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TIMED UP AND GO TEST AND RISK OF FALLS IN OLDER ADULTS: A SYSTEMATIC REVIEW

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Abstract: *Objective:* To assess the association and the predictive ability of the Timed Up and Go test (TUG) on the occurrence of falls among people aged 65 and older. *Methods:* A systematic English Medline literature search was conducted on November 30, 2009 with no limit of date using the following Medical Subject Heading (MeSH) terms "Aged OR aged, 80 and over" AND "Accidental falls" combined with the terms "Timed Up and Go" OR "Get Up and Go". The search also included the Cochrane library and the reference lists of the retrieved articles. *Results:* Of the 92 selected studies, 11 met the selection criteria and were included in the final analysis. Fall rate ranged from 7.5 to 60.0% in the selected studies. The cut-off time separating non-fallers and fallers varied from 10 to 32.6 seconds. All retrospective studies showed a significant positive association between the time taken to perform the TUG and a history of falls with the highest odds ratio (OR) calculated at 42.3 [5.1 - 346.9]. In contrast, only one prospective study found a significant association with the occurrence of future falls. This association with incident falls was lower than in retrospective studies. *Conclusions:* Although retrospective studies found that the TUG time performance is associated with a past history of falls, its predictive ability for future falls remains limited. In addition, standardization of testing conditions combined with a control of the significant potential confounders (age, female gender and comorbidities) would provide better information about the TUG predictive value for future falls in older adults.

Key words: Timed up and go, falls, older adults.

Introduction

The Timed Up and Go test (TUG) measures in seconds the time it takes a subject to rise from a chair, walk a distance of 3 meters, turn, walk back to the chair and sit down (1). This test has been used extensively in geriatric medicine to examine balance, gait speed, and functional ability that would be required for the performance of basic activities of daily living in older people (2, 3). The fall prevention guidelines from the American Geriatric Society, the British Geriatric Society and The Nordic Geriatricians Meeting, recommend the use of the TUG as one of the bedside tests to screen for the presence of gait and balance disorders in older adults (1-5). But to date, although the TUG has been recommended as a key test for fall risk screening, the optimal cut-off value to detect older adults at an elevated fall risk remains controversial as there have been a wide range of reported threshold values in the literature (10 to 33 seconds) (6-16).

Simple and efficient detection of fall risk in older adults is a paramount objective of geriatric medicine. Unfortunately, falls in this population are multifactorial making the identification of older adults at an elevated risk often complex and time intensive for a comprehensive evaluation. The comprehensive evaluation of fall risk involves a thorough consideration of not only intrinsic (subject-related) but also extrinsic (environment-related) and behavioral (activity-related) factors (1-5). The assessment process therefore requires clinical tests that are easy to administer and have demonstrated predictive validity for future falls with acceptable clinimetric properties for use in the clinical setting (3-5). Therefore, health care professionals need a simple and pragmatic clinical approach to identify older adults at an elevated risk of falls. The TUG is a simple to perform test that requires no specific equipment and has demonstrated good inter-rater reliability, with an intra-class correlation of 0.80 (5). For all these reasons, the TUG has been increasingly advocated over the years for use to predict fall in older people.

Although the TUG has been shown to be useful for functional mobility evaluation (2,3), the literature on its predictive value and diagnostic accuracy for identifying future falls is not as straight forward. The variation of threshold values reported in the literature has not optimally facilitated knowledge translation for use in clinical practice (7-17). To the best of our knowledge, no systematic review exploring the association between the TUG score and falls has been performed yet. Consequently, we performed a systematic review of the literature with the objective to assess the association and the predictive ability of the TUG time performance on the occurrence of falls among individuals aged 65 years and older.

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Methods

Literature search

A detailed literature search was conducted to identify articles published in the English language evaluating the use of the Timed Up and Go Test and fall risk. The following electronic databases were searched: MEDLINE, Cochrane library (Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effectiveness, and Cochrane Controlled Trials). The search was conducted on November 30, 2009 to include all publications from 1991 (publication of the original article on the TUG test) to the search date. The following Medical Subject Heading (MeSH) terms "Aged OR aged, 80 and over"[MeSH] AND "Accidental falls"[MeSH] combined with the block terms ("Times Up and Go"[TIAB] OR "Get Up and Go"[TIAB]). An iterative process was used to ensure all relevant articles had been obtained. A further hand search of bibliographic references of extracted papers and existing reviews was also conducted to identify potential studies not captured in the electronic database searches.

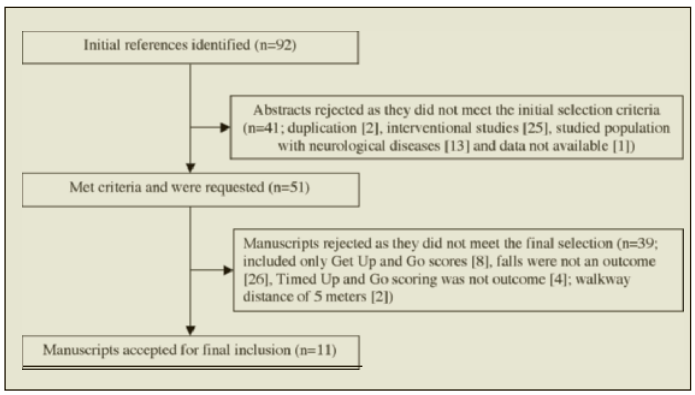
Study selection and analysis

One member of the team (OB) screened abstracts from the initial search and obtained articles deemed potentially relevant. The abstracts were independently evaluated by two reviewers (CA and OB) to determine if they met the inclusion criteria for full review. Initial screening criteria for the abstracts were: 1) observational studies (cohort, case-control and cross-sectional studies were included), 2) data collection of Timed Up and Go or Get Up and Go scores, 3) subjects without neurological disease and 4) aged 65 years and older. The full articles were lastly screened, using the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) checklist method criteria for observational studies, for the inclusion of falls (single or recurrent) and TUG performance as a primary outcomes and description of the TUG test as timed over a distance walked of 3 meters in order to include studies which had some variation in the test methods compared to the initial description of TUG (1, 18). The definition of fall was an event resulting in a person coming to rest unintentionally on the ground or at other lower level, not as the result of a major intrinsic event or an overwhelming hazard. Performance was considered as a measurable or calculable result, not to be confused with the ability to perform the requested action. The study selection is shown on a flow diagram (Figure 1). Articles selected for the full review had the following information extracted: authors, date of publication, study design, setting and study population, Timed Up and Go scores and falls information.

To standardize reporting of performance of the TUG test, data was also extracted from the studies to allow the calculation of odds ratio if not already presented in the paper. Odds ratio for falls were calculated for studies as necessary using Dag-stat a spreadsheet for the calculation of comprehensive statistics for the assessment of diagnostic tests and inter-rater agreement that provides a comprehensive range of statistics for 2 by 2 tables (19).

Figure 1

Flowchart of the literature search for the selection of studies to be included in the systematic review



Results

A total of 92 abstracts were identified as potentially relevant based on the key search terms and the hand search of bibliographic references. Fifty one of the 92 identified abstracts were first identified after screening using the initial inclusion criteria. Review of the full text papers resulted in the further exclusion of 40 studies because of Get Up and Go scoring (i.e.; time taken to perform TUG not measured) (n=8), falls were not an outcome (n=26), TUG performance was not an outcome (n=4) and walkway distance of 5 meters (n=2). The remaining 11 observational studies were included in this systematic review (7-17) and were summarized in Table 1.

Among the included studies, the number of participants ranged from 30 to 2388 (7, 16). The majority of studies (n=7, 64%) examined the association between the time taken to perform the TUG and falls in community-dwelling older adults (7, 9, 10, 12-14, 17). Three studies focused on older inpatients (11, 15, 16), one on older adults living in seniors housing facilities (8) and one on a mixed sample of community-dwelling and senior housing facilities (8). Women represented from 16.6% to 84.5% of the studied populations (9, 17).

There was variation in the methodology for the administration of the test over the 3 meters distance. The TUG was performed either at usual pace (8, 12, 17) or at fast pace (7,9,13) as safety as possible. In the majority of studies, participants were allowed to use their walking aid during the test (7-9, 11, 12, 15, 17). Three studies used an armchair (8, 12, 13) and 3 a chair (7, 9, 17) with no other specifications provided. Detailed information on the testing methodology was not provided in the remainder of the studies (10, 11, 14-16). In all studies, a line marked on the floor was used to show the walkway distance (7-17).

The majority of studies were cross-sectional in nature (n=7,

Table 1
Summary of main characteristics of the studies included in the systematic review

References	Design	Setting / Population	Outcomes Timed Up and Go	Falls	Odds ratio [95% CI]	Falls association?	Falls prediction?
Retrospective studies							
Shumway-Cook et al.; 2000 (7)	- Case-control study	- Community- dwelling - N=30 (15 non-fallers; 15 fallers) - Mean age: non-fallers 78.4±5.8; fallers 86.2±6.4 - Women, n (%): 18 (60.0)	- Time (mean; s): Non-fallers 8.4±1.7; fallers 22.2±9.3 - Cut-off value (s): >13.5 - Conditions : 3 meters, chair, fast-pace, use walking aid possible, line floor	- Definition standardized - > 2 falls - Number of fallers [n (%)]: 15 (30.0) - Follow-up period: 6 months	- Unadjusted OR = 42.3 [5.1 - 346.9]	- Yes	- No
Gunter et al.; 2000 (8)	- Cross-sectional	- Community-dwelling and senior housing facilities - N=157 (48 non-fallers; 56 single fallers, 53 recurrent fallers) - Mean age: non-fallers 75.9±5.9; single fallers 78.3±5.0; recurrent fallers 77.7±5.3 - Women, n (%): 26 (16.6)	- Time (mean; s): Non-fallers 7.4±1.2; single fallers 8.9±1.3; recurrent fallers 9.1±1.3 - Cut-off value (s): >13.5 - Conditions : 3 meters, armchair, usual-pace, use walking aid possible, line floor	- Definition standardized - Single and recurrent falls (i.e., > 2) - Number of fallers [n (%)]: single 56 (35.7); recurrent 53 (33.8) - Follow-up period: 12 months	- Data no available	- Yes	- No
Rose et al.; 2002 (9)	- Case-control study	- Community-dwelling - N=134 (71 non-fallers; 63 fallers) - Mean age: non-fallers 76.7±6.2; fallers 78.4±6.5 - Women, n (%): 112 (83.6)	- Time (mean; s): Non-fallers 8.2±1.8; fallers 12.3±3.9 - Cut-off value (s): > 10 - Conditions : 3 meters, chair, fast-pace, use walking aid possible, line floor	- Definition standardized - > 1 fall - Number of fallers [n (%)]: 63 (47.0) - Follow-up period: 12 months	- Unadjusted OR = 19.7 [7.9 - 49.2]	- Yes	- No
Chiu et al.; 2003 (10)	- Case-control study	- Community-dwelling - N=78 (39 non-fallers; 17 single fallers, 22 recurrent fallers) - Mean age: non-fallers 81.7±7.8; single fallers 82.1±8.2; recurrent fallers 82.9±6.6 - Women, n (%): 52 (66.6)	- Time (mean; s): non-fallers 17.2±3.2; single fallers 21.0±6.3; recurrent fallers 42.1±23.2 - Cut-off value (s): single fallers > 20.1; recurrent fallers > 24.7 - Conditions : Not available	- Definition standardized - Single and recurrent falls (i.e., > 2) - Number of fallers [n (%)]: single 17 (21.8); recurrent 22 (28.2) - Follow-up period: 6 months	- Single fallers: unadjusted OR = 13.6 [3.3 – 56.6] - Recurrent fallers: unadjusted OR = 23.1 [5.9 – 90.9]	- Yes	- No
Thomas et al.; 2005 (11)	- Observational study	- Inpatients - N=30 (12 non-fallers; 18 recurrent fallers) - Mean age: non-fallers 79.7±6.7; recurrent fallers 81.4±6.7 - Women, n (%): 18 (60.0)	- Time (mean; s): Non-fallers 30.1±22.6; recurrent fallers 52.3±34.9 - Cut-off value (s): >32.6 - Conditions : 3 meters, use walking aid possible	- No definition - Recurrent falls (i.e., > 2) - Number of fallers [n (%)]: 18 (60.0) - Follow-up period: 12 months	- Unadjusted OR = 7.0 [1.4 – 35.9] - Adjusted OR = 11.5 [1.3 – 103.5]	- Yes	- No
Thrane et al.; 2007 (12)	- Observational population-based study	- Community-dwelling - N= 974 (578 non-fallers; 396 fallers) - Mean age: non-fallers 77.4±2.2; fallers 77.5±2.3 - Women, n (%): 560 (57.5)	- Time (mean; s): Non-fallers 12.2±4.8; fallers 13.5±8.3 - Cut-off value (s): not found; use of upper quartile - Conditions : 3 meters, armchair, usual-pace, line floor	- Definition standardized - > 1 fall - Number of fallers: 396 (40.7) - Follow-up period: 12 months	- Men: Unadjusted OR = 2.1 [1.4 – 3.3] Adjusted OR = 1.8 [1.1 – 2.9] - Women: Unadjusted OR = 1.0 [0.7 – 1.4]	- Yes	- No
Arnold et al.; 2007 (13)	- Observational study	- Community-dwelling - N= 106 (58 non-fallers; 48 fallers) - Mean age: 74.4±6.2 - Women, n (%): 77 (72.6)	- Time (mean; s): 12.8±5.3 - Cut-off value (s): highest (> 14s) lowest quartile (> 10s) - Conditions : 3 meters, armchair, fast-pace, line floor	- Definition standardized - > 1 fall - Number of fallers [n (%)]: 48 (45.3) - Follow-up period: 12 months	- Highest quartile: Unadjusted OR = 1.0 [0.4 – 2.3] - Lowest quartile: Unadjusted OR = 1.4 [0.6 – 3.4]	- Yes	- No
Prospective studies							
Okumiya et al.; 1998 (14)	- Cohort study	- Community-dwelling - N= 243 (175 non-fallers; 68 fallers) - Age: > 75 years - Women, n (%): data not available	- Time (mean; s): data not available - Cut-off value (s): > 16 - Conditions : 3 meters	- No definition - > 1 fall - Number of fallers [n (%)]: 68 (28.0) - Follow-up period: 5 years	- Unadjusted OR = 3.4 [1.9 – 6.1] - Adjusted OR = 2.7 [1.3 – 5.8]	- Yes	- Yes
Lindsay et al.; 2004 (15)	- Cohort study	- Inpatient - N= 160 (143 non-fallers; 17 fallers) - Mean age: 81 years - Women, n (%): 105 (65.6)	- Time (mean; s): 45.7 - Cut-off value (s): No - Conditions : 3 meters, use walking aid possible	- Definition standardized - > 1 fall - Number of fallers [n (%)]: 17 (10.6) - Follow-up period: Data not available	- Data not available	- No	- No
Large et al.; 2006 (16)	- Cohort study	- Inpatient - N= 2388 (2208 non-fallers; 180 fallers) - Mean age: 82.1±7.7 years - Women, n (%): 1476 (61.8)	- Time (median; s): 28.2 - Cut-off value (s): No - Conditions : 3 meters	- No definition - > 1 fall - Number of fallers [n (%)]: 180 (7.5) - 9 days (median length of hospital stay)	- Adjusted OR = 1.08 [0.6 – 1.9]	- No	- No
Beauchet et al.; 2007 (17)	- Cohort study	- Community-dwelling - N= 187 (133 non-fallers; 54 fallers) - Age: 84.8±5.2 years - Women, n (%): 158 (84.5)	- Time (mean; s): 25.0±8.3 - Cut-off value (s): 20 - Conditions : 3 meters, chair, usual-pace, use walking aid possible, line floor	- Definition standardized - > 1 fall - Number of fallers [n (%)]: 54 (28.9) - Follow-up period: 12 months	- Unadjusted OR = 2.6 [1.2 – 5.6] - Adjusted OR = 1.8 [0.7 – 4.7]	- No	- No

OR: Odds ratio; s: Seconds; ±: Standard deviation

63%), comparing the TUG score to a past history of falls over a selected time frame prior to the start of the study (7-13). None of these studies were identified by the authors as cross-sectional, instead terms such as case-control or observational study were used instead. Additionally, none of these studies identified the limitations of using this design to evaluate predictive ability of the TUG on future fall risk identification, the format the test would be used in a clinical setting.

In the cross-sectional studies, older adults who had fallen took more time to complete the test than non-fallers, 7.4 seconds in non-fallers to 52.3 seconds in recurrent fallers (i.e., those who reported at least 2 falls during the previous 12-month period) (8, 11). The cut-off values separating non-fallers and fallers varied from 10 to 32.6 seconds (9, 11). Data collection of fall events was retrospective in 7 studies (7-13) and prospective in 4 studies (14-17). Falling at least once was the most common outcome evaluated and fall risk ranged from 7.5% to 60% (16, 11). All retrospective studies showed a significant positive association between TUG time and a history of falls with an odds ratio (OR) for falls ranging from 1.8 to 42.3 (12, 7). The OR associated with recurrent falls was higher than the association with single falls. By contrast, the association between the TUG time and the occurrence of new falls was mixed in prospective studies, as one study showed a significant association (14) while three did not (15-17). In addition, the statistical significance of the OR was lower in the prospective studies compared with the retrospective studies.

Lastly, six studies included analyses of diagnostic accuracy by presenting values of sensitivity, specificity or area under the Receiver Operating Characteristic (ROC) Curve. The area under the ROC curve, a measure of diagnostic accuracy, was reported in three studies (10, 12, 13) and this value ranged from 0.50 to 0.93 with regard to the the association with a past history of falls. Measures of diagnostic accuracy were available only in the retrospective studies; there was insufficient data in the manuscripts of the prospective studies for the authors to do similar calculations for the TUG performance to identify future falls.

Discussion

Although the retrospective studies showed a significant association between time taken to perform the TUG and a past history of falls, conflicting results were observed in the prospective cohort studies. Only one of the four prospective studies found a significant association between the TUG time and future falls. The divergence of results raises a number of issues that are mainly related to the methodology of the retrospective and prospective studies. Additionally, other factors such as the type of population studied and the lack of control of potential confounders may also be relevant.

Methodological aspects of the different study designs when evaluating the performance of the TUG test are very important when appraising the literature. The majority of studies, and those specifically evaluating measures of diagnostic accuracy, used a cross-sectional design evaluating the association of TUG score with a past history of falls. The use of a cross-sectional study design is problematic in falls research as the temporal order between the balance score and falling cannot be established as they are determined at the same time. The competing explanations that people could fall because of balance impairment and that balance impairment could be the result of falling cannot be disentangled. This study design cannot evaluate the predictive validity of the TUG test's score on the identification of future fallers, which is the clinically relevant question. The exposure must confidently be determined to precede the outcome to establish the temporal order to the relationship and this is not possible with this group of studies which are more accurately called backward prevalence designs. Backward prevalence studies act like a cross-sectional study as previous case occurrences, incident cases for a given time period, are identified retrospectively before the study commences. There is no follow-up done in this design, but exposure is determined at the time the study commences which is after all the outcomes have occurred. Threshold values for the TUG from these studies are not appropriate for use in a clinical setting.

Additionally, most selected studies provided no information about the number of subjects required to predict falls and did not include any post-hoc power analysis. Only two studies estimated the sample size of subjects with an a priori analysis (10, 12), therefore equivocal or negative results could be the result of a lack of power (14-17).

The limited number of prospective studies (n=4) which explored the predictive value of TUG for falls may also explain the mixed results. Only one of these studies showed a significant positive association while 75% did not, which looked like the effect of chance and makes it impossible to conclude whether TUG performance is or is not predictive of falls. Furthermore, follow-up periods were heterogeneous, with a varying range of 9 days (16), 6 months (7, 10) and up to 5 years (14). Short follow-up periods such as 9 days may underestimate the number of falls, and thus explain the failure to establish any association between falls and the time taken to perform TUG.

Variations in the administration and conditions of testing the TUG may also help to explain the mixed results. Although a line marked on the floor was the usual format, there were differences in terms of the pace condition and type of used chair. First, some studies used a fast-pace walking (7, 9, 13), whereas others used usual-pace or did not provide any information (10, 14, 16-18). Podsiadlo & Richardson described in the methods section of the original publication ambulation at a comfortable and safe pace (1). While use of a fast pace is a variation from the original description of the test, performance of the test under this condition did not change the nature of the association with falls compared to the studies which used a usual-pace format. Second, the type of chair used (i.e., with or

without armrest) was also different across the studies. Previous research has shown that the time to perform the TUG is dependent on the type of chair used (20). For instance, Siggeirsdottir et al. reported that performance was significantly more difficult when participants were asked to stand up from a chair without armrest and it also increased the time to perform TUG (20).

The type of methods used to ascertain the falls outcome may also be a source of divergence between the results of selected studied in this systematic review. The recall of falls used in the retrospective studies is a potential source of bias as older adults tend to under-report recalled fall occurrences compared with a prospective standardized collection of falls (21). Another source of variation relates to the type of fall outcome evaluated, as some studies examined the occurrence of the first fall (7, 12-17), while others focused on recurrent falls, defined as > 2 falls during the relevant time period of interest (7, 8, 10, 11). Compared to a single fall, recurrent falls are seldom due to a single cause and the combination of multiple risk factors for falls is complex, and thus probably contributes to falls in different ways in single or recurrent fallers (1-5).

The diversity of the results could also be related to the heterogeneity of the considered populations across the selected studies. Populations assessed ranged from healthy community-dwelling older adults with high functional to (7-10, 12-14, 17) very frail older adults in senior housing facilities (8) and geriatrics inpatients (11, 15, 16). This highlights that measurement scales and thresholds demonstrating validity in one population are not necessarily directly transferable to other populations of older adults. There may be true variation in test performance when applied to older adults living independently in the community or institutional-dwelling subjects and this must be established separately.

Though there was a positive association found in only one of the study on future fall risk, it could be postulated that a three meters distance may be insufficient for detecting subtle mobility problems in older adults. In other words, the TUG may lack sensitivity to detect future falls due to the fact that it is a simple and easy test which does not exceed or challenge the functional capacity of this population. For instance, Montero-Odasso et al. demonstrated in a longitudinal study of 102 high-functioning older adults that subtle changes in gait velocity assessed over a 6-meter distance predicted falls earlier than a poor performance in the Get Up and Go test (22). Two prospective studies, not included in this systematic review, have shown that a TUG time above 30 seconds over a distance of 5 meters was predictive of the occurrence of falls (23, 24). In addition, it has been shown that living in an institutional setting was associated with an impaired TUG performance. Bischoff-Ferrari et al. (25) reported that 92% of community-dwelling elderly women performed the TUG test in less than 12 seconds and all community-dwelling women had times below 20 seconds. In contrast, only 9% of institutional-dwelling elderly women performed the TUG test in less than 12 seconds, 42% were below 20 seconds, 32% had results between 20 and 30 seconds and 26% were above 30 seconds.

A variation in age of study participants, which ranged 74.4 to 84.8 years (13, 17) could also account for some variation in the results. It has to be noted that falling is strongly related to intrinsic (i.e., subject-related) factors corresponding to various cumulated effects of chronic diseases and physiological decline (2). These effects become even more pronounced and diverse with age, contributing to a vicious cycle of increasing frailty and increasing risk of falling. An age-related physiological decline has been associated with a decrease in TUG performance by Bohannon et al. (2). In their meta-analysis to describe the population reference values for TUG test, they highlighted in 4395 subjects from 21 studies that the TUG time increased significantly with age. These values ranged from 8.1 seconds for subjects between 60 and 69 years up to 11.3 seconds for those between 80 and 99 years (2). A few of the selected studies reported adjusted risk estimates controlling for potential confounders such as age or comorbidities (11, 12, 14, 17). Except in Thomas's study (11), adjusted estimates provided lower magnitudes of association between the TUG performance and falls.

Female gender may also account for the mixed results of the association between the TUG time and falls. The variation in percentage of female subjects across studies was high and ranged from 16.6% to 84.5% (8, 17). It has been demonstrated that falls are more common in female than in male subjects (3, 26-29). It has also been suggested that the effects of chronic diseases and physiological decline could be different between women and men (28, 29), notably the greater loss of fat-free mass with aging, that could lead to different performance in TUG and thus to a higher risk of fall in women than in men. Contrary to this expectation, the study by Thrane et al. (12) did not find female gender as a higher risk. Two separate analyses were performed, stratifying by women and men, with and without adjustment on other potential confounders. This study showed that the association between performance on the TUG and past history of falls were greater and significant in men, an unadjusted OR = 2.1 (1.4 – 3.3) and an adjusted OR = 1.8 (1.1 – 2.9), while the risk for women was not significant at an OR=1.0 (0.7 – 1.4).

In conclusion, the literature supporting the predictive ability of TUG for the occurrence of future falls is limited. Cross-sectional studies are unable to provide information that is clinically relevant to patient care practices as the association is between a past history of falls and the TUG score. A better standardization of testing conditions combined with a prospective study design where fall occurrence information is collected over a clinically relevant time frame after the performance of the TUG test is required. Additionally, further studies with a rigorous statistical methodology to evaluate the predictive validity of the test as it would be used in clinical practice are required in different patient populations to further refine threshold values that can be translated into clinical practice.

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