Geriatr Gerontol Int 2015; **15:** 204–210

ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Motor dual-task Timed Up & Go test better identifies prefrailty individuals than single-task Timed Up & Go test

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Aim: The present study investigated whether dual-task Timed Up & Go tests (TUG) could identify prefrail individuals more sensitively than the single-task TUG (TUG_{single}) in community-dwelling middle-aged and older adults.

Methods: This cross-sectional study recruited adults aged 50 years and older who actively participated in local community programs. Time taken to complete single-task TUG and dual-task TUG, carrying a cup of water (TUG_{manual}) or carrying out serial-3 subtraction ($TUG_{cognitive}$) while executing TUG, was measured. Prefrailty status was defined based on Fried's phenotypic definition.

Results: Of the 65 participants (mean age 71.5 ± 8.1 years), 33.3% of the 12 middle-aged (50–64 years) and 62.3% of the 53 older (≥65 years) adults were prefrail, mainly as a result of weak grip strength. The receiver operating characteristic curve analyses for differentiating prefrailty from non-frailty showed that the area under the curve (AUC) for TUG_{manual} (0.73, 95% CI 0.60–0.86) was better than that for TUG_{single} (0.67, 95% CI 0.54–0.80), whereas the AUC value was not significant for $TUG_{cognitive}$ (0.60, 95% CI 0.46–0.74). The optimal cut-off points for detecting prefrailty using TUG_{single}, TUG_{manual} and $TUG_{cognitive}$ were 7.7 s (sensitivity 68%), 8.2 s (sensitivity 83%), and 14.3 s (sensitivity 29%), respectively. After adjusting for age, logistic regression analyses showed that individuals with TUG_{manual} 8.2 s or slower were 7.2-fold more likely to have prefrailty than those with TUG_{manual} faster than 8.2 s.

Conclusion: TUG_{manual} is more valid and sensitive than TUG_{single} in identifying prefrail individuals. The TUG_{manual} thus could serve as a screening tool for early detection of individuals with prefrailty in community-dwelling middle-aged and older adults. **Geriatr Gerontol Int 2015; 15: 204–210.**

Keywords: frail elderly, middle aged, mobility limitation, sensitivity and specificity.

Introduction

Frailty is highly prevalent with increasing age,[1] and is associated with various adverse health outcomes.[2] Because a substantial amount of healthcare is required for frail individuals, concern has been increasing regarding the screening of frailty for efficient comprehensive assessment and targeted early interventions.[3–5] Prefrailty occurs at an earlier stage of the frailty spectrum, and is associated with later development of frailty.[6] Hence, prefrailty might be a better target of screening, especially when considering the middle-aged people who, when living an inactive lifestyle[7] or having midlife obesity,[8] are at risk of developing frailty with aging.

For the purpose of screening, single objective mobility measures, such as the Timed Up & Go test (TUG) or walking speed tests, might be more easily applicable in the majority of community settings[9] than the widely used multidomain measures required according to Fried's phenotypic definition of frailty.[6] Recent research has shown that both TUG and walking speed tests can be used to identify frail older adults with good accuracy.[3–5] The TUG measures functional mobility by asking an individual to rise from a seated position, walk 3 m, turn, walk back and sit down.[10] Compared

Accepted for publication 30 December 2013.

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with walking speed measures, the highly standardized administration procedures and the smaller required testing space make TUG potentially even more practicable for clinical use and epidemiological research.

Dual-task TUG, adding either a cognitive task, such as a serial-3 subtraction task,[11] or a manual task, such as carrying a cup of water,[11,12] measures executive function on the platform of physical mobility.[13] Previous research documents that the time difference between dual- and single-task TUG is a valid marker of frailty and falls.[12] Furthermore, it has been reported that dual-task tests might have an added value for fall prediction than single-task tests.[12,14,15] A recent meta-analysis and systematic review of fall prediction suggests to heighten task complexity for relatively higher functioning populations.[16] Hence, for the population of middle-aged and older adults at risk of prefrailty, dual-task TUG could have the potential to identify prefrail individuals better than single-task TUG.

To the best of the authors' knowledge, no study has probed screening for prefrailty among middle-aged and older adults by using dual-task TUG tests. Therefore, the purposes of the present study were to: (i) investigate whether or not dual-task TUG could identify prefrail individuals better than single-task TUG; and (ii) determine the optimal cut-off points that could best identify prefrail individuals by using single- and dual-task TUG in a relatively active group of Taiwanese community-dwelling middle-aged and older adults. We hypothesized that dual-task TUG has a superior ability to identify prefrail individuals as compared with single-task TUG.

Methods

Participants

Participants were recruited from local communities. Adults who participated in activities at community centers including aerobic dance, calligraphy, karaoke and so on were asked for their consent to participate. The inclusion criteria were: (i) aged 50 years or older; (ii) living in the community; (iii) able to understand the instructions; and (iv) able to walk continuously for at least 180 m. The exclusion criteria were: (i) diagnosis of nervous system diseases, such as stroke or Parkinson's disease; and (ii) recent injury or acute onset of disease of the musculoskeletal system that would hamper their ability to carry out the physical tests. One person was excluded because she was unable to follow instructions, another was excluded because of his stroke history and another three persons refused to participate. A total of 65 participants met the criteria, participated in the present study and signed the informed consent form approved by the institutional review board.

Procedures

Participants were face-to-face interviewed to obtain demographic and health status information, including age, sex, education, fall history in the previous 6 months and number of comorbidities. Comorbidities referred to hypertension, diabetes mellitus, kidney disease, heart disease, asthma, cancer, back problems, arthritis or dizziness in the present study. In addition, body height and weight were measured, and the body mass index was calculated. Participants' mental status was assessed by the Mini-Mental State Examination (MMSE).[17]

The five frailty indicators were operationalized as closely as possible to the phenotypic definition of Fried *et al*.[6] First, the self-reported unintentional weight loss was indicated by more than 3 kg or greater than 5% of bodyweight loss in the previous year.[18] Second, exhaustion was indicated by a self response of "more than 3 days a week" to either of the following statements: "I felt everything I did was an effort" or "I could not get going" on the Center for Epidemiological Studies-Depression Scale.[6,19] Third, physical inactivity was measured by the Taiwan International Physical Activity Questionnaire-Short Form.[20] The criterion of the minimum weekly energy expenditure was 383 Kcal for men and 270 Kcal for women.[6] Fourth, slow walking speed was indicated by a usual walking speed slower than the sex- and height-adjusted criterion-specific thresholds.[6] To measure walking speed, participants carried out three walks at their usual pace along a 4.58-m walkway, which extended 1 m at both ends to allow for acceleration and deceleration. Fifth, weakness was indicated by grip strength below criterion-specific thresholds adjusting for sex and body mass index.[6] Two peak grip measures of the dominant hand were taken by using a hydraulic hand-held dynamometer (North Coast Medical). Each of the aforementioned frailty indicators, if present, contributed 1 point of the frailty coding, and a summary score was obtained from all five indicators. Participants scoring 0 were classified as nonfrail, 1–2 as prefrail and 3–5 as frail.[6]

Participants also carried out the single- and two types of dual-task Timed Up & Go tests. In the single-task TUG (TUG_{single}), participants were asked to stand up from a seated position, walk forward 3 m as quickly as possible, turn around, walk back to the chair and sit down. In one of the dual-task TUG tests (TUG_{manual}), participants were asked to complete the TUG task while carrying a cup of water with the surface of water 3 cm from the top edge of the cup. In the other dual-task TUG test ($TUG_{cognitive}$), participants were asked to complete the TUG test while counting backward by threes from a randomly selected number between 80 and 99. The time to complete the TUG tasks was measured by a stopwatch from when the participant's back left the back of the chair until when the participant's buttocks touched the seat of the chair. One practice trial and three formal trials were taken for each TUG test, carried out in random order; the average of three trials was analyzed. A subgroup of seven participants was invited to return 1 week later for a second measurement on the three TUG tests, in order to determine the test–retest reliability. The intraclass correlation coefficient values for TUG_{single}, TUG_{manual} and $TUG_{cognitive}$ were 0.989 (95% CI 0.943–0.998), 0.991 (95% CI 0.935–0.999), and 0.976 (95% CI 0.878–0.996), respectively, which are comparable with values reported previously.[21]

Data analysis

Data were analyzed by using PASW Statistics 18.0 (SPSS Inc., Chicago, IL, USA). The group differences were examined by using independent *t*-tests for continuous variables, and by using χ^2-tests for discrete variables. The validity of TUG_{single}, TUG_{manual} and $TUG_{cognitive}$ for discriminating the prefrail from the non-frail group was determined by using AUC and its 95% CI from the ROC curve analysis. The AUC for non-significant discrimination was set at 0.5. The optimal cut-off point for each TUG task was determined with the greatest sum of sensitivity and specificity. Finally, crude and age-adjusted odds ratios (OR) were obtained using logistic regression models, which estimated the risk of prefrailty when the TUG performance was "poorer" relative to "better" according to the optimal cut-off points.

Results

A total of 65 community-dwelling middle-aged (age range 50–64 years; n = 12) and older adults (age above 65 years; n = 53) participated in the present study (mean age 71.5 ± 8.1 years). None of them was classified as frail. There were 28 non-frail and 37 (56.9%) prefrail individuals. As shown in Table 1, four out of the

Table 1 Demographics and health status for participants in the non-frail and prefrail groups

Characteristics	Non-frail (n= 28)	Prefail (n = 37)	P value
Age (years)	68.5 ± 7.7	73.7 ± 7.7	0.009
Middle-aged (50–64 years)	58.9 ± 3.3	60.8 ± 2.5	
	8 (28.6%)	4 (10.8%)	
Elderly (≥65 years)	72.4 ± 5.0	75.3 ± 6.6	
	20 (71.4%)	33 (89.2%)	
Sex			0.634
Male	9 (32.1%)	14 (37.8%)	
Female	19 (67.9%)	23 (62.2%)	
Education (years)			0.404
≤12	16 (57.1%)	27 (73.0%)	
13–17	8 (28.6%)	7 (18.9%)	
≥18	4 (14.3%)	3 (8.1%)	
Fall history			0.022
No	27 (96.4%)	28 (75.7%)	
Yes	1 (3.6%)	9 (24.3%)	
No. comorbidities			0.673
≤1	21 (75.0%)	26 (70.2%)	
≥2	7 (25.0%)	11 (29.7%)	
BMI (kg/m^2)	24.7 ± 2.3	24.7 ± 3.3	0.998
MMSE (0–30)	27.1 ± 2.4	26.0 ± 3.6	0.122
Energy expenditure (Kcal/week)	1656 ± 1089	1182 ± 893	0.059
Walking speed (m/s)	1.2 ± 0.2	1.0 ± 0.2	0.022
Grip strength (kg)	24.9 ± 6.5	18.3 ± 6.9	<0.001
Frailty indicators			
Weight loss	0 (0.0%)	0 (0.0%)	
Exhaustion	0 (0.0%)	2 (5.4%)	
Physical inactivity	0 (0.0%)	4 (10.8%)	
Slow walking speed	0 (0.0%)	2 (5.4%)	
Weak grip	0 (0.0%)	34 (91.9%)	

Values expressed as mean ± SD or n (%). Significant values are based on independent t-test in cases of mean ± SD, or on χ^2-test for categorical variables. BMI, body mass index; MMSE, Mini-Mental State Examination.

12 (33.3%) middle-aged adults were classified as prefrail, whereas 33 out of the 53 (62.3%) older adults were classified as prefrail. Among the prefrail individuals, two people reported exhaustion, four had low physical activity, two had slow walking speed and 34 (91.9%) had weak grip strength. Demographic and health status statistics of the non-frail and prefrail groups are listed in Table 1. The two groups were comparable in distributions of sex, education, number of comorbidities, body mass index and mental status ($P > 0.05$). However, the prefrail group was significantly older ($P = 0.009$), and had a significantly higher percentage of people who had experienced falls in the previous 6 months ($P = 0.022$) compared with the non-frail group. Independent t-tests also showed that the prefrail group had marginally less energy expenditure ($P = 0.059$), significantly slower walking speed ($P = 0.022$) and significantly lower grip strength ($P < 0.001$) than the non-frail group. In order to examine the relationship between grip strength and the TUG tests, we carried out further correlation analyses for all participants, and found a significant negative relationship between grip strength and TUG_{manual} performance ($r = -0.283$, $P = 0.023$), but not between grip strength and TUG_{single} ($r = -0.243$, $P = 0.051$) or $TUG_{cognitive}$ ($r = -0.229$, $P = 0.073$).

Figure 1 illustrates the ROC curves showing discriminative ability of TUG_{single}, TUG_{manual} and $TUG_{cognitive}$ as a single screening tool for prefrailty. The AUC value for TUG_{manual} was at moderate accuracy[22] (AUC 0.73 with 95% CI 0.60–0.86), and was better than that for TUG_{single} (AUC 0.67 with 95% CI 0.54–0.80). The AUC value was not significant for $TUG_{cognitive}$ (AUC 0.60 with 95% CI 0.46–0.74).

The optimal cut-off points, determined by the greatest sum of sensitivity and specificity, are listed in Table 2. Independent t-tests showed a significant between-group difference for all three TUG measures ($P < 0.05$). The optimal cut-off point was 7.7 s for TUG_{single} (sensitivity 68%, specificity 61%), 8.2 s for TUG_{manual} (sensitivity 83%, specificity 64%) and 14.3 s for $TUG_{cognitive}$ (sensitivity 29%, specificity 93%). Table 2 also shows the logistic regression analyses results for estimating the risk of prefrailty when the TUG performance was "poorer" relative to "better" according to the optimal cut-off point. In the unadjusted crude model, all three TUG measures poorer than the optimal cut-off point were significantly associated with the risk of prefrailty. After adjusting for age, the OR values became insignificant for TUG_{single} and $TUG_{cognitive}$, but remained statistically significant for TUG_{manual} (OR 7.2 with 95% CI 1.9–27.6).

Discussion

This was the first study that focused on community-dwelling middle-aged and older adults in order to

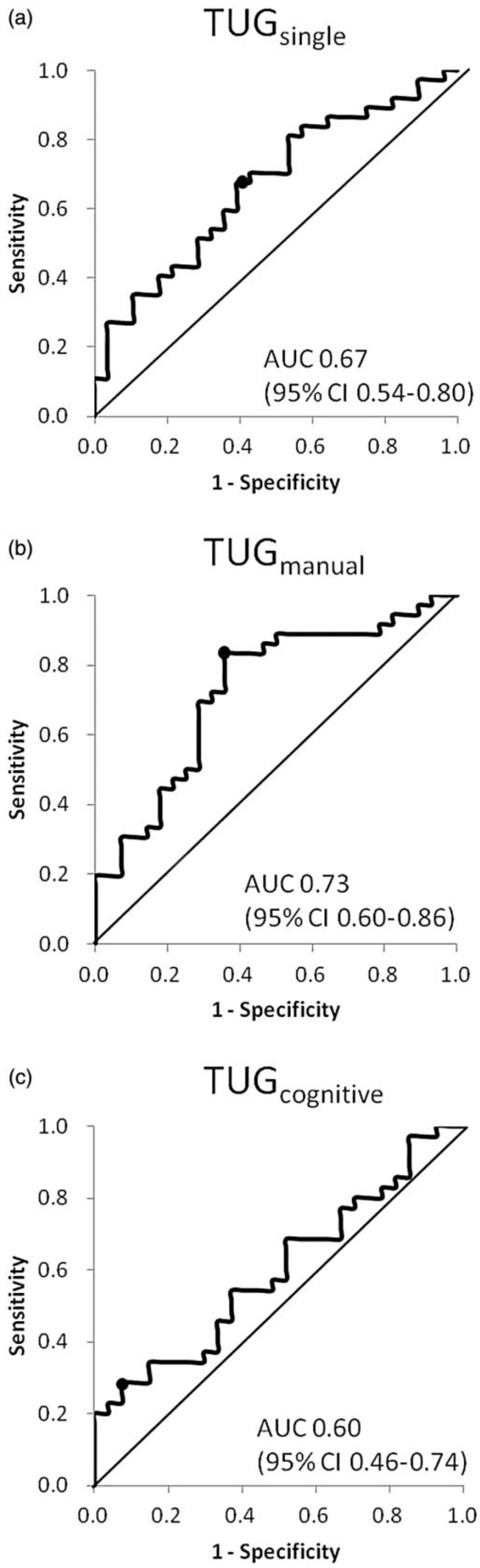

Figure 1 Receiver operating characteristic curves for identifying prefrailty by using (a) single-task Timed Up & Go test (TUG_{single}), (b) dual-task TUG carrying a cup of water (TUG_{manual}) and (c) dual-task TUG carrying out serial-3 subtraction ($TUG_{cognitive}$), in middle-aged and older adults. Area under the curve (AUC) and its 95% confidence interval is shown.

Table 2 Optimal cut-off points of three Timed Up & Go test tasks, and their crude and age-adjusted odds ratios for separating the prefrailty from the non-frail group

	Non-frail $n = 28$ mean ± SD (s)	Prefrail $n = 37$ mean ± SD (s)	Optimal cut-off (s)	Sensitivity	Specificity	OR (95% CI)	Age-adjusted OR (95% CI)
TUG_{single}	7.8 ± 1.5	8.9 ± 1.9*	7.7	68%	61%	2.8 (1.0–7.7)	1.6 (0.5–5.1)
TUG_{manual}	8.3 ± 1.6	10.0 ± 2.6*	8.2	83%	64%	9.0 (2.8–29.0)	7.2 (1.9–27.6)
$TUG_{cognitive}$	10.3 ± 2.6	12.5 ± 5.7*	14.3	29%	93%	5.0 (1.0–25.2)	2.8 (0.5–15.4)

*Significant difference between non-frail and prefrail groups (*t*-test, $P < 0.05$). $TUG_{cognitive}$, dual-task Timed Up & Go test carrying out serial-3 subtraction; TUG_{manual}, dual-task Timed Up & Go test carrying a cup of water; TUG_{single}, single-task Timed Up & Go test.

discriminate individuals at high risk of prefrailty by using single- and dual-task TUG tests. Overall, our prefrail and non-frail groups showed similar characteristics in some factors associated with frailty, including the education level, number of comorbidities and mental status,[18,23] but the prefrail group was older and a higher portion of them had experienced falls. An inspection of their frail indicators showed that 10.8% of them had low physical activity and 91.9% had weak grip strength. Weak grip strength is not only a valid indicator for frailty, but also for mobility limitation.[24] Indeed, the grip strength of our non-frail group was comparable with those found in a disability-free group in Taiwan, whereas the grip strength of our prefrail group was lower than those found in the group who could not carry out heavy housework or carry 11-kg objects.[25] Together, these findings suggest that our prefrail group also likely had some limitations in carrying out instrumental activities of daily living or higher-level physical mobility tasks. Therefore, they should be targeted for early interventions to prevent the development of frailty and disability.[26,27]

We hypothesized that dual-task TUG would have superior ability to identify prefrail individuals as compared with single-task TUG. Partially consistent with our prediction, we found that dual-task TUG that required participants carrying a cup of water while executing TUG (TUG_{manual}) was more sensitive than single-task TUG in identifying prefrail individuals, but the dual-task TUG that required a concurrent mathematical task ($TUG_{cognitive}$) was not. The different discriminating abilities of TUG_{manual} and $TUG_{cognitive}$ might be explained by several factors. First, TUG_{manual} involves a secondary task of carrying a cup of water (weighted approximately 135 g) without spilling the water. This task challenges sustained attention, the endurance of exerting a continuous grip force beyond a certain force level, and the ability to keep a stable arm and trunk posture while the body's center of mass is in continuous motion in the horizontal and vertical planes.[12] As weak grip strength was the primary frailty manifestation that our prefrail participants presented, we speculated that the fact that carrying out TUG_{manual} demands some grip strength, although not maximum, could have contributed to its discriminating ability for prefrailty. Indeed, our further analysis showed a significant negative relationship between grip strength and TUG_{manual} performance, but not with TUG_{single} or $TUG_{cognitive}$. These findings suggest that participants who had poorer grip strength took longer to complete the TUG_{manual}. Second, the fact that TUG_{manual} demands high dynamic balance control ability[12] might also account for our finding, as poor postural control ability is known to contribute to frailty.[28] The reason that $TUG_{cognitive}$ failed to significantly identify people with prefrailty could be due to the fact that the secondary task of $TUG_{cognitive}$ mainly demands cognitive ability beyond mobility; for example, sustained attention, information processing speed and working memory abilities.[29–31] However, the relationship of cognitive ability with frailty or prefrailty remain controversial.[32] In the present study, there was no significant difference in MMSE scores between the prefail and non-frail groups of participants. This could explain why $TUG_{cognitive}$ could not sensitively detect prefrailty in the present study. However, it is worth noting that using a cut-off $TUG_{cognitive}$ value of 14.3 s, the specificity for excluding persons without prefrailty was 93%. Future studies using larger sample sizes and including participants with different cognitive levels might better elucidate the validity of using $TUG_{cognitive}$ to detect prefrailty.

The predictive values of TUG_{single} for prefrailty in the present study (sensitivity 68%, AUC 0.67) are comparable with the values reported by Savva *et al.* (sensitivity 60%, AUC 0.73);[3] both are smaller than the predictive values of TUG_{manual} (sensitivity 83%, AUC 0.73). Using a cut-off of 8.2 s of TUG_{manual} would identify 83% of the prefrail population with 64% of the non-prefrail being excluded, suggesting TUG_{manual} as a sensitive screening test to exclude approximately two-thirds of the population without prefrailty while capturing a substantial majority of prefrail individuals. Although a highly sensitive test might result in higher false-positive results, as a screening tool for prefrailty, it is more important for the TUG_{manual} to be able to identify most individuals with prefrailty rather than to exclude individuals without prefrailty. In addition, the age-adjusted odds ratio showed that individuals with TUG_{manual} performance slower than 8.2 s were 7.2-fold more likely to be prefrail than those with TUG_{manual} performance faster than 8.2 s. This reported cut-off value of TUG_{manual} could serve as a reference value to monitor functional mobility performance of people older than 50 years-of-age, and to identify those at risk of developing prefrailty in the community settings.

The cut-off value of 7.7 s for TUG_{single} is similar to the 7.1 s reported by Kim *et al.* who used fast-pace TUG performance to discriminate frail older adults in the community setting in Japan.[4] However, Savva *et al.* in Ireland reported a higher cut-off point of 10 s for using the usual-pace TUG performance to discriminate frail older adults.[3] This cut-off point discrepancy might be as a result of the different protocols (fast *vs* usual pace) used in carrying out TUG, or also the cultural differences. The meta-analysis of TUG norms conducted by Bohannon *et al.* in African Americans and Caucasians[33] were 2.3 s and 3.4 s longer than those reported by Kamide *et al.* in Japanese[34] for the fast-pace and usual-pace protocols, respectively. These results suggest that Eastern people have faster TUG performance than Western people. Apart from these two factors, previous studies also show that TUG performance could be influenced by age,[33,35] sex[33] and body height.[35]

We acknowledge the limitation that we did not explicitly instruct our participants about task prioritization, in order to observe their nature strategy in dividing attention. However, Oh-Park *et al.* have documented the effects of task prioritization, such that healthy older adults used the posture first strategy even when their attention was directed toward a secondary motor task while walking.[36] The present study was also limited by our small convenience sample. The convenience sample represented community-dwelling middle-aged and older adults who were ambulatory and willing to participant in research and community-based activities. Thus, the present results can only be generalized to adults who are similar to our study population. Nevertheless, the prevalence of prefrailty in our aged sample, 62.3%, is close to the value (58.5%) reported in a study that was carried out on a larger representative sample in a northern Taiwan community using the same prefrailty criteria.[18] The small sample impeded us from carrying out further separate analyses of TUG cut-off points suitable for people of different age, sex and height stratifications. As TUG is an important indicator of frailty/prefrailty, and there seems to be cultural influences on TUG performance,[33,34] future studies are warranted to determine the criterion-specific cut-off points by using population-representative samples in both Western and Eastern countries.

In a group of community-dwelling middle-aged and older adults in Taiwan who were ambulatory and actively participated in community-based activities, we examined how well the single- and dual-task TUG tests could detect prefrailty. Our results suggest that approximately one-third of the middle-aged people already experienced prefrailty syndromes, and should also be targeted in frailty research. While focusing on screening of prefrailty, which occurs at an earlier stage of the frailty spectrum,[6] the TUG_{manual} is more sensitive than single-task TUG in identifying prefrail individuals. The optimal cut-off point of TUG_{manual} of 8.2 s has 83% sensitivity and 64% specificity, and could serve as a reference value to identify those at risk for prefrailty, and hence facilitate early interventions. However, the cut-off point was determined from a group of Taiwanese middle-aged and older adults; therefore, generalization of the present results is limited to middle-aged and older adults in Taiwan, and those with a similar lifestyle in other Eastern countries.

Disclosure statement

This work was supported by a university grant from Chung Shan Medical University (CSMU-INT-101-08 to HC).

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