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Abstract

Background and Purpose: The backward walk test (BWT) has been used to evaluate the balance, gait and fall risk for older adults, but its psychometric properties in older adults with dementia have not been investigated. This study aims at examining the test-retest and inter-rater reliability, construct and known-group validity, and absolute and relative minimal detectable changes at the 95% level of confidence (MDC_{95}) of the BWT in older adults with dementia.

Methods: This study was a cross-sectional study with repeated measures. Thirty older adults with a mean age of 83.3 years and a diagnosis of dementia who were able to walk backward independently for at least 3 meters were recruited from day care and residential care units. The BWT was conducted on three separate testing occasions within two weeks under two independent raters using a modified progressive cueing system. The 10-meter walk test (10MWT), Berg Balance Scale (BBS), and Timed Up and Go Test (TUG) were used to assess the gait, balance and mobility performances of the participants.

Results and Discussion: The BWT had excellent test-retest reliability [intra-class correlation coefficient (ICC) = 0.96] and inter-rater reliability (ICC = 0.97–0.97) in the participants. Moderate correlations between the BWT and BBS [Spearman's rho (ρ) = 0.60], and strong correlations between the BWT and 10MWT (ρ = 0.84) and TUG (ρ = -0.82) were found. The BWT could distinguish between the participants who ambulated with walking aids and those who did not ($p < 0.001$). The participants who had experienced a fall in the past year did not differ significantly in the BWT compared with those who had not fallen ($p = 0.13$). The absolute and relative MDC_{95} of the BWT in the participants were 0.10 m/s and 39.3%, respectively.

Conclusions: The BWT is reliable and valid in assessing balance and gait performances in older adults with dementia. Further investigation is needed to determine whether the BWT can identify those with an increased risk of falls.

Keywords: Dementia, psychometrics, balance, gait, falls

1. Introduction

Backward walking is a daily task that requires high levels of balance and gait control for older adults to perform. Older adults need to walk backward when, for instance, opening a door, backing up to a chair or bed, and adjusting their position in a narrow space [1]. Walking backward is considered to be more balance- and gait-challenging than forward walking due to the reduced visual input, lower automaticity, and higher demand on neuromuscular and proprioception control [2]. Moreover, backward walking demands more cognitive resources, particularly executive function, in controlling neuromuscular action and maintaining postural stability during the task [3,4]. A prior study has shown that age was more closely associated with the performance in backward walking than that in forward walking, indicating that older adults with an advanced age are more likely to have a more noticeable deterioration in the performance in backward walking compared to that in forward walking [5]. The same study has also reported that older adults who had a previous fall walked backward more slowly with shorter stride length and wider base of support than those without a history of falls [5]. This indicates that older adults with impaired balance and gait may have an increased difficulty in backward walking. Assessing the ability to walk backward may therefore provide valuable information for clinicians to evaluate the balance, gait, and risk of falls in older adults.

Older adults with dementia (OwD) are more likely to have postural instability and gait impairment, resulting in an increased risk of falls in this population (Sterke et al., 2012; Taylor et al., 2013b, 2013a; Whitney et al., 2012). Approximately 60% of OwD fall at least once annually (Sterke et al., 2012; Taylor et al., 2013a). OwD are two to five times more likely to experience a fall than those without dementia [11,12]. Falls are the leading cause of functional decline, morbidity, and mortality in OwD [11]. Considering the devastating consequences associated with falls in OwD, it is urgently necessary to develop an effective and efficient tool to evaluate balance and gait performances and identify those with an increased fall risk.

Numerous clinically oriented assessment tools have been developed to examine balance and gait performances for OwD [13–19]. Nevertheless, none of these tools was developed to examine the backward walking performance or predict the fall risk in this population. Recently, a novel assessment tool, the backward walk test (BWT), has been developed to evaluate the backward walking performance in older adults [1]. Prior studies have shown that the BWT is reliable and valid in measuring balance and gait performances in healthy older adults [1] and older adults who have undergone total knee arthroplasty [2]. The test can also identify older adults who have had a fall in the past year [1]. However, the reliability and validity of the BWT in OwD have not been established. Moreover, the ability of the BWT to identify OwD with balance deficit, gait impairment, and an increased risk of falls is yet to be determined.

The reliability and validity of a functional outcome measure predict its applicability in both clinical and research settings. Reliability indicates the degree to which test results are free from measurement errors in a particular population [20]. Test-retest reliability refers to how consistent the ranking of individuals' scores is in repeated measurements conducted by the same rater, while inter-rater reliability indicates how consistent the ranking is in the test conducted by two different raters [21]. Validity is further divided into construct validity, which indicates how much the score of a measure exhibits the underlying concept of interest it is supposed to measure [22], and known-group validity, which represents how well a measure can differentiate between two groups of individuals with respect to the concept of interest [21]. Additionally, the minimal detectable change (MDC) is useful to identify the smallest difference in the score of a measure indicating a "true" change in the performance of an individual [23,24]. MDC can be expressed as an absolute value in the same units as the measure at the 95% confidence level (MDC_{95}) or a relative value representing the proportion of change over time (MDC_{95}%). All of these psychometric properties of a functional measure need to be determined before being used in evaluating patient performance at individual level or comparing group performances in an intervention.

This study aimed at examining the test-retest and inter-rater reliability, construct and known-group validity, and MDC of the BWT for OwD. We hypothesized that the BWT is highly reliable, and moderately to strongly correlated with other balance, gait and functional measures, including the Berg Balance Scale (BBS), Timed Up and Go Test (TUG), and 10-meter walk test (10MWT). We expected that the BWT performance of OwD who did not need walking aid to ambulate, and did not fall in the last year is better than those who needed a walking aid, and did fall in the last year. We also compared the BWT performance of OwD who required different verbal and physical cues during the test to determine whether those who needed a higher level of cueing during the BWT walked slower in the test.

2. Methods

2.1. Study design

This was a cross-sectional, non-experimental study with repeated measures. The reliability of the BWT was examined by asking participants to complete the test with two raters on three separate testing occasions. The scores given by the same rater on the two testing occasions were used to evaluate the test-retest reliability of the BWT, while the scores given by the two different raters were used to examine the inter-rater reliability. The construct validity was investigated based on the correlations between the BWT and the BBS, TUG, and 10MWT. The BBS, TUG, and 10MWT were selected because these tools have been validated in OwD and recommended for measuring postural stability, functional mobility, and gait performance in this population, respectively [25–27]. To assess the known-group validity, the BWT performance was compared between participants using different walking aids, between those attending day care and living in nursing homes, and between those who had a fall or had not fallen in the past year. The MDC of the BWT was determined based on the findings in the test-retest reliability and the performance in backward walking using standardized formulae.

2.2. Participants

Participants were recruited from March to July 2019 from one day care and two residential care facilities. Individuals who were 1) 65 years old or above; 2) able to walk 3 meters backward independently with or without walking aids; and 3) diagnosed with dementia or Alzheimer's disease were eligible to participate in the study. Older adults with significant or acute exacerbation of cardiac, pulmonary, neurological, or musculoskeletal conditions that affected their walking ability; with significant auditory or visual impairment that limited effective communication; who scored below 10 in the Chinese Mini-Mental State Examination (CMMSE) [28]; or who were recently hospitalized in the last month were excluded. Individuals who had severe cognitive impairment (i.e., scored below 10 in the CMMSE) were excluded because they were unlikely to be able to follow instructions and concentrate on unfamiliar procedures [25,29,30]. Potential individuals were first identified by the health care professionals working in the participating facilities and then referred to a research physiotherapist (the first author) who had more than 10 years of experience in managing OwD for screening. The medical records and backward walking abilities of the potential individuals were reviewed by the research physiotherapist to ensure their eligibility.

2.3. Sample size calculation

Strong test-retest reliability of the BWT has been previously reported in people with total knee arthroplasty [intra-class correlation coefficient (ICC) = 0.97] [2]. We expected that a sample size of 30 would be required to achieve 90% power at a confidence level of 0.05 to detect a strong reliability (ICC ≥ 0.90). Anticipating a 20% drop-out rate, this study aimed at recruiting 38 participants.

2.4 Procedures

This study complied with the Declaration of Helsinki. A human subject ethics approval was sought from the Human Subjects Ethics Committee of The Hong Kong Polytechnic University and the participating facilities. Written information about this study, including the study objectives, tests, and duration of participation, was distributed to eligible participants, their main caregivers, and family members via the centers. The details were explained by our investigators face-to-face to every participant and their main caregiver. The main caregiver signed the informed consent on behalf of each participant prior to data collection.

The characteristics of the participants, including age, sex, height, weight, past medical history, and current medications, were first reviewed by the health care professionals in the facilities and then collected by our investigators. The CMMSE was conducted by the research physiotherapist during the screening to assess the participants' global cognition. The use of walking aids (i.e., walking without aid or with a stick, quadripod, rollator, or frame) in the participants was recorded based on the aid used in the BWT.

Falls are defined as "events that result in a person coming to rest unintentionally on the ground or other lower level, not as the result of a major intrinsic event or an overwhelming hazard" [31]. A faller was defined as a person who had experienced one or more falls in the last 12 months, while a non-faller was defined as a person who had not fallen. The history of falls in the past 12 months was collected from the falls surveillance records of the participants and through interviews with the health care professionals in the facilities, supplemented with the information given by the main caregivers of the participants from the day care facility.

The BWT was conducted from June to September 2019. Two physiotherapy students (Raters A and B) first received a 2-hour training conducted by the research physiotherapist (the first author) on the procedures of the BWT, safety issues in conducting functional tests, and skills in communicating with OwD [32]. Each participant was required to repeat the BWT on three separate testing occasions within two weeks. The three occasions were at least one day apart to minimize fatigue and practice effect among the participants [33]. The sequence of the three testing occasions was randomized for each participant to reduce any potential bias. The raters were blinded to the performances in the BWT on the previous testing occasion.

The BBS, TUG, and 10MWT were measured by Rater A on the two testing occasions. To minimize the attentional demand and fatigue among the participants, the BBS was conducted on one testing occasion, while the TUG and 10MWT were performed on the other testing occasion conducted by Rater A.

The participants who had any acute medical condition (e.g., exacerbation of cardiorespiratory or musculoskeletal conditions that required medical attention or hospitalization) during the testing period were first identified by the raters and were eventually excluded from the study. Figure 1 shows the study procedure.

2.5 Measures

2.5.1 Backward walk test (BWT)

A six-meter straight, leveled course in each participating facility was reserved for the BWT. An indoor hallway with walls on two sides was selected in each participating facility to conduct the test. Colored markings were placed at both the start and the end, as well as at the 1.5-meter and 4.5-meter points of the course, using black plastic tape. The first and last 1.5 meters of the course were reserved for acceleration and deceleration, respectively, and the middle three meters was used to measure the BWT. A chair was placed next to the start and the end of the course to allow the participants to sit when listening to the instructions before the test and to rest after completing each trial. Figure 2 shows the set-up of the BWT.

The participants were instructed to wear comfortable clothing, footwear, and corrective eyewear (if applicable) and use their usual walking aids. The participants were not allowed to participate in any vigorous exercise in the two hours before the test started. The heart rates and pulse oxygen saturation of the participants were measured using a finger pulse oximeter prior to and after each trial when the participants were sitting in the chair. The participants were instructed to tell the raters if they had any discomfort, such as nausea, dizziness, chest pain, and excessive fatigue, during the test.

The BWT was conducted based on the procedures described in previous studies [1,2]. The participants were instructed to align their bilateral heels with the colored marking at the start of the course. The participants were told to "walk backward at your usual, comfortable speed." They were allowed to look behind as they walked. The raters walked beside the participants to ensure safety. The time required to walk for the middle three meters of the course was recorded using a stopwatch. The raters started timing when the heel of the leading limb crossed the 1.5-meter marking and stopped when the heel went across the 4.5-meter marking. Three trials were conducted on each testing occasion. After completing each trial, the participants were permitted to rest in the chair for at least one minute until their heart rates returned to baseline. The BWT result was then calculated by dividing three meters by the time used (i.e., meters/second). The average BWT results of three trials were recorded for analysis.

Several strategies were implemented to accommodate the cognitive deficits of the participants and improve their adherence to the test protocol of the BWT [34]. The testing environment was quiet to minimize distraction to the participants [35]. The two testing occasions were arranged at the same time of the day for each participant to reduce the possible diurnal change of behavioral and psychological symptoms in OwD. A progressive cueing system, which has been applied and validated in gait assessment for OwD [27], was modified and incorporated in the BWT to help the participants to finish the test and assist the raters to provide consistent external cues during the test. External cues were provided by the raters when the participants started to deviate from the walkway, to run or slow down, or to stop walking during the BWT based on the following sequence: 0) no cue; 1) verbal cue; 2) one-off physical cue; and 3) intermittent physical cue. When the participants failed to respond to the cue, a higher level of cueing was given. The raters tapped on the participants' on the shoulder once or repeatedly at the level 2 or 3 of cueing respectively. The maximum level of cueing provided in each trial was recorded. The raters were trained to deliver external cues according to the published protocol [33]. A practice trial was arranged before the three trials to determine the level of cueing needed by the participants on each testing occasion.

2.5.2. 10-Meter walk test (10MWT)

The 10MWT was conducted by asking the participants to walk a 10-meter straight, leveled course at their usual speed [33,36]. The first and last 2-meter stretches of the course were reserved for acceleration and deceleration, respectively. The time required to walk the middle six meters of the course was recorded. The 10MWT performance was calculated by dividing six meters by the time used (i.e., meters/second). Two practice trials and one test trial were conducted. The 10MWT has been shown to be reliable (ICC = 0.91–0.94) and valid in frail older people with dementia [27].

2.5.3. Berg Balance Scale (BBS)

The BBS uses 14 functional tasks, including sit-to-stand, chair transfer, turning, tandem standing, and single leg standing, to assess the postural stability of older adults [37]. Each item scores from zero (cannot perform) to four (can fully perform), which add up to a total score between zero and 56. A higher score indicates better postural stability. Strong reliability (ICC = 0.97) and high internal consistency (Cronbach's α coefficient = 0.95) have been reported among people with dementia [18,38].

2.5.4. Timed Up and Go Test (TUG)

The TUG assesses the functional mobility of older adults [39]. The participants were asked to stand up from an armed chair, walk 3 meters at their usual walking speed, turn, walk back to the chair, and sit down in the chair again. The raters started timing as soon as the participants' back left the chair's back, and stopped timing when they sat down and their backs touched the chair's back (timed in seconds). The TUG has excellent reliability (ICC = 0.94–0.99) among older adults with dementia [18,19,40].

2.6. Statistical analysis

The characteristics were compared between the participants using no walking aid and those using walking aids to ambulate using the Mann-Whitney U test and chi-square test. Two-way random, single measures, and consistency model of ICC was used to analyze the test-retest reliability of the BWT, and two-way mixed, average measure, absolute agreement model of ICC was used to analyze the inter-rater reliability of the BWT [41]. The same ICC analyses were repeated for the participants using walking aid and no aid separately to determine whether the test-retest and inter-rater reliability of the BWT were different between these two groups. ICC values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.9 indicate a poor, moderate, good, and excellent reliability, respectively [42]. The correlations between the BWT and functional measures were analyzed using Spearman's rho (ρ) to determine the construct validity of the BWT. Correlation coefficients between 0.3 and 0.6 and higher than 0.6 indicate moderate and excellent correlations, respectively [43]. The BWT performance recorded by Rater A on Occasion 1 were used in the correlation analyses. The BWT results measured by Rater A on Occasions 1 were compared between the participants in different subgroups (i.e., no aid versus any walking aid, and fallers versus non-fallers) using the Mann-Whitney U test to examine the known-group validity of the test. The BWT results of the participants who needed different levels of cueing (no cue, verbal cue, and physical cue) during the test measured by Rater A on Occasion 1 were compared using the Kruskal-Wallis H test.

The MDC of the BWT was calculated using the data collected by Rater A (i.e., test-retest reliability). The standard error of measurement (SEM) was first calculated using the following equation [23]:

$$SEM = sd \times \sqrt{(1 - r)}$$

where sd is the standard deviation of the BWT on Occasion 1, and r is the reliability coefficient, i.e., the ICC of the test-retest reliability. The absolute MDC at the 95% confidence level (MDC_{95}) was calculated using the following equation [23,24]:

$$MDC_{95} = SEM \times 1.96 \times \sqrt{2}$$

where 1.96 represents the z-score at the 95% confidence interval from a normal distribution. The square root of two adjusts for the errors found in the repeated measurements.

The relative MDC at the 95% confidence level ($MDC_{95}\%$) was calculated as follows [23]:

$$MDC_{95}\% = (MDC_{95}/mean) \times 100$$

where "mean" is the average of the three trials on Occasion 1.

The data were analyzed using the SPSS software (version 24). A significance level of 0.05 was used for all analyses.

3. Results

Thirty-three older adults (10 men, 23 women) fulfilled our study criteria and participated in the study. Three participants did not finish the assessments due to acute exacerbation of eczema (n = 1), undue depressive symptoms (n = 1), and fatigue (n = 1) (Figure 1). The age, sex, CMMSE score, and number of chronic diseases of the participants who were unable to complete the study did not differ significantly from those who completed (all $p > 0.05$).

No adverse event during the BWT was reported by the 30 participants who completed the study. The mean age of the participants was 83.3 years. Most of them were female (70%). Approximately half of them were using residential care services (57%). Most participants walked unaided (57%) or with a stick (20%). The participants had an average CMMSE score of 15.3. Eight participants (27%) had had one or more falls in the past year. The participants who did not use walking aid to ambulate were significantly younger, had better CMMSE score, and performed better in the BBS, 10MWT and TUG (all $p < .05$). No significant difference was found in the demographics between the fallers and non-fallers (all $p \geq .05$). The characteristics of the participants are summarized in Table 1.

Table 2 shows the BWT measured by the two raters on the three testing occasions and the reliability coefficients of the BWT. The BWT achieved excellent test-retest reliability (ICC = 0.96) and inter-rater reliability (ICC = 0.97 – 0.97) in the participants.

The correlations between the BWT and other functional measures are shown in Table 3. The BWT was moderately correlated with the BBS ($\rho = 0.60$), and strongly correlated with the 10MWT ($\rho = 0.84$), and TUG ($\rho = -0.82$).

The participants who did not need a walking aid to ambulate walked significantly faster in the BWT than those who needed a walking aid ($p < 0.001$) (Table 4). The difference in the BWT performance between fallers and non-fallers was not significant ($p = 0.13$). The SEM, MDC_{95}, and MDC_{95}% of the BWT were 0.04 m/s, 0.10 m/s, and 39.3%, respectively.

Most of the participants required no cue (level 0; 43%) or a verbal cue (level 1; 43%) during the BWT on Occasion 1. Very few participants needed one-off physical cues (level 2; 3%) and intermittent physical cues (level 3; 10%). The BWT speed of the participants who did not need any cue (0.27 ± 0.13 m/s) and those who needed a verbal cue (0.30 ± 0.21 m/s) was significantly higher than that of the participants who required a physical cue (0.08 ± 0.04 m/s) ($p = 0.032$).

4. Discussion

This study is the first to investigate the reliability and validity of the BWT in OwD. Our findings showed that the BWT was generally safe, reliable, and valid for evaluating balance and gait performances in

OwD. Specifically, the BWT had excellent test-retest and inter-rater reliability in OwD. The test was moderately to strongly correlated with a number of gait, balance, and mobility measures and could distinguish OwD who ambulated with a walking aid from those who did not. OwD who needed higher levels of cueing during the BWT walked significantly slower in the test than those who completed the test independently or using verbal cues only. However, the BWT was unable to identify OwD who had had a fall in the past year.

The excellent test-retest reliability of the BWT found in this study (ICC = 0.96) is consistent with the findings in a previous study on older adults who had undergone knee surgery (ICC = 0.94) [2]. This study is the first to examine the inter-rater reliability of the BWT in any population. The high reliability might be attributable to the use of the standardized protocol of the BWT [1]. Strategies to help the participants to adhere to the test protocol, such as using a non-distracting testing environment, using effective communication skills, conducting the test at the same time of the day, and using practice trials, may also have helped to enhance the reliability of the BWT [15,18,19,33,34].

The strong correlations between the BWT and other functional measures shown in this study (ρ = 0.60–0.84) are consistent with the findings in another study, which showed that the BWT was strongly correlated with the TUG (r = 0.82), four square step test (r = 0.65), and five-time sit-to-stand test (r = 0.61) in healthy older adults [1]. Our findings further demonstrated that the BWT is valid in measuring general mobility, balance, and gait performance in OwD. Our study also showed that the BWT can differentiate OwD who use no walking aid from those who use any walking aid. Despite the large magnitude of the difference in the BWT speed between fallers (0.17 m/s) and non-fallers (0.29 m/s), the difference was insignificant. This differs from a previous study, which reported that fallers had a significantly lower BWT speed than non-fallers among younger, cognitively intact, and functionally independent older adults [1]. Large prospective studies are required to determine whether the BWT is an effective tool to predict falls in OwD.

The MDC_{95} (0.10 m/s) and $MDC_{95}\%$ (39.3%) of the BWT found in this study provide essential information for clinicians to understand how much change in the test results is required to signify a real change in the backward walking performance of OwD. However, the MDC_{95} and $MDC_{95}\%$ of the BWT in this study were in fact quite large, indicating that a large change in the BWT is required to reflect a real change in the backward walking performance of OwD. In other words, the BWT may not be sensitive to changes in the backward walking performance of OwD. Our findings are consistent with those of previous studies that reported good to excellent test-retest reliability but large MDCs of other outcome measures of mobility, balance, and gait in OwD [16,25,44,45]. OwD, particularly those with moderate to severe cognitive impairment, tend to have large individual variability in functional performances, contributing to an increased measurement error when they are assessed by functional measures commonly applied in older populations [44,45]. Previous studies have argued that these functional or performance-based measures may not be applicable in monitoring changes in individual patients due to the unacceptable individual variability (as shown in the MDCs) [44–46]. Clinicians who would like to apply the BWT in their routine practice should be aware of the large variation in the backward walking performances of OwD.

Our study demonstrated that the modified progressive cueing system can be incorporated into the BWT to help the participants complete the test. The high reliability and validity of the BWT in this study may be attributable to the application of the cueing system, which has been used in previous studies to help OwD in completing different functional measures while retaining their original test protocols [19,27,38,47]. Our previous study reported that the cognitive function of OwD was associated with the level of cueing required during walk tests [33]. The present study further showed that the participants who performed worse in the BWT needed more cueing during the test. The interactions between the physical and cognitive functions of OwD and the level of assistance needed during functional measures warrant further evaluation to assist clinicians in providing precise external cues.

Study limitations

This study recruited OwD who were relatively old, had multiple chronic conditions, and were using day care or residential care services. The findings of this study cannot be generalized to younger, community-dwelling OwD. The participants were heterogeneous in nature as they were recruited from two different health care settings with mixed types of dementia. The sample size was rather small and lacked sufficient power for subgroup comparisons. The falls records of the participants were retrieved from their medical records supplemented by the reports of health care professionals as well as the caregivers of the day care participants, which may have resulted in missing information or recall bias.

A longitudinal study design with ongoing monitoring of falls history is necessary to fully examine if the BWT can predict falls in OwD.

5. Conclusion

The BWT had excellent test-retest and inter-rater reliability in assessing balance and gait performances in OwD attending day care and residential care centers. The test was valid and strongly correlated with other general mobility, balance, and gait measures that are commonly used in OwD. The BWT could differentiate between OwD using different walking aids and between those using different health care services, but failed to differentiate those who had had a fall from non-fallers. The MDC_{95} and $MDC_{95}\%$ of the BWT for OwD were recommended. Future investigations using a longitudinal approach to monitor falls history and a larger sample focusing on younger, community-dwelling OwD are warranted.

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Table 1

Characteristics of participants

	Total (n=30)	Unaided (n=17)	With a walking aid (n=13)	*p-value**	Fallers (n=8)	Non-fallers (n=22)	*p-value**
Age (years)							
Mean ± SD	83.3 ± 7.8	79.4 ± 7.5	87.5 ± 5.9	.006	83.3 ± 8.6	82.8 ± 7.8	.80
Sex, n (%)							
Female	21 (70.0)	12 (70.6)	9 (69.2)	.94	5 (62.5)	16 (72.7)	.59
BMI (kg/m^2)							
Mean ± SD	23.3 ± 3.0	23.3 ± 3.0	23.3 ± 3.1	.97	24.3 ± 3.2	23.0 ± 2.9	.24
Number of chronic diseases							
Mean ± SD	4.6 ± 2.0	3.9 ± 1.4	5.5 ± 2.3	.079	4.9 ± 1.9	4.6 ± 2.1	.70
CMMSE (0–30)							
Mean ± SD	15.3 ± 2.8	16.2 ± 2.5	14.0 ± 2.6	.031	15.0 ± 3.3	15.4 ± 2.6	.80

Use of walking aids, n (%)							.41
Unaided	17 (56.7)				4 (50.0)	13 (59.1)	
Stick	6 (20.0)				1 (12.5)	5 (22.7)	
Quadripod	1 (3.3)				0 (0.0)	1 (4.5)	
Frame	1 (3.3)				1 (12.5)	0 (0.0)	
Rollator	5 (16.7)				2 (25.0)	3 (13.6)	
Fall status, n (%)							
Fallers	8 (26.7)	4 (23.5)	4 (30.8)	.66			
BBS (0–56)[a]							
Mean ± SD	43.7 ± 10.4	49.2 ± 4.5	36.3 ± 11.4	<.001	39.6 ± 14.2	45.1 ± 8.5	.28
10MWT (m/s)							
Mean ± SD	0.63 ± 0.3	1.36 ± 0.4	0.64 ± 0.3	<.001	0.76 ± 0.4	1.15 ± 0.5	.06
TUG (s)							
Mean ± SD	30.0 ± 17.9	19.6 ± 7.1	43.1 ± 17.7	<.001	39.4 ± 19.4	26.3 ± 15.4	.05

Note: 10MWT – 10-Meter walk test; BBS – Berg Balance Scale; BWT – Backward walk test; CMMSE – Mini-Mental State Examination; TUG – Timed Up and Go Test.

* Mann-Whitney U test and chi-square test were used.

[a] The brackets indicate the range of scores of the BBS. A higher score indicates better postural stability.

Table 2

Mean ± SD, test-retest, and inter-rater reliability coefficients of the BWT

Mean ± SD (m/s)		Test-retest reliability coefficient $ICC_{3,2}$ (95% CI)	Inter-rater reliability coefficient $ICC_{2,1}$ (95% CI)
Rater A	Rater B		
Occasion 1	Occasion 3	Occasion 1 and 2 (Rater A)	Occasion 1 (Rater A) and Occasion 3 (Rater B)
0.26 ± 0.17	0.25 ± 0.18	0.96 (0.91 – 0.98)	0.97 (0.95 – 0.99)
Occasion 2			Occasion 2 (Rater A) and Occasion 3 (Rater B)
0.27 ± 0.18			0.97 (0.94 – 0.99)

Notes: BWT – Backward walk test

0

Table 3

Correlations between the BWT, TUG, 10MWT, and BBS

	BWT*	BBS	10MWT	TUG
BWT*				
ρ	1.00			
p-value				
BBS				
ρ	0.60	1.00		
p-value	<0.001			
10MWT				
ρ	0.84	0.73	1.00	
p-value	<0.001	<0.001		
TUG				
ρ	−0.82	−0.65	−0.92	1.00
p-value	<0.001	<0.001	<0.001	

Notes: The results of the BWT measured by Rater A on Occasion 1 were used for analyses.

10MWT – 10-Meter walk test, BBS – Berg Balance Scale, BWT – Backward walk test, TUG – Timed Up and Go Test

ρ - Spearman's rho coefficient

Table 4

Comparisons of the BWT between subgroups

	Mean ± SD (m/s)
Walking aids	
No aid (n = 17)	0.37 ± 0.15
Any walking aid (n = 13)	0.11 ± 0.03
*p-value**	< .001
History of falls	
Fallers (n = 8)	0.17 ± 0.09
Non-fallers (n = 22)	0.29 ± 0.19
*p-value**	.13

Notes: The results of the BWT measured by Rater A on Occasion 1 were used for analyses.

BWT – Backward walk test

* Mann-Whitney U test was used.

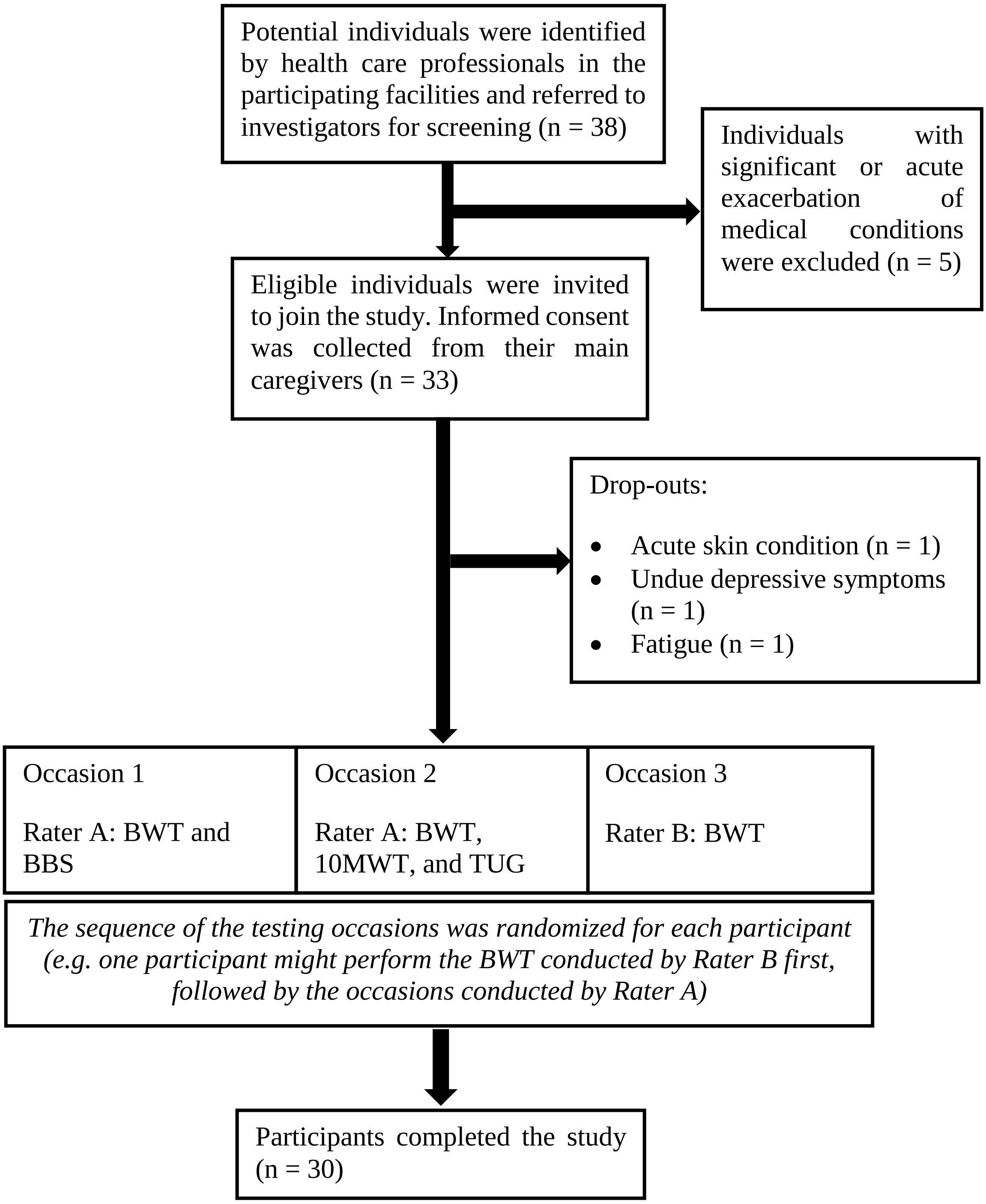

Figure 1. Participant recruitment and study procedure

Notes: 10MWT – 10-Meter walk test, BBS – Berg Balance Scale, BWT – Backward walk test, TUG – Timed Up and Go Test

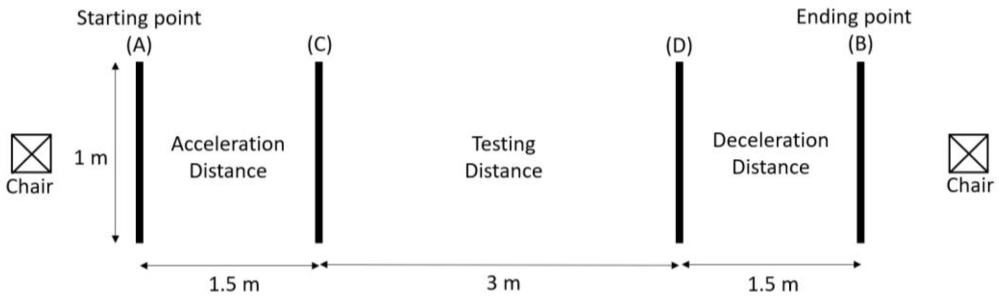

Figure 2. The set-up of the BWT