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Original Article

The Application of 'Timed up and Go' Test in Fall Screening of Elderly People in Shanghai: A Cross-Sectional Study

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Abstract

Background: We aimed to evaluate the predictive value of the 'Timed Up and Go' test (TUGT) for identifying fall risk in community-dwelling elderly.

Methods: From Aug 2016 to Feb 2017, cluster sampling was conducted among residents aged over 60 from 15 communities in Songjiang district, Shanghai. Face-to-face questionnaire interviews and TUGT measures were conducted to collect data.

Results: 6,014 participants were enrolled, with an average age 72.7±7.0 years. 637 (10.6%) elderly people had a fall experience in the past year. TUGT for the non-fall group, one-fall group and recurrent-fall group was 9.02±4.39, 10.00±5.26 and 10.78±4.51 seconds respectively (P<0.001). ROC analysis showed that the TUGT cut-off point for the elderly was 12.5 seconds and AUC was 0.573 for any-fall group and 0.613 for recurrent-fall group respectively. After adjusting for age and gender, the predictive value was not high for any-fall group (AUC=0.614) and recurrent-fall group (AUC=0.648). The TUGT cut-off point for the elderly aged below 65, 65-74, 75-84 and 85 and above was 13.52s, 12.51s, 12.51s, 12.00s, respectively. After adjustment of the confounding factors, the OR values for the risk of fall for the elderly men and women who completed TUGT longer than the cut-off point was 2.404 and 2.075 times higher than those who completed TUGT shorter than the cut-off point, respectively.

Conclusion: TUGT with the cut-off score of 12.5s has limited capability in predicting fall risk in community-dwelling elderly.

Keywords: Elderly; Fall risk; Timed up; Screening; Receiver operating

Introduction

A fall is defined as an event that results in a person inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest in furniture, wall or other objects (1). Falls are a leading cause of morbidity and mortality in elderly people and are associated with various negative health outcomes. The direct and indirect individual, household and

societal costs associated with falls are enormous. Therefore, falls in older people have been recognized as a major public health problem (2).

In China, falling is the number one cause of death from injury for people over 65 (3). At least 20 million elderly people fall a collective number of 25 million times every year in China, which directly results in more than 5 billion yuan in medical expenses (4). Shanghai is one of the first cities in China to enter an aging society. In 2013, the burden coefficient of the population of the elderly over 60 in Shanghai reached nearly 30%, and the health of the elderly has become an important issue in the social development of Shanghai (5). As the incidence of falls among older adults is high and the consequences are severe, we must screen for elderly individuals who are prone to falls and who may benefit from interventions designed to prevent falls. Such fall-risk screening requires the use of test tools that are as simple and clinically reliable as possible.

The Timed "Up-and-Go" Test (TUGT) is a simple, comprehensive measure to assess functional mobility (6). It was originally developed based on the "get-up and go test" (7). TUGT had high reliability and validity, with both retest reliability and inter-evaluator reliability of 0.99 (8). It is one of the fall screening tools identified in foreign clinical guidelines as an appropriate screening tool and is widely used to assess the risk of falls in the elderly (2,9,10). This simple test does not require special equipment, is sensitive and specific to screening for falls, and is suitable for primary care (11). However, the optimal cut-off point to identify those with higher risk for future falls for Chinese elderly has not been identified.

The purpose of this study was to explore the cut-off point of TUGT for predicting the fall risk of the elderly in community in China, to provide reference for screening the risk of fall and taking targeted intervention measures.

Methods

Cluster sampling was carried out among permanent residents, aged over 60 yr, from 15 communities in Songjiang District. Suppose the incidence of falls in the elderly is 10% in the past year, according to the formula

$$n = t^2 \frac{pq}{d^2} = 1.96^2 \times \frac{0.1 \times 0.9}{0.05^2} = 140$$

the number of our study participants N=diff*n*districts and counties=3*140*15=6300.

The inclusion criteria were that the subjects had to be aged 60 yr or older, with normal cognitive functioning, able to follow the instructions, without severe physical disabilities or diseases, and able to walk without the assistance of another person.

All the participants were informed of the content and process of the test. The exclusion criteria were that the subjects had severe physical disabilities that prevented them from standing up, walking, or any elderly subject who could not respond to verbal instruction or cooperate on research.

Face-to-face questionnaire interviews were used to collect data. The questionnaire collected information on demographics, sociological characteristics and fall-related information. The interview was carried out in 15 community healthcare centers (CHCs). In each CHC, two General Practitioners carried out the interview and the timed "Up and Go" test (TUGT) after formal training.

TUGT measures, in seconds, the time taken by an individual to stand up from a standard armchair (approximate seat height of 46cm, arm height 65cm), walk a distance of 3 meters, turn around, walk back to the chair, and sit down. The subject wore their regular footwear. If a walking aid was usually used inside the home, then the walking aid was used during the test. Participants were asked to complete the task at a comfortable walking speed (12). During the test, the assessor walked beside the participant (without touching or supporting) to prevent falls. Either a stopwatch or a wristwatch with a second hand could be used to time the trial. Participants had one practice trial. Each individual was tested three times, and the meantime to complete TUGT was taken as the result.

Ethical approval

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted following the Declaration of Helsinki. Approval of this study was obtained from the Ethics Committee of Zhongshan Hospital, Fudan University.

Statistical analysis

Epidata 3.0.1 bilateral data entry was performed, and SPSS 17.0 (Chicago, IL, USA) was used for data analysis. Data that did not conform to normal distribution were expressed by median and quartile spacing (M, Q), while enumeration data were expressed by case number and percentage. A non-parametric test was used to analyze the demographic factors that may affect the TUG test. According to the TUGT results of the elderly and their fall experience in the past year, the receiver operating characteristic curve was drawn and analysis was performed. The highest point of the Youden index was chosen as the optimal cut-off point of TUGT for the prediction of fall risk of the elderly. The area under the curve (AUC) analyses were conducted. Logistic regression was used to analyze the predictive value of the TUGT threshold for falls and $P<0.05$ is considered statistically significant.

Results

Demographic and sociological characteristics and the incidence of falls of the participants

Cluster sampling was applied and 6,014 eligible participants were included in the study, with an average age of 72.7±7.0 yr (ranging from 60 to 101 yr) old. Residents in the age group of 65-74 yr old were the majority, accounting for 52.9%. Most of the participants were female, with 3,383 people, accounting for 56.3%. 73.6% of the participants had received primary school education or below. 637(10.6%) reported falling in the past year. Among them, 504 had fallen once in the past year, accounting for 8.4% of the participants, and 133 had fallen twice or more in the past year, accounting for 2.2% of the participants.

Time to complete TUGT of the participants

The participants' median time required to complete TUGT was 10.02 seconds with the quartile time 7.00-12.17 seconds. TUGT for the non-fall group, one-fall group and recurrent-fall group was 9.02±4.39, 10.00±5.26 and 10.78±4.51 seconds, respectively. There was statistic difference in TUGT among different fall groups ($P<0.001$) (Table 1).

Table 1: Demographic and Sociological Characteristics and Number of fall in the Last Year

Variable	*Total*	*Non-fall group*	*One-fall group*	*Recurrent-fall group*	*P value*
	n=6014	n=5377	n=504	n=133	
Gender					<0.001
Male	2631(43.7)	2426(45.1)	167(33.1)	38(28.6)	
Female	3383(56.3)	2951(54.9)	337(66.9)	95(71.4)	
Age					<0.001
<65	649(10.8)	588(10.9)	53(10.5)	8(6.0)	
65-74	3184(52.9)	2897(53.9)	223(44.2)	64(48.1)	
75-84	1749(29.1)	1537(28.6)	166(32.9)	46(34.6)	
≧85	432(7.2)	355(6.6)	62(12.3)	15(11.3)	
Living alone					
No	5632(93.6)	5045(93.8)	463(91.9)	124(93.2)	0.221
Yes	382(6.4)	332(6.2)	41(8.1)	9(6.8)	
Education level					0.001
Primary school	4428(73.6)	3920(72.9)	391(77.6)	117(88.0)	
Junior high school	1136(18.9)	1052(19.6)	72(14.3)	12(9.0)	
Senior high school/technical secondary school	329(5.5)	296(5.5)	31(6.2)	2(1.5)	
Junior college or above	121(2.0)	109(2.0)	10(2.0)	2(1.5)	
TUGT	9.14±4.48	9.02±4.39	10.00±5.26	10.78±4.51	<0.001

Diagnostic value of TUGT for any-fall and recurrent-fall group

ROC analysis was conducted according to the time used to complete TUGT of the elderly and whether they had fall experience. The results showed low predictive values for any-fall (AUC=0.573) and recurrent-fall groups (AUC=0.613). After adjusting for age and gender, the predictive value was also not high for the any-fall group (AUC=0.614) and recurrent-fall group (AUC=0.648) (Table 2).

Table 2: Diagnostic value of TUGT for any-fall and recurrent-fall group

	Any-fall group *N=637/6014*		***Recurrent-fall group*** *N=133/6014*	
	AUC[a] value	95%CI	AUC value	95%CI
TUGT				
TUGT[b]	0.573	0.547-0.600	0.613	0.560-0.666
TUGT[c]	0.614	0.590-0.637	0.648	0.605-0.692

Notes: [a] Areas under the curve (AUCs) of the receiver operating characteristic (ROC) curves for TUGT for fallers versus non-fallers and recurrent fallers versus non-fallers; [b] no adjustments; [c] adjusted for gender and age.

ROC Analysis of TUGT Cut-off point for Different Group

As shown in Table 3 and Fig. 1, the TUGT cut-off point for the elderly aged below 65, 65-74, 75-84 and 85 and above was 13.52s, 12.51s, 12.51s and 12.00s, respectively, and the AUC was 0.495(95%CI: 0.414-0.577), 0.553 (95%CI: 0.513-0.593), 0.564 (95%CI: 0.520-0.609), and 0.614 (95%CI: 0.540-0.687), respectively (Table 3) (Fig. 1).

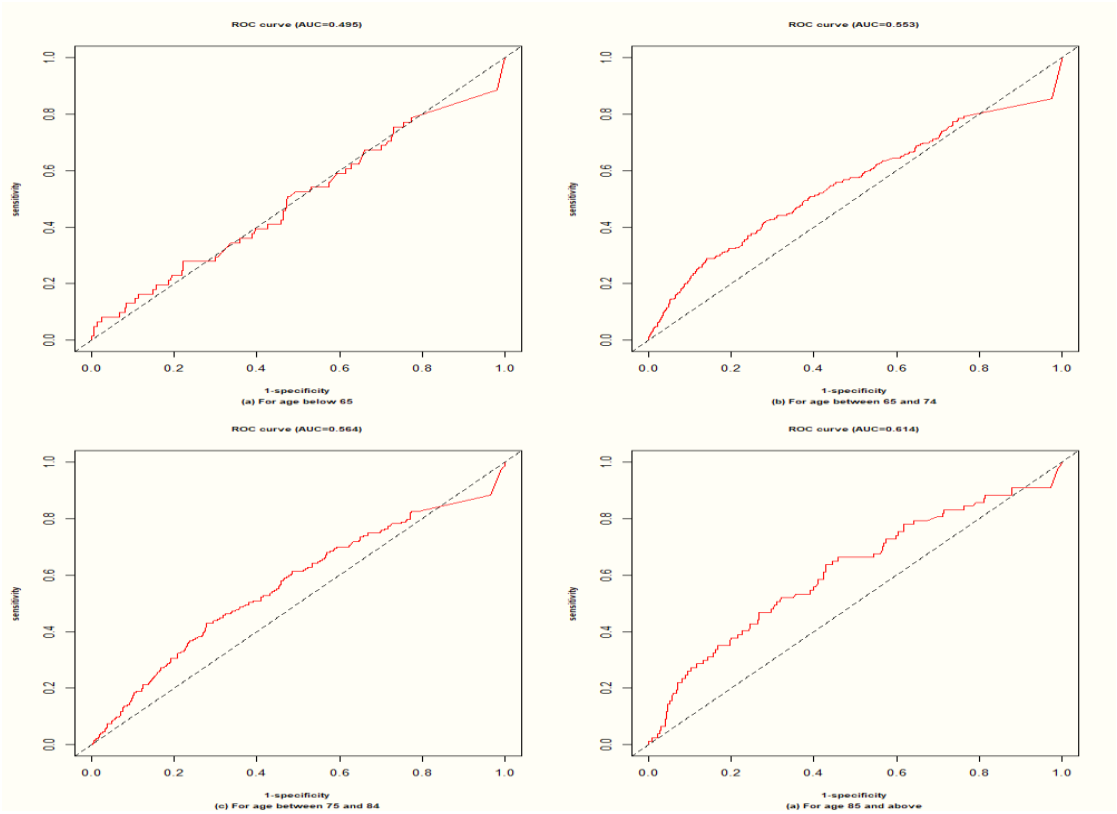

Fig. 1: The ROC Curve of TUGT for the Prediction of Fall Risk for Different Age Group
a) For age below 65; b) for age between 65 and 74; c) For age between 75 and 84 and d) for age 85 and above

Table 3: ROC Analysis of TUGT Cut-off point of Different Age Group

Age Group	***under 65***	***65-***	***75-***	***85 -***
Cut-off point	13.52	12.51	12.51	12.00
AUC [95%CI]	0.495 [0.414-0.577]	0.553 [0.513-0.593]	0.564 [0.520-0.609]	0.614 [0.540-0.687]
Sensitivity (%)	8.2	13.2	22.2	51.9
Specificity (%)	97.6	85.6	85.6	66.8
PPV (%)*	26.3	17.5	17.5	17.7
NPV (%)*	91.1	88.9	88.9	91.4
Positive likelihood ratio	3.416	2.588	1.542	1.563
Negative likelihood ratio	0.941	0.915	0.909	0.720

*PPV: positive predictive value; NPV: negative predictive value

TUGT cut-off point was 13.00 for elderly men and 12.49 for elderly women (Fig. 2). For men, the sensitivity and specificity of TUGT were 30.7% and 85.6% respectively while the positive predictive value and negative predictive value were 0.153 and 0.936 respectively (Table 4). For women, the sensitivity and specificity of TUGT were 37.3% and 79.5% respectively while the positive predictive value and the negative predictive value were 0.210 and 0.896 respectively (Table 4).

Table 4: ROC Analysis of TUGT Cut-off point of Different Gender

Gender	***Male***	***Female***	***Total***
Cut-off point	13.00	12.49	12.50
AUC (95%CI)	0.567(0.521-0.614)	0.576(0.544-0.608)	0.573(0.547-0.600)
Sensitivity (%)	30.7	37.3	36.6
Specificity (%)	85.6	79.5	79.9
PPV (%)*	15.3	21.0	17.7
NPV (%)*	93.6	89.6	91.4
Positive likelihood ratio	2.132	1.820	1.821
Negative likelihood ratio	0.810	0.789	0.793

*PPV: positive predictive value; NPV: negative predictive value

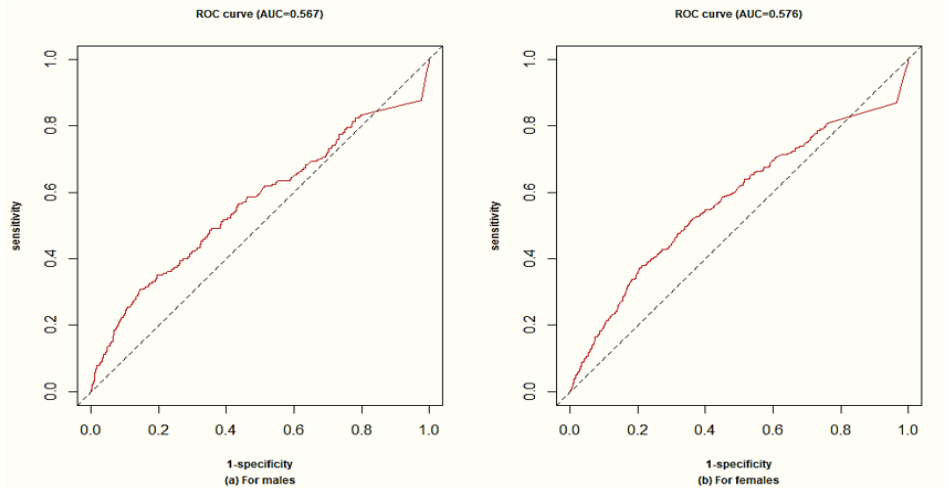

Fig. 2: The ROC Curve of TUGT for the Prediction of Fall Risk for male (left) and female (right)

Multivariate Logistic Regression Analysis of the Fall Risk for the Elderly

After the adjustment of confounding factors such as age, education level, and whether the participant lived alone, the risk of fall for the elderly men and women who used time to complete TUGT longer than the cut-off point was 2.404 (95%CI:1.723-3.355) and 2.075 (95%CI:1.652-2.607) times higher than those who used time to complete TUGT shorter than the cut-off point. The OR values for the risk of fall for the elderly aged below 65, 65-74, 75-84 and 85 and above who used time to complete TUGT longer than the cut-off point were 3.703(95%CI:1.269,10.808), 2.449 (95%CI:1.853,3.237), 1.892 (95%CI:1.404,2.550) and 2.312 (95%CI:1.373,3.892) times higher than those who used time to complete TUGT shorter than the cut-off point, respectively (Table 5).

Table 5: Multivariate Logistic Regression Analysis of the Fall Risk for the Elderly

Independent variable	***B value***	**P *value***	***OR value***	***95%CI***
Male				
constant	-2.777	<0.001	0.062	
TUGT	0.877	<0.001	2.404	1.723-3.355
Female				
constant	-2.105	<0.001	0.122	
TUGT	0.730	<0.001	2.075	1.652-2.607
Below 65				
constant	-20.957	0.998	0.000	
TUGT	1.309	0.017	3.703	1.269-10.808
65-74				
constant	-2.412	<0.001	0.090	
TUGT	0.896	<0.001	2.449	1.853-3.237
75-84				
constant	-1.636	<0.001	0.195	
TUGT	0.638	<0.001	1.892	1.404-2.550
85 and above				
constant	-2.001	<0.001	0.135	
TUGT	0.838	0.002	2.312	1.373-3.892

Discussion

Of the 6,014 eligible participants, 637 elderly people reported a fall experience in the past year, accounting for 10.6 percent of the participants. Stratified cluster sampling method was adopted to select the elderly aged 60 yr and above in an urban area of Beijing (13). Among the 1,512 elderly participants, 272 fell in the past year, with a fall incidence of 18.0%. Jiang et al. adopted stratified random sampling method to select 1,800 people aged 60 and above from 10 communities in Changning district, among which 372 had fall experience in the past year, with a fall incidence of 20.7% (14). Their results were lower than the fall incidence (33.3%) of the elderly living in the community reported in western countries (15). The fall incidence of our research was lower than that in other domestic research, which was potentially related to the size of the sample, the proportion of men and women, and the proportion of different age groups. Additionally, culture, lifestyle, daily activities, family structure and social system might be the cause of the differences

in fall incidence rate between Chinese and western people. Chinese elderly tend to stay home and are less likely to go out, camp or climb mountains, so they are less exposed to falls than western people.

TUGT for the non-fall group, one-fall group and recurrent-fall group was 10.1±2.3, 10.6±2.4 and 12.5±4.1 seconds, respectively (16). In our study, TUGT for the non-fall group, one-fall group and recurrent-fall group was 9.02±4.39, 10.00±5.26, and 10.78±4.51 seconds, respectively. Both studies demonstrated that with the increase in the number of falls for the elderly, the TUGT time was prolonged. This was consistent with foreign studies (17, 18).

In our study, the percentage of men who had a fall experience was different from that of women, and women were more likely to fall than men, which was the same as the results of other domestic studies (3,13). Sociodemographic factors, such as gender, have been reported as independent biological risk factors for falls (1).

Our study showed that the median time to complete TUGT of the participants was 10.02 sec, and the time to complete TUGT appeared to be age-dependent. Elderly individuals between 60 and 65 yr of age performed the test in 8.96 seconds, those between 65 and 75 yr of age in 9.60 seconds, those between 75 and 85 yr of age in 11.07 seconds and those above 85 yr of age in 12.70 seconds. TUGT is a comprehensive test of the ability to stand up, walk, turn, and sit down, including strength, flexibility, balance, etc. (6). Balance, including static and dynamic balance, is fundamental to the formation of normal gait. Dynamic balance ability refers to the ability to maintain and control the balance of the body's central gravity during walking. As humans age, various organs, as well as proprioception, and vestibular and visual function, decline. Simultaneously, joints and muscles decline due to diseases of the nervous system and osteoarthropathy, and dynamic balance ability declines (19). An age-related physiological decline has been associated with a decrease in TUG performance (6).

Up until now, the TUG test is still lacking a recommended international cut-off point for elderly individuals (20). We conducted ROC analysis according to the time to complete TUGT of the elderly and whether they had a fall experience. The cut-off value was 12.5 seconds. Older adults who took longer than 12.5 seconds to complete TUG could be considered to have high risk of falls. Despite the TUGT's demonstrated effectiveness for assessing risk of falls, the TUGT's predictive threshold of falls varies among studies, and data on the TUGT's cut-off point of the Chinese population are sparse (2,11,12,17,21,22). Overall, 1,072 Chinese suburb-dwelling elderly aged over 60 (average age: 67.35±5.93 yr) studied and the cut-off point of TUGT was 9.7150 seconds (23). The difference in TUGT cut-off point between Wang's and ours was caused by age. The average age of our study was 72.7±7.0 yr, much older than Wang's study.

In our study, as a fall risk-screening tool, TUG had higher specificity (79.9%) than sensitivity (36.6%), which was similar to foreign studies (24). Our AUC result (0.573) was the same as the studies home and abroad, which ranged from 0.607 to 0.72, indicating low accuracy to predict future falls (16,17,25,26). The cause of falling in elderly people is multifactorial, which could help explain the limited ability of TUGT to predict future falls. Because the TUGT only evaluates basic balance and mobility function, it does not take into account other factors that may contribute to fall risk, such as environmental or intrinsic factors. Therefore, it may not be comprehensive enough to cover all of the factors that contribute to fall risk.

After adjusting for age and gender, the predictive value of TUGT was not improved both in any-fall group (AUC: 0.573 vs. 0.614) and recurrent-fall group (AUC: 0.613 vs. 0.648), which was different from Kang's study (16). After adjusting for age and gender, the predictive value of TUGT was not high for the any-fall group (AUC=0.642), but the AUC for recurrent-fall group improved to 0.733. The reason for this

difference may be due to the different study types, as Kang's study was a prospective study and our study was a retrospective study, and the age of study subjects, as our study subjects were older than Kang's.

There are some limitations to this study. This study was a cross-sectional study. People who were not willing to participate in the research or were not able to participate because of their illnesses were not included. Therefore, this study included a selection bias for the study population, and the extrapolation of conclusions is limited to some extent. Further prospective cohort studies and clinical application research should be applied to prove the TUGT's threshold value.

Conclusion

The TUGT cut-off point for the elderly was 12.5 seconds and AUC was 0.573 (95%CI:0.547,0.600). TUGT with the cut-off point of 12.5 seconds has limited capability in predicting fall risk in community-dwelling older adults. TUGT should not be performed independently as a screening tool alone for assessing an individual's fall risk. Rather, it should be conducted in tandem with other sensitive measures to improve screening efficiency.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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