BALTIC JOURNAL OF HEALTH AND PHYSICAL ACTIVITY
© Gdansk University of Physical Education and Sport in Gdansk, Volume 4, No 3, 2012, 147-154

ORIGINAL ARTICLE

DOI: 10.2478/v10131-012-0015-y

Proposal to Use an Obstructed Timed "Up & Go" Test to Assess the Risk of Falling in Healthy Elderly Individuals

Masanobu Uchiyama[1 (A, B, C, D, E, F, G)], **Shinichi Demura**[2 (A, D, E, G)]

[1] Research and Education Center for Comprehensive Science, Akita Prefectural University, Japan
[2] Graduate School of Natural Science and Technology, Kanazawa University, Japan

Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

Key words: *physical examination, accidental falls, gait, postural control, obstacle crossing*

Abstract

Background: *Obstacles are a common cause of falls. Mobility tests for healthy elderly that involve maneuvering over an obstacle have not been fully developed. We have shown that a small box placed on the walkway of a representative mobility test, the Timed Up & Go (TUG) for the frail elderly, influences the test performances of the healthy female elderly. However, the validity of this obstructed TUG (OTUG) as a fall risk assessment tool has not yet been clarified. This study examined the relationship between the OTUG and the fall risk for the healthy elderly.*

Material/Methods: *66 healthy community-dwelling elderly and 19 healthy elderly persons living in a nursing home participated in the study. In the TUG, participants stood up from a chair, walked 3 m, turned around, walked back to the chair and sat down. In the OTUG, a box (height 5 cm, depth 10 cm) was placed at the midpoint of the walkway. Participants were instructed to step over it safely. Times required to perform the respective test were recorded. Fall risk scores, the required times (s) for the TUG and OTUG and difference ratios (OTUG/TUG x 100) (%) were analyzed.*

Results: *Correlations between fall risk and other mobility performances were all significant. However, the correlation between fall risk and the OTUG ($r = 0.60$) was significantly higher than that between fall risk and the TUG ($r=0.49$) ($t=3.733$, $p<0.001$).*

Conclusions: *Compared to the TUG, the OTUG is more valid for assessing the fall risk of community-dwelling healthy elderly.*

Word count: 3,043
Tables: 1
Figures: 5
References: 23

Received: June 2012
Accepted: September 2012
Published: October 2012

Corresponding author:
Masanobu Uchiyama
Research and Education Center for Comprehensive Science, Akita Prefectural University
Kaidobata-Nishi, Shimoshinjo-Nakano, Akita, 010-0195, Japan
E-mail: masanobu.uchiyama@gmail.com
Phone: +81-18-872-1602 Fax: +81-18-872-1672

Introduction

In daily life, basic movements that require a shift in the center of gravity, such as walking, standing up, sitting down and turning, are frequently used. Physical mobility supporting these various basic movements declines with age even in healthy elderly individuals [1]. Further, the decline in mobility induces fall accidents and restricts activities of daily-life (ADL) and the quality of life (QOL). Therefore, it is important to objectively assess the functional mobility of the healthy elderly [2].

The timed Up & Go (TUG) test developed by Podsiadlo and Richardson [3] is a representative mobility assessment test. The TUG test assesses the mobility of the frail elderly by focusing on basic mobility skills (walking, sit-to-stand, etc.) in daily life. This test can be completed with some simple tools in about 30 seconds and has high reliability. Thus, this test has been used in many previous studies. However, the TUG test is frequently used as an index for assessing dynamic balance in patients with orthopedic disorders, visceral disorders, or disorders of the central nervous system such as post-stroke hemiplegia, Parkinson's disease, knee osteoarthritis, and acute lymphatic leukemia [4]. In short, it is fairly easy for the healthy elderly to perform the TUG test, and thus their individual differences in the TUG performances may not be detected. To assess physical mobility of the healthy elderly, it may be necessary to increase the difficulty level of the TUG test.

Pavol et al. [5] reported that 53% of falls are due to tripping (false step). So, one of the main causes of falls in the elderly includes tripping. Furthermore, falls by tripping often result in serious injuries [6-8]. Tests of physical mobility for fall prevention on the basis of tripping, which involves maneuvering over an obstacle, have not been sufficiently developed. We revealed in our previous study [10] that a small box 5 cm in height, i.e. an obstacle, placed on the walkway of the TUG for the frail elderly, significantly influences the mobility performances of healthy female elderly individuals. However, the validity of the obstructed TUG (OTUG) as a fall risk assessment tool has not been sufficiently clarified. Recently, it was revealed that balance assessment using multiple tasks is more sensitive as an index of balance disorder or fall risk [11-14]. By adding a task of stepping over an obstacle as a secondary task during level walking in the TUG test, it may become possible to increase the difficulty level of the TUG test and to better assess the mobility level of the healthy elderly.

This study examined the validity of the OTUG as a fall risk assessment tool for the healthy elderly's fall prevention by testing the relationship between scores of the OTUG and the fall risk chart using healthy elderly with a wide variety of physical fitness levels.

Material and Methods

Participants

Seventy-one independent community-dwelling healthy male and female elderly (age: mean = 68.6 yrs, SD = 5.8; height: mean = 153.9 cm, SD = 7.5; weight: mean = 56.9 kg, SD = 8.9) and 22 healthy male and female elderly residents of a nursing home for the elderly (age: mean = 73.9 yrs, SD = 6.2; height: mean = 150.6 cm, SD = 9.8; weight: mean = 54.1 kg, SD = 8.0) volunteered to participate in this study. All participants could walk autonomously and there was no person with a markedly inferior ability with respect to the activities of daily living (ADL). A fall risk questionnaire survey was carried out for all the participants. If there was at least one "no" response item, the participant was excluded. Valid responses were obtained from 66 community-dwelling elderly and 19 elderly residents. The participants' characteristics are shown in Table 1. We used the Fall Assessment Chart of Suzuki [15], which consists of 15 items relating to internal and external factors (Appendix). Each item was assessed on a dichotomous scale. Fall risk is considered to be high when a total score of 5 or higher is obtained [16, 17]. Because no sex difference was found in the TUG test score of our pilot study, pooled data of both sexes was used for further analysis. This experimental protocol was approved by the ethics committee (Kanazawa University Health & Science Ethics committee). Prior to the measurements, the purpose and procedures of this study were explained in detail to all participants.

Procedure

First, characteristics (sex, age, physiques and ADL ability) and fall risk of participants were measured. Then, the Timed Up & Go (TUG) test proposed by Podsiadlo and Richardson [3] and the obstructed TUG (OTUG) were conducted. The TUG can totally assess mobility, muscle strength and coordination of the lower limbs and trunk, balance, etc., which are necessary to achieve basic movements in daily life. The TUG was conducted in the manner indicated by Podsiadlo and Richardson [3]. In the OTUG, a box (5 cm in height; 10 cm in depth; 100 cm in width) was set on a 3 m walkway of the TUG (described later). The obstacle height was determined as 5 cm by referencing previous reports [8-10]. If the height of an obstacle is 5 cm or higher, the obstacle has a significant influence on the TUG time scores of both healthy young and healthy elderly adults [9, 10]. Each participant' trial order for both tests was randomly assigned using a table of random numbers. In addition, ADL ability was assessed by the ADL test for the elderly approved by the Ministry of Education, Culture, Sports, Science and Technology of Japan. The ADL test consisted of 12 items representing ADL ability domains of walking ability, changing and holding posture, balance, muscular strength and dexterity (manual activity). In addition, we also used the fall risk assessment chart [15]. The assessment chart is composed of 15 items with each item assessed using a dichotomous scale (yes or no).

1. Timed "Up & Go" (TUG) and Obstructed TUG (OTUG)

In the TUG, the participants were instructed to sit, stand up from a standard 46 cm high chair at the tester's start signal, walk 3 meters, turn the body 180 degrees, walk back to the chair, and sit down. In the OTUG, an obstacle (5 cm in height, 10 cm in depth) was placed on the midpoint of a 3 m walkway (1.5 m from the start line) and participants were instructed to safely step over the obstacle (Fig. 1). The color of the obstacle was in high contrast (off-white) to the floor (dark brown) to ensure visibility. Each participant was instructed to perform the required motions at a comfortable and safe pace [3]. Using a stopwatch, a tester recorded the time (s) elapsed from the starting signal "Up" to when subjects sat down again. Arnadottir and Mercer [18] reported that the TUG test score (time required to accomplish the TUG) differed depending on the participants' footwear. Therefore, in this study, all participants performed the TUG and the OTUG with bare feet. To make each participant walk naturally in each test, one familiarization trial for each test condition was conducted. Actual measurements were conducted twice in each test with a 1-minute rest in between trials. A mean value of two trials was used for further statistical analysis. Further, the percentage of time required in the TUG by time required in the OTUG was calculated as a difference ratio (OTUG (s)/TUG (s) x 100) (%).

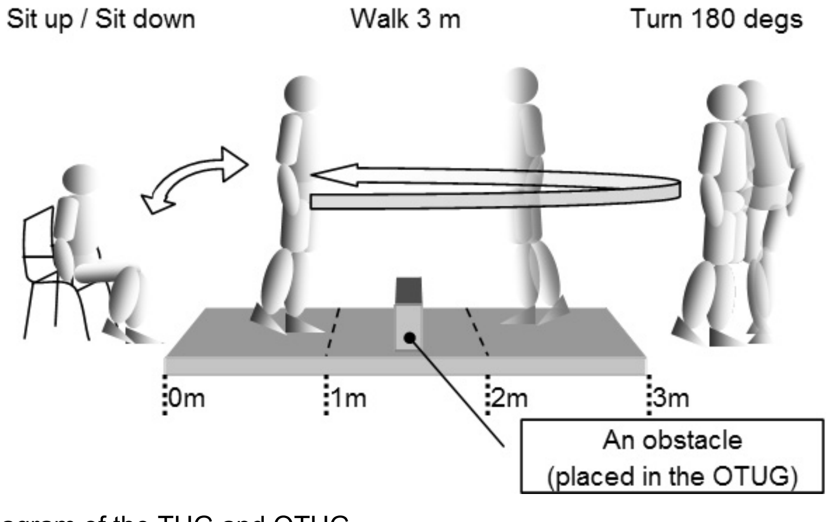

Fig. 1. Schematic diagram of the TUG and OTUG

Movement order is as follows; 1. Stand up from the chair, 2. Walk (and step over an obstacle in the OTUG), 3. Turn 180 degrees in either direction, 4. Return to the chair and sit down again.

Statistical analysis

The test-retest reliability of the TUG and the OTUG was examined by an intra-class correlation coefficient [ICC (1.1)]. To clarify the participants' characteristics (basic attribute and ADL ability) and fall risk in each age level, one-way analysis of variance (ANOVA) was used. Tukey's honestly significant difference (HSD) test was used for a multiple comparison test if the one-way ANOVA showed a significant main effect.

The relationship between the fall risk score and mobility test performances, i.e. times required to complete the TUG and the OTUG, and the difference ratio between the TUG and the OTUG, was examined by the Pearson's product-moment correlation coefficients. Further, the differences among each correlation coefficient (coefficients between fall risk and the TUG, between fall risk and the OTUG, and between fall risk and the difference ratio) were examined. A significance level was set at 0.05 in this study.

Results

The reliability of the TUG and OTUG scores was very high (ICC = 0.97, 0.95, respectively). The power analysis (post-hoc) showed sufficient power (1 – β = 0.81) under two tails of the probability density curve (α = 0.05, effect size = 0.3 (middle), sample size = 85). Table 1 shows the participants' characteristics. Significant mean differences between age groups were found in parameters other than weight. Height tended to show gradually lower values with age levels. Groups in their late 70s and 80s, i.e. the latter-stage elderly, compared to the early 60s group were significantly lower in the ADL score and higher in the fall risk. Moreover, 14 of 85 subjects (16.5%) were judged to have high fall risks by the Fall Assessment Chart of Suzuki [15], because their total score was over five points (Fig. 2). The breakdown of high risk subjects by age groups is: 0% of the early 60s age group (0/22 subjects), 7.7% of the late 60s age group (1/13 subjects), 18.8% of the early 70s age group (6/32 subjects), 28.6% of the late 70s age group (4/14 subjects) and 75% of the80s age group (3/4 subjects).

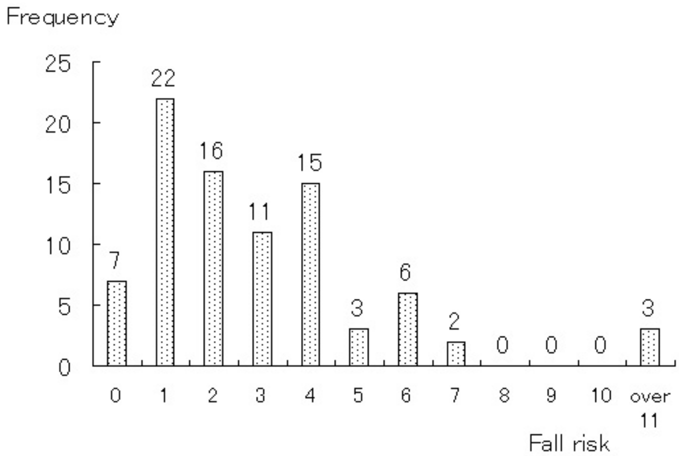

Fig. 2. The frequency distribution of the total fall risk score (n = 85)

The correlation coefficients among the fall risk and 3 parameters for mobility performance (times required in the TUG and the OTUG, and the difference ratio between both tests) were all significant (r = 0.49, 0.60, 0.46, respectively) (Figs. 3, 4, and 5). Correlation coefficients between fall risk scores and the OTUG (r = 0.6) were significantly higher than those between fall risk scores and the TUG (r=0.49) (t=3.733, p<0.001). No significant difference was found between the other pairs of correlation coefficients.

Tab. 1. Participants' chracteristics

	Early 60s (n = 26)		Late 60s (n = 13)		Early 70s (n = 33)		Late 70s (n = 15)		80s (n = 6)		Two-way ANOVA			Post-hoc (HSD)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F-value	p-value		
Age [yrs]	61.88	1.76	67.46	1.15	71.61	1.41	77.00	1.37	82.17	2.11	357.65	< 0.001	*	E60s < L60s < E70s < L70s < 80s
Height [cm]	158.42	6.55	151.06	7.86	153.54	7.85	153.82	7.28	142.00	6.18	7.69	< 0.001	*	E60s < L60s, 80s; E70s, L70s < 80s
Weight [kg]	58.45	7.40	54.34	8.67	56.73	8.80	55.53	9.87	49.30	7.40	1.06	0.382		
ADL ability [points]	30.62	2.95	26.92	4.43	27.77	5.19	25.50	5.46	29.00	1.63	2.87	0.028	*	E60s < L70s
Fall risk [points]	1.50	1.27	2.77	1.42	2.94	1.85	3.50	3.16	6.00	3.61	4.69	0.002	*	E60s < 80s

** p < 0.05; E60s: early 60s; L60s: Late 60s; E70s: early 70s; L70s: late 70s*

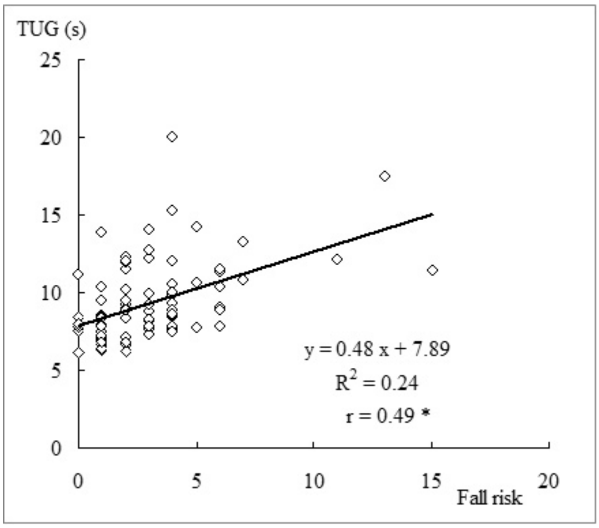

Fig. 3. The relationship between TUG and fall risk

*Lateral axis: fall risk (points); Vertical axis: TUG (s); * p < 0.05*

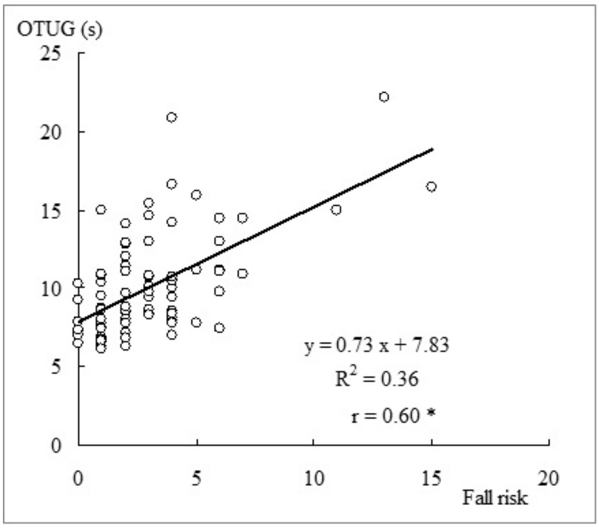

Fig. 4. The relationship between OTUG and fall risk

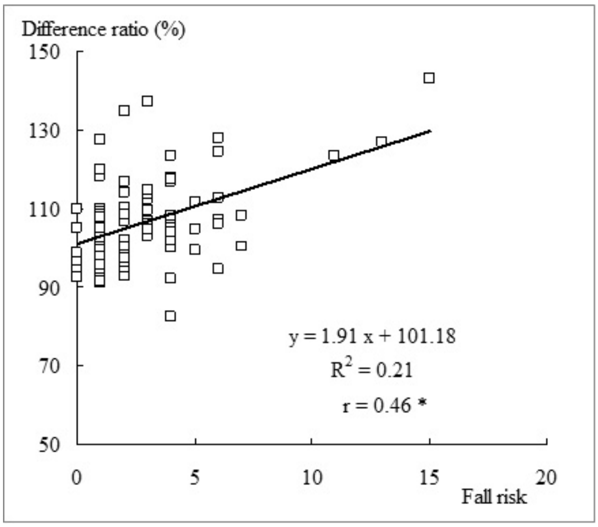

Fig. 5. The relationship between the difference ratio and fall risk

Discussion

In our previous study [10], we found that adding an obstacle 5 cm in height to the TUG results improved the validity of the TUG for assessing the functional mobility of the healthy female elderly. This study was conducted to examine the validity of the above-stated obstructed TUG (OTUG) as a fall risk assessment tool for the healthy elderly. In this study, the relationship between the OTUG and fall risk in healthy elderly people with a wide variety of physical fitness levels was analyzed. Independent community-dwelling healthy elderly and healthy residents of a nursing home for the elderly were selected as participants. As shown in Table 1, the participants' characteristics (physiques, physical fitness and ADL abilities) and fall risk showed a significant difference with age except for body weight. Of these characteristics, ADL ability and fall risk showed a tendency to be significantly inferior for participants in their late 70s and 80s compared with those in their early 60s.

First, it was confirmed that the TUG and the OTUG have very high reliabilities (ICC=0.96 – 98). Regardless of the presence or absence of an obstacle, it is inferred that reliability of these tests is sufficiently high (TUG: ICC = 0.97; OTUG: ICC = 0.95) and that if an obstacle is placed on the walkway of the TUG (the obstructed TUG test: O-TUG), we exact stable values similar to those in the original TUG test. Also in the previous studies, comparable reliability coefficients (ICC = 0.92 – 99) were reported [3, 19, 20].

In Shumway-Cook's et al. [20] previous study, the relationship between the TUG and fall risk of the elderly was examined. They conducted the original TUG for community dwelling elderly people who can live an independent life and reported that sensitivity and specificity for identifying elderly individuals who are prone to falls were high from their analysis results using 15 older adults with no history of falls (mean age = 78 yrs) and 15 older adults with a history of 2 or more falls in the previous 6 months (mean age = 86.2 yrs). Therefore, the TUG test may have enough sensitivity to distinguish the fall risk level of the healthy elderly. However, unlike this study, many participants with a history of fall accidents used in Shumway-Cook's et al. [20] study were older adults with markedly decreased physical fitness, who needed assistive devices to walk safely (cane: 47%; walker: 33%). In this study, as a result of correlation analysis in independent community-dwelling healthy elderly and healthy residents of nursing homes for the elderly who did not need the above-stated assistive devices, a significant relationship was found between fall risk and the OTUG in addition to the TUG.

Furthermore, when comparing the scatter plot between the required time for the TUG and fall risk (Fig. 3) to the plot between the required time for the OTUG and fall risk (Fig. 4), the tendency of the delay in the performance particularly for the higher risk participants was more apparent in the OTUG than in the TUG. This difference found between the plots was indicated as a significant difference between the correlation coefficients. In short, the correlation coefficient between the OTUG and fall risk scores was significantly higher than that between the TUG and fall risk scores. This may seem to be because the prolongation of the required time for the OTUG due to the obstacle in the participants with higher fall risk expanded the inter-individual differences of the data, i.e. the required time for the OTUG. This result is also explained by the fact that a significant positive relationship was found between the difference ratio and the fall risk score (Fig. 5). As follows from Fig. 5, the participants with low risk had equivalent scores between the TUG and the OTUG, i.e. the difference ratio was equal to about 100%. In contrast, the participants with high risk tended to have a higher value of the difference ratio greater than 100%. This expanding of the inter-individual differences in the OTUG suggests that the OTUG is better suited for the fall risk assessment for the healthy elderly rather than the original TUG.

Furthermore, the present results suggest the possibility that even a small box (obstacle) 5 cm in height on a walkway could be an apparent obstructive factor against the various mobility performances in the daily life for the high-risk elderly. Although the height of the obstacle used in this study was low, the visibility was high enough for the participant to be able to see it. The elderly frequently trip over small obstacles in the daily life and fall without perceiving it. Behind this, the influence of the above-stated decline in mobility may also contribute to the fall. For the elderly with high fall risk, obstacle negotiation should be performed while keeping in mind their decreased mobility and the resultant need to be careful of the obstacle, even when crossing over a high visibility obstacles in daily life.

If a small obstacle 5 cm in height is placed on the walkway of the original TUG test, participants are required to step over it while supporting their entire body weight with one leg (exerting balance ability and leg strength) and to dexterously maneuver their entire body (exerting coordination ability), after selecting appropriate motor programs by having positional awareness between self and the obstacle using their visual system. Even healthy people show marked changes in the gait pattern with aging. This includes, for example, decreases in gait velocity and step length due to decreased hip and ankle range of motion, increases in double-support phase and step width, and a forward-bent posture [21-23]. Even if a task of obstacle negotiation during walking was added, it may be very easy for healthy young adults to achieve it. However, obstacle negotiation is considered to be more difficult for the elderly with diminished leg strength and unstable gait pattern and particularly with high fall risk. From this, in comparison to the TUG, the OTUG can properly discriminate high-risk people from low risk ones. That is to say, the OTUG seems to be a more valid tool as to the fall risk assessment.

In this study, the cross-sectional data was used for examining the relationship between the fall risk and the OTUG. Therefore, it considered impossible to state positively that the low-scored participants in the OTUG will actually fall in the near future. Some important issues including the development of a statistical predictive model using a longitudinal design and setting of a norm for the OTUG, etc. remain to be done.

Conclusion

In conclusion, the OTUG with a 5 cm height obstacle has a very high test-retest reliability equivalent to the TUG and has a higher relationship to fall risk than the TUG. This suggests a validity of the use of the OTUG for fall risk assessment of the healthy elderly.

Conflict of Interest

This research was partially supported by the Grant-in-Aid for scientific research, Japanese Society of Test and Measurement in Health and Physical Education.

References

1. Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. *J Am Geriatr Soc* 1986;34(2):119-126.
2. Takahashi T, Ishida K, Hirose D, et al. Vertical ground reaction force shape is associated with gait parameters, timed up and go, and functional reach in elderly females. *J Rehabil Med* 2004; 36(1):42-45.
3. Podsiadlo D, Richardson S. The timed “Up and Go”. A test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1991;39:142-148.
4. Gokan H. Timed “Up and Go” test (TUG). In: Uchiyama Y, Kobayashi T, Shiomi T, editors. *A manual for clinical assessment tools*. Tokyo, Kyodo Isho Shuppan; 2006: 108-118.
5. Pavol MJ, Owings TM, Foley KT, Grabiner MD. Mechanisms leading to a fall from an induced trip in healthy older adults. *J Gerontol A Biol Sci Med Sci* 2001;56(7):428-437.
6. Pavol MJ, Owings TM, Foley KT, Grabiner MD. Gait characteristics as risk factors for falling from trips induced in older adults. *J Gerontol A Biol Sci Med Sci* 1999;54(11):583-590.
7. Schillings I, Mulder T, Duysens J. Stumbling over obstacles in older adults compared to young adults. *J Neurophysiol* 2005;94(2):1158-1168.
8. Troy KL, Grabiner MD. The presence of an obstacle influences the stepping response during induced trips and surrogate tasks. *Exp Brain Res* 2005;161:343-350.
9. Demura S, Uchiyama M. Influence of various obstacle height on the Timed “Up & Go” test in young adults. *Sport Sci Health* 2007;2:23-28.
10. Demura S, Uchiyama M. Proper assessment of the falling risk in the elderly by a physical mobility test with an obstacle. Tohoku J Exp Med 2007;212:13-20.
11. Guerts ACH, Mulder TW, Nienhuis B, Rijken RA. Dual task assessment of reorganization in persons with lower limb amputation. *Arch Phys Med Rehabil* 1991;72(13):1059-1064.
12. LaJoie Y, Teasdale N, Bard C, Flueury M. Attentional demands for static and dynamic equilibrium. *Exp Brain Res* 1993; 97(1):139-144.

13. Lundin-Olsson L, Nyberg L, Gustafson Y. "Stops walking when talking" as a predictor of falls in elderly people. *Lancet* 1997;349(9052):617.
14. Shumway-Cook A, Woollacott M, Kerns KA, Baldwin M. The effects of two types of cognitive tasks on postural stability in older adults with and without a history of falls. *J Gerontol A Biol Sci Med Sci* 1997;52(4):M232-240.
15. Suzuki T. Development and its use of a falling risk assessment chart for the elderly population. In: *Health Assessment Committee editors. Health Assessment Manual*. Tokyo, Kosei Kagaku Kenkyusyo; 2001: 142-152.
16. Yokoya T, Demura S, Sato S. Relationships between physical activity, ADL capacity and fall risk in community-dwelling Japanese elderly population. *Environ Health Prev Med* 2007;12:25-32.
17. Yokoya T, Demura S, Sato S. Fall risk characteristics of the elderly in an exercise class. *J Physiol Anthropol* 2008;27:25-32.
18. Arnadottir SA, Mercer VS. Effects of footwear on measurements of balance and gait in women between the ages of 65 and 93 years. *Phys Ther* 2000;80(1):17-27.
19. Hughes C, Osman C, Woods AK. Relationship among performance on stair ambulation, Functional Reach, and Timed Up and Go tests in older adults. *Issues Aging* 1998;21:18-22.
20. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Phys Ther* 2000;80(9):896-903.
21. Murray MP, Drought AB, Kory RC. Walking pattern of normal man. *J Bone Joint Surg Am* 1964; 46:335-360.
22. Yoshizawa M, Nakata K, Kumamoto N, Okano T. [Changes in gait pattern with aging] [In Japanese] *Japanese Journal of Sports Science* 1989;8(3):134-141.
23. Nishijima Y, Kato T, Nakagawa H, Yoshizawa M, Miyashita M. Postural and electromyographical analysis of gait in the aged person. *Walking Research* 2005;9:89-94.

Appendix

Fall Assessment Chart		
1.	In the past year, have you slipped or stumbled and then fallen down?	1. Yes; 0. No
2.	At a pedestrian crossing, can you cross the road while the light is green?	0. Yes; 1. No
3.	Can you walk continuously for about 1 km?	0. Yes; 1. No
4.	Can you stand on one foot and put a sock on the other foot?	0. Yes; 1. No
5.	Are you strong enough to wring out a wet towel or cloth effectively?	0. Yes; 1. No
6.	Have you been hospitalized in the past year?	1. Yes; 0. No
7.	Do you ever feel dizzy on standing up?	1. Yes; 0. No
8.	Have you ever had a stroke?	1. Yes; 0. No
9.	Have you ever been diagnosed as having diabetes?	1. Yes; 0. No
10.	Are you taking any sleeping drugs, blood pressure medications or tranquilizers?	1. Yes; 0. No
11.	Do you wear sandals or slippers a lot ever day?	1. Yes; 0. No
12.	Can you see well (newspaper, people's faces, etc.)?	0. Yes; 1. No
13.	Can you hear well (people talking, etc.)?	0. Yes; 1. No
14.	Do you often slip or stumble when at home?	1. Yes; 0. No
15.	Do you generally worry a lot about falling or do you refrain from going out because you are afraid of falling?	1. Yes; 0. No
Note: The scores in the above fifteen questions were totaled and subjects with scores of 5 or higher scores were evaluated as having a high risk of falling. This chart was translated from Japanese into English by Yokoya et al. [17] and corrected by native English speakers.		

BALTIC JOURNAL OF HEALTH AND PHYSICAL ACTIVITY
© Gdansk University of Physical Education and Sport in Gdansk, Volume 4, No 3, 2012, xxx-xxx
ORIGINAL ARTICLE