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Factors Associated with the Timed Up and Go Test Score in Elderly Women

HIROYUKI SHIMADA, PhD, MSc, PT[1)], HUNKYUNG KIM, PhD[2)], HIDEYO YOSHIDA, PhD, MD[2)], YUKO YOSHIDA, PhD[2)], KYOKO SAITO, PhD[2)], MEGUMI SUZUKAWA, MSc, PT[2,3)], HYUMA MAKIZAKO, PhD, MSc, PT[1)], TAKAO SUZUKI, PhD, MD[4)]

[1)] *Section for Health Promotion, Department of Health and Medical Care, Center for Development of Advanced Medicine for Dementia, National Center for Geriatrics and Gerontology: 35 Gengo, Morioka-machi, Obu, Aichi 474-8511, Japan. TEL: +81 562-44-5651 (ext.5254), E-mail: shimada@ncgg.go.jp*

[2)] *Research Team for Promoting Independence of the Elderly, Tokyo Metropolitan Institute of Gerontology*

[3)] *Graduate School of Human Health Sciences, Tokyo Metropolitan University*

[4)] *Research Institute, National Center for Geriatrics and Gerontology*

Abstract. [Purpose] The purpose of this study was to determine the relationship between the Timed Up and Go (TUG) test score and the physical performance of women aged 75 years and over according to orthopedic status. [Subjects] The participants were 832 elderly women (mean age, 78.6 ± 2.7 years) who carried out their daily activities independently in their own homes and did not have histories of stroke or osteoarthritis of the hip. [Methods] Maximal voluntary contractions of the knee extensor and ankle plantar flexor muscle groups were measured using a hand-held dynamometer. One-leg standing time and usual walking speed were assessed as balance and walking performances. [Results] The TUG score was more strongly correlated with walking speed (r = –0.776) than the other measures of physical performance (r = –0.228 to –0.399). Correlations between the TUG score and walking speed were strongest for participants with knee osteoarthritis (r = –0.824) and fractures after 60 years of age (r = –0.809). A linear regression model of data from all participants showed that all performance scores and age were determinants of the TUG score (R^2 = 0.634). The determinants of the TUG score for participants with osteoarthritis or fractures were walking speed and one-leg standing score, and age (R^2 = 0.701) and walking speed, age, and knee strength (R^2 = 0.688). Beta estimates of walking speed for all participants and for the subgroups were higher (–0.69 to –0.76) than those for the other determinants (–0.06 to 0.14). [Conclusion] Walking speed is a stronger determinant of the TUG score than muscle strength or balance for elderly women.

Key words: Walking, Muscle strength, Balance

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INTRODUCTION

In the elderly, an accumulation of deficits such as muscular weakness, poor balance and neuromuscular abnormalities decreases mobility and may cause falls and make performance of the activities of daily living (ADL) difficult[1–4)]. This is especially relevant for women, as they experience more falls than men[5,6)]. Falls are the main sources of hip fractures and functional decline[7–9)].

The American Geriatrics Society, British Geriatrics Society and the American Academy of

Orthopaedic Surgeons Panel On Fall Prevention recommended the Get Up and Go test for routine assessment of the risk of falling[10]. The timed version of the Get Up and Go test was modified from the original as a measure of functional mobility of elderly adults, primarily neurological patients[11]. The Timed Up and Go (TUG) test is objective, quick and easy to perform, and its reliability and validity for elderly adults has been well established[11]. Consequently, the TUG test is one of the most frequently applied balance and gait tests for assessing the risk of falls for elderly people[12].

Many researchers have used the TUG test to assess mobility[13–15] because it includes transition from a sitting to a standing stance, balance and gait. However, the TUG test does not provide information on the nature of a physical deficiency; nor is it useful for developing training regimens because it is unclear how the various elements of physical performance contribute to the TUG score. The initial publication of Podsiadlo and Richardson described a strong curvilinear relationship between the TUG score and walking speed (WS)[11]. A subsequent publication described linear relationships between walking speed and the TUG score for an elderly orthopedic rehabilitation population, the strength of which varied according to diagnosis, mobility and admission vs discharge status[16]. Although these studies described the relationship between the TUG score and walking performance, it is not clear whether physical variables such as muscle strength and balance are associated with the TUG score in elderly adults. Elucidation of these associations is important for developing interventions for elderly adults who have been identified by the TUG test as being at high risk of falls or functional decline.

The purpose of this study was to determine the associations between the TUG score and physical variables such as muscle strength, balance and walking in elderly women aged 75 years or older according to orthopedic status.

SUBJECTS AND METHODS

Subjects

Participants were selected from 1,289 women aged 75 years or older, who were living in Tokyo, Japan, and who had participated in mass health checkups for the elderly community (Otasha-Kenshin) conducted in 2008. Otasha-Kenshin, which means "health checkups for successful aging" in Japanese, is a comprehensive mass health examination for the community-dwelling elderly and its aim is to prevent geriatric syndromes. Details of Otasha-Kenshin are described in our previous reports[17,18]. All participants were ambulatory, lived independently in their homes and had sound functional capacity. Exclusion criteria were lack of measurements (n=89), dependency on others for ADL (n=54), a history of stroke (n=53), osteoarthritis of the hip joint (n=21) or the ability to perform the one-leg standing (OLS) test for 60 seconds (n=240). Participants who were able to perform the OLS test for 60 seconds were excluded because the maximum value of the OLS was set at 60 seconds to enable analysis of the OLS score as a continuous variable. The remaining 832 participants (mean age, 78.6 ± 2.7 years) were enrolled in the study. The characteristics of the subjects are presented in Table 1. Participants provided their written, informed consent regarding their participation in the study, which was approved by the Institutional Review Board and Ethics Committee of the Tokyo Metropolitan Institute of Gerontology.

Methods

The TUG test evaluates basic mobility skills: the subject rises from a chair, walks 3 m, turns, walks back and sits down on the chair again[11]. Subjects were instructed to complete the TUG and walking tests at their usual pace, e.g., if they normally used a walking aid at home, it was used during the tests.

Maximal voluntary contraction of the knee extensor (MVC-knee) and ankle plantar flexor (MVC-ankle) muscle groups in the subjects' dominant (stronger) leg were measured using a hand-held dynamometer (μ-tus, Anima, Tokyo, Japan) under isometric conditions in a seated position with the ankle, knee and hip joints at 90 degrees of flexion. The test was performed twice and the greater value was used for analysis of isometric strength. The highest torque (Nm) was calculated in the MVC-knee, although we could not determine correctly the lever arm in the MVC-ankle. Balance was assessed using the OLS test. In the OLS test, the subject was asked to stand on one leg for 60 seconds with his or her eyes open[19]. Two measurements were taken and the best result was used for analysis. Walking speed (WS) was used to

Table 1. Characteristics of subjects

	All participants (n = 832)	OA group (n = 183)	Fracture group (n = 208)
Age, yr*	78.6 (2.7)	78.7 (2.6)	78.7 (2.6)
BMI*	22.9 (3.4)	24.0 (3.0)	22.8 (3.4)
MVC-knee, Nm/kg*	1.2 (0.3)	1.1 (0.3)	1.1 (0.3)
MVC-ankle, N/kg*	10.0 (3.0)	9.6 (3.0)	10.0 (2.9)
OLS, s*	17.2 (14.7)	16.5 (15.8)	16.7 (15.0)
TUG, s*	10.3 (2.8)	11.1 (3.5)	10.6 (3.4)
WS, m/s*	1.2 (0.2)	1.2 (0.2)	1.2 (0.2)
Hearing, normal**	777 (93.4)	169 (92.3)	194 (93.3)
Vision, normal**	813 (97.7)	179 (97.8)	201 (96.6)
History of heart disease, yes**	162 (19.5)	35 (19.1)	51 (24.5)
Osteoarthritis of the knee , yes**	183 (22.0)	183 (100)	47 (22.6)
History of fracture after 60 yr, yes**	208 (25.0)	47 (25.7)	208 (100)
History of falls, yes**	162 (19.5)	35 (19.1)	54 (26.0)
Fear of falling, yes**	623 (74.9)	150 (82.0)	175 (84.1)
Use of walking aid, yes**	84 (10.1)	41 (22.4)	32 (15.4)
Frequency of going outdoors**			
Everyday	650 (78.1)	131 (71.6)	161 (77.4)
1 per 2 to 3 days	163 (19.6)	46 (25.1)	44 (21.2)
1 per week	18 (2.2)	6 (3.3)	3 (1.4)
<1per week	1 (0.1)	0 (0)	0 (0)
Frequency of exercise**			
Everyday	346 (41.6)	90 (49.2)	94 (45.2)
5 to 6 per week	28 (3.4)	7 (3.8)	9 (4.3)
2 to 4 per week	101 (12.1)	27 (14.8)	25 (12.0)
≤1 per week	64 (7.7)	5 (2.7)	11 (5.3)
None	293 (35.2)	54 (29.5)	69 (33.2)
Regular sports, yes**	257 (30.9)	48 (26.2)	62 (29.8)

Represented data indicate *mean (standard deviation) and ** number (percent).
BMI; body mass index, MVC-knee; maximum voluntary contraction of the knee extensors, MVC-ankle; maximum voluntary contraction of the plantar flexors, OLS; one-leg standing, TUG; Timed Up & Go.

assess walking performance[19]. Two markers indicated the start and end of the 5 m path. A 3 m approach path before the start marker was used to enable the subjects to reach their usual walking pace before the start of the timed path. The subjects were instructed to walk for 3 m beyond the end of the path to ensure that their walking pace was consistent throughout the measurement path.

Interviews were conducted to assess age, chronic disease conditions, general health and physical activity. Body mass index was calculated as weight (kg) / height^2 (m).

Data were analyzed using SPSS software (Version 17; SPSS Inc., Chicago, IL). Variables with right-skewed distributions were log-transformed for all analyses. Relationships between TUG score and physical performance variables were examined using Pearson's correlation coefficient. Stepwise linear regression analysis was used to construct a physical performance model for predicting the TUG score. The independent variables included age, BMI, MVC-knee, MVC-ankle, OLS score and WS. The variance inflation factor (VIF) was used to assess multicollinearity among the independent variables in the regression model. Subgroup analysis was conducted for subjects with osteoarthritis of the knee (OA group) and a history of fracture after 60 years of age (Fracture group). Student's t test was used to compare means between the OA and Fracture groups. The alpha level for significance was set at <0.05.

Table 2. Correlation coefficients between the TUG score and physical and demographic variables (n=832)

	Age	BMI	MVC-ankle	MVC-knee	OLS	WS
TUG	.296*	.018	−.228*	−.399*	−.316*	−.776*
Age		−.093*	−.064	−.121*	−.203*	−.252*
BMI			−.353*	−.278*	−.114*	−.003
MVC-ankle				.408*	.164*	.191*
MVC-knee					.212*	.349*
OLS						.305*

*p<0.01
TUG; Timed Up & Go, BMI; body mass index, MVC-knee; maximum voluntary contraction of the knee extensors, MVC-ankle; maximum voluntary contraction of the plantar flexors, OLS; one-leg standing, WS; walking speed.

Table 3. Correlation coefficients between the TUG score and physical and demographic variables in the elderly with osteoarthritis of the knee (n=188) or a history of fracture (n=208)

		Age	BMI	MVC-ankle	MVC-knee	OLS	WS
TUG	OA group	.317**	.002	−.215**	−.330**	−.378**	−.824**
	Fracture group	.310**	−.027	−.238**	−.394**	−.343**	−.809**
Age	OA group		−.113	−.035	−.198**	−.208**	−.267**
	Fracture group		−.119	−.051	−.070	−.160*	−.226**
BMI	OA group			−.335**	−.330**	−.153*	−.001
	Fracture group			−.312**	−.176*	−.083	.040
MVC-ankle	OA group				.401**	.116	.166*
	Fracture group				.379**	.109	.242**
MVC-knee	OA group					.152*	.294**
	Fracture group					.253**	.336**
OLS	OA group						.319**
	Fracture group						.326**

**p<0.01, *p<0.05
TUG; Timed Up & Go, BMI; body mass index, MVC-knee; maximum voluntary contraction of the knee extensors, MVC-ankle; maximum voluntary contraction of the plantar flexors, OLS; one-leg standing, WS; walking speed.

RESULTS

When data for all the participants were analyzed, TUG scores had slight to moderate correlations with age, MVC-knee, MVC-ankle, OLS score and WS (Table 2). The correlation between the TUG score and WS (r = –0.776) was stronger than that between the TUG score and other physical variables (r = –0.228 to –0.399). All physical performance variables were significantly correlated. Age was correlated with all physical variables except MVC-ankle. BMI was not significantly correlated with the TUG score or WS but was significantly correlated with age, MVC-ankle, MVC-knee and the OLS score. These correlations were stronger for the OA and Fracture groups than for the total study population (Table 3). The strongest correlations were between the TUG score and WS in the OA (r = –0.824) and Fracture (r = –0.809) groups. There were no significant correlations between age and BMI and between age and MVC-ankle in either group or between age and MVC-knee in the Fracture group. BMI was not correlated with WS in either group even though BMI was significantly correlated with the TUG score in both groups.

In the multivariate model, WS, MVC-knee, age, and the OLS score were significant determinants of the TUG score when data from all participants were analyzed (R^2 = 0.634). The TUG score determinants in the OA and Fracture groups were WS, OLS, and age (R^2 = 0.701) and the WS, age, and MVC-knee (R^2 = 0.688) (Table 4). Beta estimates of WS for all participants and for the OA and Fracture groups (–0.69 to –0.76) were higher

Table 4. Determinants of the TUG score for all participants, the OA group and the Fracture group

	β estimates (95% CI)
All participants (n = 832), R^2 = 0.63	
WS	–0.69 (–0.90 to –0.79)**
MVC-knee	–0.13 (–0.15 to –0.08)**
Age	0.09 (0.36 to 0.97)**
OLS	–0.06 (–0.03 to 0)**
OA group (n = 183), R^2 = 0.70	
WS	–0.76 (–1.05 to –0.83)**
OLS	–0.12 (–0.05 to –0.01)**
Age	0.09 (0.05 to 1.48)*
Fracture group (n = 208), R^2 = 0.69	
WS	–0.73 (–1.01 to –0.80)**
Age	0.14 (0.47 to 1.80)**
MVC–knee	–0.14 (–0.23 to –0.06)**

* p<0.05, ** p<0.01
MVC-knee; maximum voluntary contraction of the knee extensors, OLS; one-leg standing, WS; walking speed.

than those for the other determinants (–0.06 to 0.14). The VIF values among the determinants were low in all three regression models (1.05 to 1.26). Therefore, there was little multicollinearity among the independent variables in the model.

In the subgroup analysis, the OA group had lower scores for the TUG (p<0.01), WS (p=0.01) and MVC-knee (p=0.01) tests, and a higher BMI (p<0.01) than subjects without OA. The Fracture group had a lower WS (p<0.05) than subjects who did not have fractures after 60 years of age.

DISCUSSION

Adequate mobility is necessary for daily living activities. This study examined the relationships between mobility, assessed using the TUG test, and muscle strength, balance and walking performance in elderly women. The TUG score was significantly correlated with scores for MVC-knee, MVC-ankle, OLS and WS when data for all participants, the OA group or the Fracture group were analyzed. However, all correlations except those between the TUG score and WS were weak. Linear regression models revealed that WS had the highest beta value when data from all participants or the orthopedic subgroups were analyzed. These results indicate that the TUG score is affected to a greater extent by walking performance than by lower-extremity muscle strength or balance. This is not surprising because the TUG test includes a walking task. These results suggest that improvement of walking performance is indicated for those who are identified by the TUG test as being at high risk for falls. This is in agreement with the results of our previous analysis in which a structural equation model revealed that impaired muscle function decreases walking performance, which is associated with falls in elderly people. Because most falls occur during walking, a task-specific intervention, i.e., walking training, may prevent falls in the elderly[20].

Correlations and beta estimates for WS were higher for the orthopedic subgroups than those for all participants. The relationship between the TUG score and WS is weak during the acute phase after an orthopedic operation such as a total hip or knee replacement[16]. However, in our study, this relationship was strong in subjects with chronic OA or a history of fracture. The OA and Fracture groups had a lower WS than subjects who did not have OA or a history of fracture after 60 years of age. A slow WS was associated with a longer walking time during the TUG test. Therefore, walking performance was more strongly correlated with the TUG score than muscle strength or balance in the orthopedic subgroups.

As the participants in this study were relatively healthy elderly people, these findings should not be extended to frail elderly people. For example, the mean TUG score in our study was 10.3 seconds, which is faster than the previously reported cutoff point for determining the risk of falls[21,22]. Secondly, although we measured some components of lower-extremity physical performance, we did not measure dynamic balance or components of the walking index such as stride length, cadence or walking variability. These measures may be correlated with TUG score.

In conclusion, WS is a stronger determinant of TUG score than muscle strength or balance in elderly women even though the TUG test includes components of muscle strength and balance.

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