



Original Article

The Korean version of relative and absolute reliability of gait and balance assessment tools for patients with dementia in day care center and nursing home

HAN SUK LEE, PT, PhD¹⁾, SUN WOOK PARK, PT, PhD^{2)*}, HYUNG KUK CHUNG, PT, PhD³⁾

¹⁾ Department of Physical Therapy, Faculty of Health Science, Eulji University, Republic of Korea

²⁾ Department of Physical Therapy, Samsung Medical Center: 81 Irwon-ro, Gangnam-gu, Seoul 06351, Republic of Korea

³⁾ Ansan University, Republic of Korea

Abstract. [Purpose] This study was aimed to determine the relative and absolute reliability of Korean version tools of the Berg Balance Scale (BBS), the Timed Up and Go (TUG), the Four-Meter Walking Test (4MWT) and the Groningen Meander Walking Test (GMWT) in patients with dementia. [Subjects and Methods] A total of 53 patients with dementia were tested on TUG, BBS, 4MWT and GMWT with a prospective cohort methodological design. Intra-class Correlation Coefficients (ICCs) to assess relative reliability and the standard error of measurement (SEM), minimal detectable change (MDC₉₅) and its percentage (MDC%) to analyze the absolute reliability were calculated. [Results] Inter-rater reliability (ICC_(2,3)) of TUG, BBS and GMWT was 0.99 and that of 4MWT was 0.82. Inter-rater reliability was high for TUG, BBS and GMWT, with low SEM, MDC₉₅, and MDC%. Inter-rater reliability was low for 4MWT, with high SEM, MDC₉₅, and MDC%. Test-retest (ICC_(2,3)) of TUG, BBS and GMWT was 0.96–0.99 and Test-retest (ICC_(2,3)) of 4MWT was 0.85. The test-retest was high for TUG, BBS and GMWT, with low SEM, MDC₉₅, and MDC%, but it was low for 4MWT, with high SEM, MDC₉₅, and MDC%. [Conclusion] The relative reliability was high for all the assessment tools. The absolute reliability has a reasonable level of stability except the 4MWT.

Key words: Reliability, Gait and balance, Dementia

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INTRODUCTION

The number of patients with dementia will increase dramatically over the next few decades¹⁾. The incidence of dementia worldwide has nearly doubled every 20 years and is estimated to reach 40.8 million in 2020 and 90.3 million in 2040²⁾. In South Korea, the prevalence of dementia in elderly people aged 65 years or older was 9.18% in 2012, and the number of patients with dementia is expected to increase from about 540,000 in 2012 to about 1,270,000 in 2030 and 2,710,000 in 2050³⁾.

The utilization rate of facility of individual with dementia almost double that of individual without dementia⁴⁾. Various programs have been developed for user in the facility such as nursing homes, day care centers and long-term hospitals. Recent studies have reported that the program had positive effects on activities of daily living, physical fitness, and functional activities in elderly people with cognitive impairment; thus, the demand for appropriate assessment of program has emerged^{5–8)}.

Dementia causes not only cognitive problems but also a decline in physical performance such as balance, mobility, and muscular strength as well as gait problems^{9–14)}. Particularly, assessment of gait and balance among physical performance is

*Corresponding author. Sun Wook Park (E-mail: assasun@hanmail.net)

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very important for individuals with dementia because those problems are different compared to subtype of dementia¹⁵⁾ and individuals without dementia.

Patients with dementia have difficulty following instructions of therapists properly due to loss of memory and communication ability¹⁶⁾. The reliability of measurements for patients with dementia may reduce significantly because of that. Therefore, it is important to select the reliable tool for therapists as well as patients.

Reliability can be classified into relative and absolute reliability¹⁷⁾. The intraclass correlation coefficient (ICC) estimates the relative reliability that shows a test's ability to differentiate between individuals and the position of individuals in sample group. However, the ICC does not supply the information of the precise measurement for an individual. Absolute reliability that quantifies reliability of scores within individuals on different tests can redeem the insufficiency of ICC. So, both relative and absolute reliability of the test-retest should be estimated to assess the reliability completely¹⁸⁾.

Previous studies examining gait and balance performance in patients with mild to moderate dementia over the recent 10 years have measured only the relative test-retest reliability, not the absolute reliability¹⁹⁻²⁵⁾. Additionally, while there has been analysis of the reliability about Korean version of examining gait and balance on healthy elders, no analysis of reliability has been made on the elders with dementia. Therefore, it is necessary to evaluate the reliability of gait and balance tool before the tools are applied for individual with dementia.

Most common tools to assess a balance are BBS, TUG, FRT (functional reach test) and OLST (one leg standing test). Among Korean physical therapists practicing in clinics, the BBS and the TUG are most commonly used for elderly person in community²⁶⁾. The 6-minute walking test, 4MWT and 10 m walking test are mainly used for assessing gait speed of elderly people. Dynamic gait Index and GMWT for assessing the dynamic gait are commonly used as well. The dynamic gait index test consists of 7 items²⁷⁾ and might be difficult for dementia patient to follow all the items. The 6-minute walking test and 10 m walking test need the large space to evaluate thus those tests are not suitable in clinic. Therefore, BBS, TUG, 4MWT and GMWT would be suitable for patients with dementia to assess.

Therefore, the present study aimed to determine the relative and absolute reliability of BBS, TUG, 4MWT and GMWT commonly used assessment tools for assessing the balance and gait performance in elderly people with cognitive impairment who use the day care center or nursing home in South Korea.

SUBJECTS AND METHODS

We used a prospective cohort methodological design. The purpose of this study was explained to all subjects or their guardians, and they provided consent to participate in this study. The present study was approved by the Institutional Review Board of Eulji University (EU 16-48).

Fifty-three participants were analyzed to determine inter-rater and test-retest reliability. With reference to the study of Bonnet²⁰⁾, considering the following parameters, $k=3$, $\alpha=0.05$, confidence interval width=0.2, and intra-class correlation coefficient (ICC)=0.7 in terms of calculation basis, the number of individuals was determined to be 68. If the dropout rate was set at 10% considering that the subjects were patients with dementia, the number of individuals was determined to be 75. However, 19 participants were dropped. Inclusion criteria were (1) able to understand of direction (2) able to walk with or without assistive device independently for 100 ft. Exclusion criteria were (1) currently receiving medical care (2) individuals with unstable emotion status.

The Timed Up and Go (TUG) test measures the time taken by the subject to stand up from a chair, turn around a cone placed at the 3-m mark ahead, and walk back to the chair¹⁸⁾. The reliability (0.97) is excellent⁴⁾.

The Berg Balance Scale (BBS) consists of 14 items, which are scored by assessing the performance of balance-related tasks. Each item is scored 0–4 points depending on the level of performance, and a higher score indicates a higher balance score. The reliability (0.99) is excellent²³⁾.

In the Four-Meter Walking Test (4MWT), each participant is instructed to walk a 4-m distance at a comfortable walking speed, and the outcome measurement is the best walking speed of two attempts. The reliability (0.90) is excellent²⁴⁾.

In the Groningen Meander Walking Test (GMWT), each participant is instructed to walk along a 6-m line with four curves. The time taken to walk and the number of oversteps outside the path were measured. The back and forth walks were timed separately, and the mean gait speed of the forth and back walks and the number of oversteps outside the path were measured. A faster time score indicates better performance²⁵⁾. The reliability (0.89) is high.

After confirming with the staff at the age care facilities that the subjects have dementia, the examiners visited the facilities from December 2016 to February 2017 to perform the measurements. Three therapists participated as examiners. The staff at the facilities assisted with moving the elderly people with dementia. After the examiners practiced the test methods according to the standardized instructions of the tests, they carried out the tests consistently in terms of time, location, and order of the tests. The second test session was performed between 3 and 7 days after the first test session. The second test session was performed in the same time slot. Three examiners simultaneously evaluated one subject. To avoid knowing each other is scoring, they were asked to put the test result sheets into an envelope, record the date, and store them. On the basis of the suggestions of Vogelpohl et al.²⁸⁾, the examiners first gave verbal instructions to each subject. Subsequently, they performed a demonstration if the subject did not understand it well. Then, tactical guidance or physical assistance was provided if the subject occasionally forgot the motions as shown in the demonstration and tried to perform different motions during the

assessment process²²). No inimical events occurred during the course of the study.

Data was analyzed using SPSS 24 (IBM Inc., Korea), and the general characteristics of the subjects were analyzed using frequency analysis. Intra-class Correlation Coefficients [ICC_(2,3)] were used to assess relative reliability for inter-rater and test-retest reliability. ICC_(2,3) was calculated by taking an average of the three rater's measurements.

The standard error of measurement (SEM) and minimal detectable change at the 95% confidence interval (MDC₉₅) and its percentage (MDC%) in the absolute reliability were calculated. The SEM was calculated using the following equation:

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

Where SD is the standard deviation of the measure and *r* is the reliability coefficient (test-retest reliability). For repeated measurements, the SEM was multiplied by the square root of the number of measurements.

The following formula was used to calculate the MDC₉₅:

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

MDC% was calculated using the following formula:

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

Where the mean value was obtained from two test sessions. An MDC% score of 30% or less is acceptable, whereas an MDC% score of 10% is excellent.

RESULTS

The height, body weight, and grip strength of the subjects were measured to determine their general characteristics. Cognitive function was assessed using the Mini-Mental Status Examination for Dementia Screening, whereas activities of daily living was measured using the Modified Barthel Index Score. Although 75 elderly people agreed to participate in this study, 22 were unable to participate in this study. Ten elderly people did not meet criteria. 9 elderly people could not participate at first test because of sudden absent from the facility (They moved or because of cold or they refused to participate due to sudden changes in emotions). There elderly people were unable to perform the second measurement session because they stopped using the facilities on the day of the second test. A total of 53 subjects were finally tested in the present study. Table 1 shows the general characteristics of the subjects.

The relative reliability for Inter-rater reliability was excellent for TUG, BBS and GMWT (ICC_(2,3)=0.99) and high for 4MWT (ICC_(2,3)=0.82). The absolute reliability for inter-rater reliability was very high for TUG, BBS and GMWT, with low SEM, MDC₉₅, and MDC% values among the three examiners, whereas the absolute reliability for inter-rater reliability was low for 4MWT, with somewhat high SEM, MDC₉₅, and MDC% values (Table 2).

The relative reliability for test-retest was excellent for TUG, BBS and GMWT (ICC_(2,3)=0.96–0.99) and high for 4MWT (ICC_(2,3)=0.85). The absolute reliability for test-retest was high for TUG, BBS and GMWT, with low SEM, MDC₉₅, and MDC% values, but it was too low to accept for 4MWT, with somewhat high SEM, MDC₉₅, and MDC% values (Table 3).

DISCUSSION

The present study was conducted to determine the inter-rater and test-retest reliability of gait and balance assessment tools by analyzing the Korean version of relative (ICC) and absolute reliability indices (SEM, MDC₉₅, and MDC%) to demonstrate their suitability for patients with dementia who use day care center or nursing home in South Korea.

The results of the present study found that the relative reliability of TUG, BBS, 4MWT and GMWT in assessing gait and balance performance ranged from the excellent to the good. The absolute reliability indices such as SEM, MDC₉₅, and MDC% were low for the assessment tools except for 4MWT, indicating that those assessment tools were reasonably sufficient to detect a true change in assessing gait and physical changes in patients with dementia.

In the present study, the relative reliability was found to be very high, with inter-rater ICC_(2,3)≥0.99 and test-retest ICC_(2,3)≥0.96 for TUG, BBS and GMWT. The relative reliability was found to be good, with inter-rater ICC_(2,3)=0.82 and test-retest ICC_(2,3)=0.85 for 4MWT. According to a study by Portney, a relative ICC_(2,3)>0.90 represents a very high reliability and relative ICC_(2,3)>0.75 represents good reliability. Therefore, the assessment tools used in the current study can be considered to have excellent relative reliability for assessing gait and balance in patients with dementia.

In Telenius's et al. study examining the inter-rater reliability of gait and balance assessment tools for patients with mild to moderate dementia residing in nursing home, a high relative reliability of BBS and 6MWT was shown²²). In addition, a study by Muir-Hunter et al.⁴) examining the inter-rater reliability of TUG for community-dwelling patients with Alzheimer disease

Table 1. Descriptive statistics for participants (N=53)

| Characteristics | Height (cm) | Age (yrs) | MMSE-DS (score) | MBI (score) | Grip strength (kg) |
|-----------------|---------------|--------------|-----------------|---------------|--------------------|
| Mean (SD) | 151.60 (9.63) | 83.83 (9.88) | 13.76 (5.74) | 72.56 (24.47) | 13.75 (6.86) |

MMSE-DS: mini-mental state examination-dementia scale; SD: standard deviation; MBI: modified barthel index

Table 2. Inter-rater reliability of gait and balance assessment tools

| Test | Mean | SD | ICC _(2,3) | SEM | MDC ₉₅ | MDC _% |
|-------------|-------|-------|----------------------|------|-------------------|------------------|
| TUG (sec) | 22.27 | 14.15 | 0.99 | 0.63 | 1.75 | 7.87 |
| BBS (score) | 36.94 | 12.44 | 0.99 | 0.78 | 2.18 | 5.09 |
| 4MWT (sec) | 2.1 | 1.72 | 0.82 | 0.74 | 2.06 | 97.98 |
| GMWT (sec) | 19.23 | 11.99 | 0.99 | 1.00 | 2.78 | 14.46 |
| GMWT (step) | 12.39 | 7.66 | 0.99 | 0.76 | 2.12 | 17.14 |

SD: standard deviation; ICC: intra-class correlation coefficients; SEM: standard error of measurement; MDC₉₅: minimal detectable change at the 95%; TUG: timed up and go; BBS: berg balance scale; 4MWT: four-meter walking test; GMWT: Groningen meander walking test

Table 3. Test-retest reliability of gait and balance assessment tools

| Test | Mean | SD | ICC _(2,3) | SEM | MDC ₉₅ | MDC _% |
|-------------|-------|-------|----------------------|------|-------------------|------------------|
| TUG (sec) | 22.28 | 14.18 | 0.99 | 1.27 | 3.52 | 15.78 |
| BBS (score) | 36.94 | 12.43 | 0.99 | 1.36 | 3.78 | 10.22 |
| 4MWT (sec) | 2.11 | 1.64 | 0.85 | 0.64 | 1.78 | 84.26 |
| GMWT (sec) | 19.24 | 11.95 | 0.99 | 1.36 | 3.78 | 19.63 |
| GMWT (step) | 12.40 | 7.75 | 0.96 | 1.49 | 4.13 | 33.32 |

SD: standard deviation; ICC: intra-class correlation coefficients; SEM: standard error of measurement; MDC₉₅: minimal detectable change at the 95%; TUG: timed up and go; BBS: berg balance scale; 4MWT: four-meter walking test; GMWT: Groningen meander walking test

found that the relative reliability was high ($ICC_{(2,3)} > 0.98$) for TUG, which is very similar to the results of the present study.

The previous studies^{4, 19–22, 23–25, 29}) investigating the test-retest relative reliability of gait and balance assessment tools for patients with mild to moderate dementia have found that BBS, TUG, 6MWT, and GMWT showed good to excellent relative reliability ($ICC = 0.80–0.99$), and the assessment tools used in the present study also showed good relative reliability for test-retest reliability ($ICC = 0.85–0.99$). Therefore, the present study demonstrated that the instruments, BBS, TUG, 4MWT and GMWT, are sufficiently applicable in gait and balance assessments of Korean elderly patients with dementia under similar conditions.

Absolute reliability refers to the degree to which repeated measurements vary in individuals, and a smaller variation indicates a higher absolute reliability¹⁸). Since SEM and MDC are expressed in the same units as in the original measurements, they have the advantage of being easy to interpret and being useful for clinicians in determining improvement of individuals. Because MDC is based on SEM, these two values are closely related^{19, 24}).

SEM is an important statistical method for researchers to determine whether the change in test scores measured in a specific group is a true value. Gait and balance assessment tools should indicate small measurement errors and should be sensitive in identifying true changes at both individual and group levels. Many researchers have suggested using the SEM as a criterion for determining whether a change in test scores in a group of subjects indicates a real improvement^{30, 31}), and a smaller SEM indicates a higher absolute reliability and there was no difference between the true scores and the recorded scores. MDC refers to the minimal amount of change that is required to distinguish a true change that exceeds measurement errors or intra-subject variability, and if a subject's score exceeds the MDC score, it reflects a true change in performance at the 95% confidence interval³²).

In the present study, SEM and MDC as absolute reliability indices for inter-rater and test-retest reliability were low (within 10% of the mean test values of the assessment tools, except for 4MWT; SEM, 30%–35%), indicating that the absolute reliability was overall high. In a study by Wittwer et al.³³) that assessed the absolute reliability of gait speed for patients with dementia using GAITRite, the SEM value was found to be very low (3.8%). In studies by Telenius et al.²²) and Blankevoort et al.¹⁹) measuring gait speed on a 6-m walking test using a stopwatch, SEMs were reported to be relatively low (5.7% and 13.1%, respectively). However, unlike the previous studies with 6-m walking test, the present study assessed the 4MWT, which measured the time that each subject completely passed through the 4-m finish line using a stopwatch. It is considered that at that point, inter-examiner and test-retest measurement errors were increased, suggesting that the SEM was high. In the present study of the 4MWT, each subject was instructed to start walking from 1 m before the starting line and to walk

naturally up to 1 m after the finish line. Therefore, it is considered that there was a time difference when each examiner pressed the stopwatch while watching the feet of each subject passing the 4-m starting line and reaching the 4-m finish line. In future studies with 4MWT, the absolute reliability of the 4MWT can be increased if examiners give verbal instructions to individual subjects when they start walking from 1 m from the starting line and pass through the 4-m starting line and when they reach the 4-m finish line.

Because of the low number of samples, the results of the present study are difficult to generalize. In addition, the selection criteria included those with or without a walking aid, and thus, subjects with walking aid might have achieved better scores than their actual gait performance. Further, as three examiners simultaneously evaluated one patient, they could watch each other's assessment; however, they did not discuss their assessment with each other. Subjects with emotional lability possibly scored lower than their actual ability due to their emotional state on the day of the test.

The present study revealed that the relative reliability was high for all gait and balance performance assessment tools such as BBS, TUG, 4MWT and GMWT. In addition, the results of the present study showed that the absolute reliability has a reasonable level of stability and that the assessment tools evaluated, except for 4MWT, are useful for detecting true change in gait and balance performance in elderly people who use the day care center or nursing home in South Korea.

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Conflict of interests

All authors declare that there is no conflict of interests regarding the publication of this article.

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