both 90-degree and 180-degree turns.[7] Additionally, participants must walk at least 20 m to complete the test, which could be a limitation for older adults with reduced walking abilities. These spatial requirements may pose practical challenges when assessing large cohorts of older individuals, particularly in space-limited environments such as community settings.

Ease of administering the measurement, simplicity, convenience and the ability to be used in settings with large populations were the primary considerations in developing the walking and turning test (WTT) in this study. The WTT evaluates the time needed to turn left and right during walking, which is consistent with human basic movement or the daily activities of older individuals. The researchers hypothesise that the WTT has the discriminative ability to separate those who have fallen and those who have not. In addition, the characteristics of the test are related to physical ability and which physical factors affect the risk of falling. The test may determine falls in community-dwelling older individuals with superior discrimination compared with existing tests including handgrip strength (HG), five times sit-to-stand test (FTSTS), timed up and go test (TUG) and Short Falls Efficacy Scale International (Short FES-I). Therefore, the primary aim of this study was to investigate and compare the ability of the WTT and physical standard measures by exploring the cut-off score for indicating falls in community-dwelling older adults, as determined by the sensitivity, specificity and area under the curve (AUC) of the test. Additionally, the study aimed to assess the potential of using the WTT in community-dwelling older adults by (1) comparing the outcomes of the WTT between older adults with and without a history of falls and (2) examining the correlation between the outcomes of the WTT and falls, balance ability and muscle strength variables.

MATERIALS AND METHODS

Study design and population

This retrospective diagnostic study was conducted among older individuals aged 60 years or older, including both males and females. Older adult participants were recruited through outreach and collaboration with community healthcare providers to target specific rural and suburban communities in the northern region of Thailand. Eligible participants were required to have the ability to stand up independently and walk, with or without external assistance from a walking device. They were also required to demonstrate normal cognitive function, as assessed by the Mini-Mental State Examination (MMSE), with a score of 23 or higher, and possess the ability to comprehend the instructions provided during the study. Exclusion criteria were based on neurological diseases that could affect walking ability, balance or significant pain in the lower extremities that could affect the outcomes in this study, as well as active infection or diagnosis of cancer, current injury, uncorrected visual deficits and amputation of an extremity.[32] The study was approved by the Institutional Ethics Committee for Human Research (Ethics Committee reference number: HREC-UP-HSST 1.2/020/67). All the participants signed written informed consent forms prior to participation in the study.

The minimum sample size requirement was estimated from the primary objective (exploring a cut-off score). Since there are no previous reports concerning sensitivity values related to walking and turning, the researchers sought sensitivity values from a pilot study. 30 participants were enrolled in a pilot study to determine the sensitivity of the sample size calculation for the study. Most participants were female (66.70%) with a mean age of 66.9 years. The results of the pilot study reported a cut-off score of 6.50s with a sensitivity of 66.70% and a specificity of 53.33% (unpublished data). The findings indicated that the study required at least 86 participants when setting acceptable error at 10%, a p-value at 0.05, and a sensitivity from a pilot study of 66.70%.

Procedure

The 86 eligible participants were interviewed and evaluated for their demographics, and none used a walking device. Fall data were recorded concerning the number of falls in the previous 6 months, and then the participants were divided into fallers (positive) and non-fallers (negative). A fall was defined as 'an event reported either by the faller or by a witness, resulting in a person inadvertently coming to rest on the ground or another lower level, with or without loss of consciousness or injury'.[33] The fear of falls (FOF) score was measured by using a 'yes/no' question and the Short FES-I. The participants in both faller and non-faller groups then performed the WTT, TUG, FTSTS and HG. These tests were executed in a random order by using simple random sampling, and the participants could take a period of rest between the tests and the trials as required in order to minimise learning effects and fatigue that might occur due to the sequences of the tests. In addition, the assessment areas for participants were conducted at their homes, and in some cases, nearby public spaces were used when the home environment had limited space. To ensure consistency, the researchers standardised the testing environment by selecting areas with smooth, even surfaces, typically concrete, to minimise environmental factors that could influence the measurements. The tests were administered by two experienced and trained raters and were assessed for acceptable intra-rater reliability (intraclass coefficients (ICCs) range from 0.858 to 0.993, p<0.001). The details of the test protocols are as follows.

The Short FES-I is used to measure 'fear of falling' or, more properly, 'concerns about falling', which are suitable for use in research and clinical practice. The tool shows excellent internal and test-retest reliability (Cronbach's alpha 0.92, ICCs 0.83), with a strong correlation between the Short FES-I and the FES-I of 0.97.[34] The seven questions were translated from English into Thai. The Short FES-I has been demonstrated to have good reliability and validity with the original FES-I.[35] It has also been validated for use in older adults with cognitive impairment.[34 36] Each activity was scored from 1='not at all concerned' to 4='very concerned', thus resulting in a total score ranging from 7 (absence of concern) to 28 (extreme concern). Scores obtained were interpreted as low (7–8 score), moderate (9–13 score) and high (14–28) concern about falling.[37]

The WTT is a test that was designed based on daily movement activities that are simple and practical, do not require much equipment and can be used among large populations in communities. In this study, participants were asked to stand on a marker, with or without a walking device. On the call of 'Start', the participants began to walk parallel to a 2-m tape line at the fastest possible pace, then turned left along the tape line and walked for another 2 m and then turned right and walked for another 2 m until reaching the stop marker (figure 1). The researchers used a stopwatch to record the time necessary to complete the test from the call of start until the participants reached the end of the distance. Participants performed three rounds of testing, and the average time was used for further statistical analysis.

The TUG is an excellent rater reliability test (ICCs=0.97–0.99) used to represent complex mobility in daily living and dynamic balance control.[38 39] The test is a sensitive and specific measure for identifying community-dwelling adults who are at risk for falls.[40] The participants stood up from a standard armrest chair, walked around a traffic cone that was placed 3 m from the front edge of the chair, and then returned to sit down on the chair. The time from the command 'Go' until the participant's back touched the backrest of the chair was recorded in seconds. The researchers used a stopwatch to record the times, and the average time over the three trials was reported.[39–41]

The FTSTS is a reliable measure with high test-retest reliability (ICC=0.89).[42] The test was used to determine functional lower extremity muscle strength and dynamic balance control while changing from a sitting to a standing position.[43–45] The test has been useful for the identification of older people who are at higher risk of recurrent falls.[46] After receiving the instruction 'Start', participants' ability to complete five chair-rise cycles was timed at the

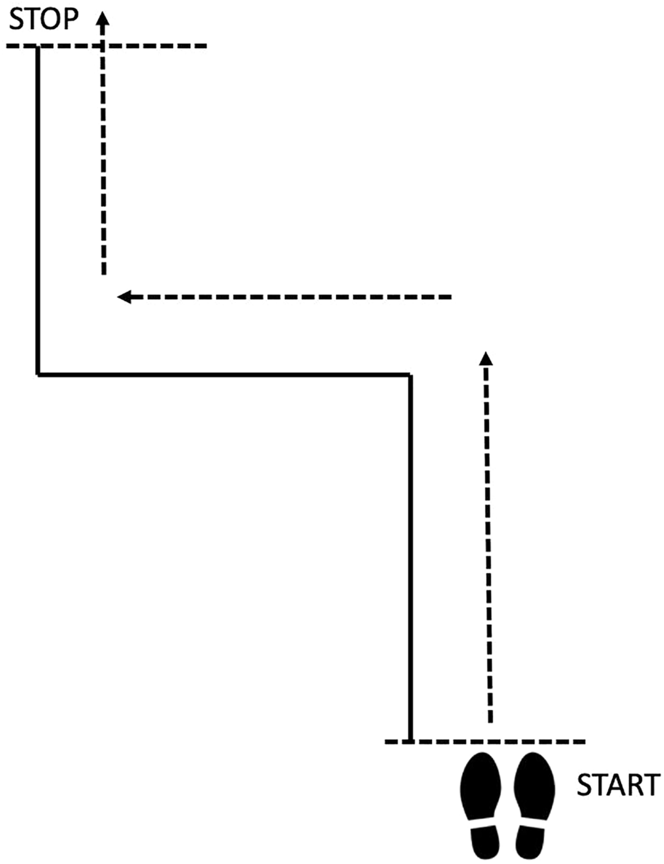

Figure 1 Walking pattern and direction while performing the walking and turning test.

fastest possible safe speed without using their arms. The researchers used a stopwatch to record the times and started the timer with the command ‘start’, after which the timer was stopped when the participant’s buttocks touched the chair the fifth time. The average time over the three trials was reported.[41]

For the HG, the test is recognised as a standard excellent reliability measure (ICCs=0.92–0.97) that is commonly used to reflect upper limb motor strength, frailty, vulnerability and risk of adverse events in older adults.[47] The participant was positioned standing with the shoulder adducted about 30 degrees and the elbow extended fully with the forearm and wrist in a neutral position.[48] A hand grip dynamometer was placed in the participant’s dominant hand, after which the investigator verbalised the words ‘squeeze’ to begin the test and ‘relax’ to end it.[49] Participants performed the test twice, and the maximum force (kg) of the two times was recorded for statistical analysis.

Statistical analysis

Descriptive statistics were used to describe the participants’ characteristics and the findings of the study. The independent samples *t*-test and χ^2 test were used to compare the demographic data. The Kolmogorov-Smirnov test was used to check the normality of the data. To avoid an increase in type I error due to multiple comparisons, multivariate analysis of covariance (MANCOVA) was performed for the WTT and standard measure outcomes (Short FES-I, TUG, FTSTS and HG) between faller and non-faller participants. In addition, it is well known that age affects the outcomes of the measures used in this study, particularly walking and balance ability. Moreover, several studies have reported that increasing age results in a decrease in walking speed.[50–52] Thus, age was treated as a covariate in the MANCOVA analysis. Spearman’s rank correlation coefficient (*rho*) and the point-biserial correlation coefficient were used to analyse the correlations of data between the WTT and standard measures (concurrent validity). Correlation levels were interpreted as very low or negligible (0.00–0.30), low (0.30–0.50), moderate (0.50–0.70), high or strong (0.70–0.90) and excellent (0.90–1.00). Therefore, the closer the correlation coefficient approaches 1, regardless of direction, the stronger the existing association, indicating a linear relationship between the data of WTT and standard measures.[53] The receiving operator characteristics (ROC) curve was further employed to explore an optimal cut-off score for WTT and standard measures, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and AUC to indicate the falls. In general, an AUC of 0.5 suggests no discriminative ability (ie, unable to diagnose individuals with or without the condition based on outcomes of the target test); 0.7–0.8 is considered acceptable; 0.8–0.9 is considered excellent, and higher than 0.9 is considered outstanding discriminative ability.[54] The level of statistical significance was set at $p<0.05$.

Patient and public involvement

No patients and/or the public were involved in the design, conduction, reporting, or dissemination of this research.

RESULTS

There was a total of 86 participants with an average age of 69.95±6.10 years (range from 60 to 88 years), most of whom were female (67.44%). Their average body mass index was within the normal range, and all participants were able to walk independently without the use of assistive devices. For fall data, 46.51% reported that they had fallen at least once in the previous 6 months.

Before analysing the data with MANCOVA, the researcher checked the multivariate outlier case using Mahalanobis distance, checked for multivariate normality using Mardia’s multivariate skewness and kurtosis and ruled out multicollinearity. The results found all variables were related according to basic assumptions. When controlling age as a covariate ($F_{\text{wilks' Lambda}}=3.87$, $p=0.003$), the variables selected (WTT, Short FES-I, TUG, FTSTS and HG) for analysis were those determined to be different between fallers and non-fallers groups by MANCOVA. The WTT, TUG, FTSTS and HG discriminated between the fallers and non-fallers ($p<0.001$). However, the scores from the Short FES-I were found to have no difference ($p=0.101$) (table 1). The findings indicated that all

Table 1 The demographics of the participants

Variables	Total (n=86)	Faller (n=40)	Non-faller (n=46)	P value
Age: years (mean±SD)	69.95±6.10	70.83±6.87	69.20±5.32	0.219*
Gender: n of female (%)	58 (67.44)	25 (62.50)	33 (71.74)	0.289†
Body mass index: kg/m^2 (mean±SD)	22.07±3.72	21.81±3.45	22.24±3.91	0.601*
Fear of falls: n of YES (%)	41 (47.67)	32 (80.00)	9 (19.57)	<0.001†
Causes of falls: n (%)				
Trips		10 (25.00)		
Postural hypotension		5 (12.50)		
Muscle weakness		4 (10.00)		
Missed steps		9 (22.50)		
Dizziness		4 (10.00)		
Other specify causes‡		8 (20.00)		
Fall-related injuries: n (%)				
No		29 (72.50)		
Pain		5 (12.50)		
Bruise		5 (12.50)		
Fracture		1 (2.50)		
Walking and turning test: s (mean±SE)	7.29±0.14	8.30±0.21	6.28±0.20	<0.001§
Handgrip strength test: kg (mean±SE)	20.03±0.55	17.97±0.80	22.09±0.75	<0.001§
Five times sit-to-stand test: s (mean±SE)	12.14±0.24	13.06±0.35	11.21±0.32	<0.001§
Time up and go test: s (mean±SE)	12.16±0.18	13.36±0.26	10.96±0.25	<0.001§
Short Falls Efficacy Scale International: scores (mean±SE)	18.50±0.63	19.56±0.93	17.45±0.87	0.101§

*The p values were analysed using the independent samples t-test.
†Using the χ^2 test.
‡This category includes muscular and joint pain, arthritis and transferring.
§Using multivariate analysis of covariance.

participants could perform the WTT without any adverse events.

The correlation level between the WTT outcomes and standard measures is demonstrated in table 2. The outcome of the WTT showed significant correlations with fall variables, balance and muscle strength (0.394–0.853, p<0.001; table 2). In addition, the outcomes of fall variables showed significant correlations with balance and muscle strength outcomes (−0.239 to 0.595, p<0.05; table 2).

A comparison of the discriminative ability of the WTT and standard measures to determine falls in older individuals is shown in table 3. In addition, figure 2 shows the comparison of the AUC of the tests, which found that WTT had the highest AUC, followed by TUG, FTSTS and Short FES-I, respectively. Therefore, among the various measures in this study, it was found that the WTT had the highest discriminative ability to indicate the risk of falls among community-dwelling older people, followed by TUG, FTSTS, HG_{max} and Short FES-I, respectively.

DISCUSSION

This study assessed the possibility and validity of using the WTT in community-dwelling older adults. All the participants completed the WTT with no adverse effects. The key results suggested the clinical usefulness of the WTT in indicating the risk of falls among community-dwelling older adults and demonstrated the discriminative power between fallers and non-fallers. In addition, the WTT showed a significant correlation with fall variables and standard functional measures.

Ageing is commonly accompanied by an overall physiological decline that greatly affects muscle strength, balance ability, mobility and independence.[55 56] The outcomes from this study have been in accordance with previous studies that reported on the physical ability outcomes and health status of older individuals with and without falls.[9 57 58] Thaweewannakij *et al* compared the physical abilities of community-dwelling older people with and without a history of falls, quantified using the 10-m walk test, TUG, FTSTS and 6 min walk test (6MWT). The study reported the functional abilities of participants with multiple falls were significantly poorer. These individuals reported balance impairment as a major factor in falls, whereas individuals with a single fall reported environmental hazards as a common cause of falls.[57] A study by Poncumhak *et al* reported a significant difference in the outcomes of the FTSTS, TUG, three times

Table 2 The correlation between the WTT, fall variables and physical ability measures

	Short FES-I	Falls	TUG	FTSTS	HG
Variables	rho (95%CI)	r_{pb} (95%CI)	rho (95%CI)	rho (95%CI)	rho (95%CI)
WTT	0.394* (p<0.001) (0.197 to 0.564)	0.609* (p<0.001) (0.524 to 0.774)	0.853* (p<0.001) (0.762 to 0.910)	0.457* (p<0.001) (0.253 to 0.622)	−0.541* (p<0.001) (-0.670 to 0.371)
HG	−0.239† (p=0.027) (-0.435 to 0.003)	−0.397* (p<0.001) (-0.610 to 0.232)	−0.558* (p<0.001) (-0.701 to 0.375)	−0.399* (p<0.001) (-0.580 to 0.214)	
FTSTS	0.262† (p=0.015) (0.032 to 0.490)	0.411* (p<0.001) (0.217 to 0.598)	0.490* (p<0.001) (0.268 to 0.666)		
TUG	0.408* (p<0.001) (0.225 to 0.562)	0.595* (p<0.001) (0.479 to 0.748)			
Falls (r_{pb})	0.309† (p=0.006) (0.216 to 0.428)				

*Significant correlation p values <0.001.
†Significant correlation p values <0.05.
FTSTS, five times sit-to-stand test; HG, hand grip strength test; Short FES-I, Short Falls Efficacy Scale International; TUG, time up and go test; WTT, walking and turning test.

stand and walk tests (TTSW), functional reach tests (FRT) and single-leg stance tests (SLS) between fallers and non-fallers (p<0.001).[9] Meanwhile, a study by Jeon *et al* suggested that walking ability, muscle strength, balance and fear of falling were significantly different among the fall group, the one-time fall group and the non-fall group.[58] The aforementioned studies were consistent with the current study, which found that muscle strength and postural ability were significantly different between the faller and non-faller groups (table 1). Moreover, it was found that the results of the WTT were statistically and significantly different between these groups, which may indicate the utility of the WTT in classifying populations with different physical abilities. However, based on the baseline characteristics of the participants in the current study, the mean age of participants was 69–70 years, which is considered 'younger' older adults. Some studies reported an average age of more than 75 years.[57 58] The literature review reported that muscle strength decreases are likely to average 3.4% annually after the age of 75 years. Therefore, the utility of the WTT test may be further confirmed by its applicability in well-functioning younger-older populations. In addition, no difference was observed between the faller and non-faller groups for Short FES-I outcomes, likely because a fundamental characteristic among most of the participants was that they were farmers, gardeners and people accustomed to working in the fields or communities, meaning they did various activities consistently, which may have given them the confidence to do various activities.

The relationship between physical ability and fall risk in older adults is complex, with key factors involving both physical performance and activity levels. Individuals with low physical performance and low activity levels, such as those with slow walking speeds, difficulty standing and reduced muscle strength, are at the highest risk for falls. However, even those with high activity levels but poor physical performance are at elevated risk due to their

Table 3 The comparison of the discriminative ability of the WTT and standard measures to determine falls in older individuals

Measures	Cut-off score	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Correctly classify (%)	AUC (95%CI)
WTT (s)	≥6.40	92.50	78.26	78.72	92.86	83.72	0.883 (0.811 to 0.955)
HG_{max} (kg)	<18	70.00	67.39	71.05	72.09	68.60	0.749 (0.642 to 0.856)
FTSTS (s)	≥12.05	72.5	76.09	75.86	68.42	74.42	0.741 (0.632 to 0.850)
TUG (s)	≥12.00 s	80.00	82.61	78.38	77.55	77.91	0.861 (0.782 to 0.940)
Short FES-I (score)	≥19	72.50	50.00	59.38	61.11	60.47	0.619 (0.498 to 0.739)

AUC, area under the curve; FTSTS, five times sit-to-stand test; HG_{max}, maximum hand grip test; NPV, negative predictive value; PPV, positive predictive value; Short FES-I, Short Falls Efficacy Scale International; TUG, time up and go test; WTT, the walking and turning test.

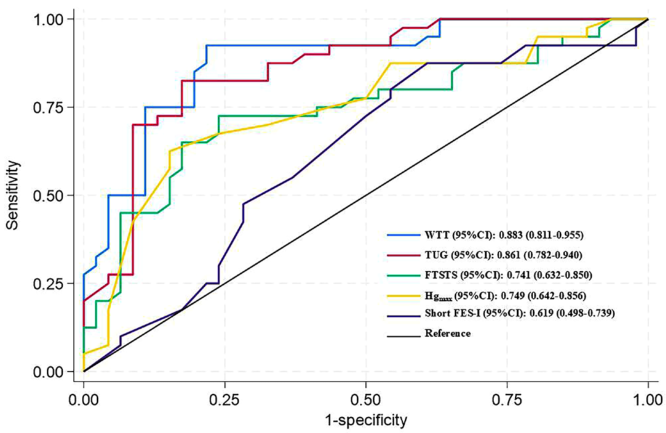

Figure 2 Area under the receiving operator characteristics curve of the WTT and standard measures. FTSTS, five times sit-to-stand test; HG_{max}, maximum hand grip test; Short FES-I, Short Falls Efficacy Scale International; TUG, time up and go test; WTT, walking and turning test.

engagement in more hazardous activities. Conversely, individuals with high physical performance, though generally at lower risk, still experience falls, particularly if they are highly active and engage in more physically demanding tasks.[59] Previous studies reported on the relationship between fall-related variables and physical ability measures.[10 51] One study reported that both dynamic and static balance tests had a significant correlation with fall history.[10] The results demonstrated a significant correlation between the FTSTS, TUG, TTSW, FRT and SLS ($p<0.05$). Moreover, the dynamic balance test, TUG, also found a high correlation with FTSTS (0.778, $p<0.001$).[9] Orwoll *et al* explored the relationship between physical performance and activity levels in predicting fall risk among older men. Their results indicated that individuals with both low physical performance and activity levels had the highest risk of falling. However, even men with high activity levels but good physical performance were still at risk, likely due to increased exposure to physically demanding activities.[59] The results of previous studies were in line with the current study, which found a statistically significant relationship between fall variables and various physical ability measures. This statistically significant relationship between the WTT and fall-related variables in the current study may indicate that the WTT can be used to assess the physical abilities of community-dwelling older people.

The discriminative ability of the WTT was developed by the ROC curves to explore an optimal cut-off score, sensitivity, specificity and AUC for the WTT to indicate fall risk. The ROC curve is a graphical approach that is generated by plotting sensitivity values on the y-axis and 1-specificity values on the x-axis of all possible cut-off scores for the tests using data from all subjects.[54 60] Sensitivity is a true positive rate or the probability of a positive result in subjects with the condition (fallers). On the contrary, specificity is a true negative rate or the probability of a negative result in subjects without the condition (non-fallers). A test that thoroughly discriminates between older participants who fall and those who do not fall would yield a curve that coincides with the left and top sides of the plot. In addition, an ideal test would have an AUC of 1.0, while a completely ineffective test would have an AUC of 0.5, indicating the poor diagnostic performance of the test.[54 61] The current study provided the possibility of cut-off scores for the WTT to determine fall risk among community-dwelling older individuals. From the six cut-off scores that were presented, it was found that a cut-off value of 6.40 s was the time with the best sensitivity, specificity and variables associated with discriminative ability. That is because this study is the first to develop walking and turning methods as physical ability tools to determine falls in older individuals. Accordingly, there are no other studies that discuss the results. However, the literature review revealed that some studies explored the association between the quality of turning during daily activities with falls and/or cognitive function in older individuals. The findings demonstrated that the quality of turning was associated with visuospatial, memory functions and the Tinetti Balance Scores.[16]

Based on the specific characteristics of the tests that require turning, several studies have proposed tests that involve half turns and full turns, such as TUG,[21] performance-oriented assessment of mobility[20] or the Berg Balance Scale.[22] Although turns are reported to account for up to half of daily walking, the tasks required to perform half and full turns are relatively less frequent than 90-degree turns and left or right turns. Moreover, turning 90 degrees at the fastest walking speed may be an indicator of increased fall risk in older adults.[62] This is consistent with the current study, which found that the 90-degree turn gait, performed at the fastest possible pace, was able to differentiate between community-dwelling older adults who had experienced falls and those who had not and was also associated with functional outcomes (table 2). Thus, it may indicate that the 90-degree turn gait is important for daily mobility.

The study has some limitations. First, the retrospective study used 6 months of fall data in older participants, meaning it may not be representative of the ability to identify future fall risk. Therefore, further studies should potentially follow falls in a straightforward manner to reduce overlooking problems and accurately identify the risk of future falls. Moreover, additional studies on the reliability and validity of the WTT may be required in order for it to be used correctly and reliably in clinical- or community-based settings. In addition, most of the participants in this study were young (56.98%) and middle-aged (38.37%). Therefore, there may be limitations in applying this result to the oldest group. Further studies should investigate the oldest group to obtain a more appropriate cut-off score and the resulting proportion correctly classified. Second, current studies report that the WTT is a valuable tool for identifying fall risk in community-dwelling older individuals, similar to the TUG, with particular emphasis on its ease of administration and high sensitivity and specificity. However, since no direct comparative data with the TUG has been presented, further comparative studies are needed to determine whether the WTT is indeed superior. These studies should specifically focus on key aspects such as community application, measurement time, complexity and personnel requirements for specific assessments.

CONCLUSIONS

This study suggests the clinical usefulness of the WTT in determining the risk of falls among community-dwelling older individuals. The WTT is a physical ability measurement that can determine balance ability and muscle strength. The testing protocol is reasonably practical, requires little space and equipment and can be used for large communities or populations. The study results suggest that a WTT cut-off time of 6.40s can effectively indicate a fall in community-dwelling older adults.

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Patient consent for publication Consent obtained directly from patient(s).

Ethics approval This study involves human participants. The protocols of this study was approved by the Institutional Ethics Committee for Human Research (Ethics Committee reference number: HREC-UP-HSST 1.2/020/67). Participants gave informed consent to participate in the study before taking part.

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