Validity and Reliability of The 3-Meter Backward Walk Test in Individuals with Stroke

Ayşe Abit Kocaman,* Saniye Aydoğan Arslan,* Kübra Uğurlu,* Zekiye İpek Katırcı Kırmacı,† and E.Dilek Keskin,‡

Objectives: The 3-m backward walk test (3MBWT) is used to evaluate neuromuscular control, proprioception, protective reflexes, fall risk and balance. The aim of our study was to reveal the test-retest reliability and validity of the 3MBWT in stroke patients. *Materials and Methods:* This study included a total of 41 stroke patients [age 59 (35−78) years]. 3MBWT, Berg Balance Scale (BBS), Timed Up and Go test (TUG) were applied to the patients. The second evaluation (retest) was carried out by the same physiotherapist two days following the first evaluation (test) in order to measure test-retest reliability. *Results:* Cronbach's alpha coefficient was found to be 0.974 (excellent). For intra-rater agreement, the ICC values in the individual test were 0.985. The SEM value was 1.11 sec, the MDC value was found to be 1.57 sec. A moderate correlation was revealed between the 3 m-backward walking speed and BBS (r: -0.691, p: 0.001) and TUG (r: 0.849, p: 0.001). *Conclusions:* The 3MBWT was observed to be valid and reliable in stroke individuals. It is an effecive and reliable tool for measuring dynamic balance and falls in stroke.

Key Words: Falls—Stroke—Backward walking—3MBWT—Validity—Reliability

Introduction

Balance disorders are one of the most important motor problems in stroke individuals. There are many factors leading to balance disorders in stroke. Factors such as; Increased postural sway, weight asymmetry due to more weight on the unaffected limb, decreased muscle strength and diminished sensory input from the affected limb, loss of strength, abnormal muscle tone, biomechanical limitations, sensory deficits, delay of automatic postural responses, instability to adjust the limits of stability and cognitive problems cause balance disorders.[1,2]

Studies show that falls are one of the most common complications after stroke.[3] The frequency of falling within the first six months after discharge from the hospital varies between 36% and 73%,[4] and the rates of falling are observed to be high between 40% and 58% one year after stroke.[5,6] Individuals with stroke have a higher risk of falling compered to healthy people of similar age and sex in the chronic period.[7]

Falls during survival after stroke may cause more physical complications such as soft tissue injuries, fractures, and limitations in functional activities.[8] In addition to injuries, the presence of a fall history leads to limited activity, increased fear of falling, and decreased functional independence in individuals with stroke.[9] They are barriers to social and community involvement and adversely affect the quality of life. Therefore, it is quite important to develop effective interventions to decrease the risk of falling by performing a detailed evaluation of balance after stroke.[10] Thus, a valid, reliable, and quantitative measure of balance is required for individuals who survive after a stroke to prevent falls by clinicians in rehabilitation units, perform direct interventions on the physiological factors underlying falls, and implement fall prevention strategies. Thus, post-stroke balance disorders should be determined by a multidimensional evaluation. In previous studies,[3,11] the Berg Balance Scale, Functional Reach Test, Timed Up and Go (TUG) Mini Balance Evaluation Systems Test

From the *Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Kırıkkale University, Kırıkkale, Turkey; †Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Sanko University, Gaziantep, Turkey; and ‡Faculty of Medical Sciences, Department of Physical Medicine and Rehabilitation, Kırıkkale University, Kırıkkale, Turkey.

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Corresponding author. E-mail: aysekocaman@kku.edu.tr.

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(Mini-BESTest), Stroke Assessment of Fall Risk (SAFR), and general fall risk measurements (e.g., questioning the history of fall) were used.[12–14] These tests primarily evaluate the ability to walk forward, return, and step. However, backward walking is apparently more difficult, and an increase occurs in the dependence on neuromuscular control, proprioception, and protective reflexes.[15] It is required to walk backward to carry out tasks, e.g., opening the door, getting rid of sudden obstacles, or backing up to chair.[16] Recent research has shown that the evaluation of backward walking is more sensitive in assessing mobility and balance disorders in comparison with forward walking.[15] A study conducted has demonstrated that backward walking is a training approach that develops after the stroke, and it has several potential benefits in terms of promoting the improvement of forward walking and on the results of balance and walking.[17]

The 3-meter backward walk test (3MBWT) is utilized to assess neuromuscular control, proprioception, protective reflexes, risk of falling, and balance. In a study conducted on healthy older adults, the 3MBWT was reported to show better diagnostic accuracy compared to the most frequently used measurement methods for falls in the past years.[16] Reliability is extremely important, in particular for research and clinical applications. Measurement methods need to be reliable and change correctly over time to evaluate balance and the risk of falling. The 3MBWT was determined to be reliable in healthy older individuals.[16] Nevertheless, in the literature, studies investigating the validity and reliability of this test in stroke individuals were not observed. Reliability is population-specific, and it is essential to investigate the reliability of the 3MBWT in stroke patients. Thus, the goal of our study is to reveal the test-retest reliability and validity of the 3MBWT.

Method

The current research was conducted at the Physical Medicine and Rehabilitation Clinic of Kırıkkale University, Faculty of Medicine, between January 2020 and May 2020. The patients, diagnosed with hemiplegic and ischemic stroke by a neurologist and with a stable condition, were enrolled in the research. Ethical permission for the research was acquired from the Non-Interventional Research Ethics Committee of Kırıkkale University with the decision number 2019.12.19. The trial was registered at ClinicalTrials.gov NCT04229914. Written informed consent was acquired from all the participants.

Sociodemographic data, dominant side, affected side, the type and duration of a stroke, and the fall history within past 12 months (yes/no) of the participants were recorded.

The inclusion criteria were as follows: the patients diagnosed with stroke by a neurologist, the patients who; were at least 18 years of age, were oriented and cooperative by general condition, and the patients with a stable condition (those who received the score of 24 or above from the Mini Mental Status Examination and could walk independently for minimum 10 m). Patients with the Mini Mental State Examination (MMSE) score < 24, patients having an orthopedic or neurological disease that might influence balance (such as Parkinson, multiple sclerosis, ataxia, vertigo, Alzheimer and similar dementia diseases, brain and spinal cord tumors), patients having severe vision and hearing impairment, and a history of brain lesions were not enrolled in the research.

Study design

Our study was conducted as "test-retest" design and the psychometric properties of 3-m backward walk test were examined in stroke petients. The Mini Mental Status Examination, 3-m backward walk test, Berg Balance Scale, Timed Up and Go test were applied to the patients. All evaluations were performed by the same physiotherapist. The second evaluation (retest) was carried out by the same physiotherapist two days following the first evaluation (test) in order to measure test-retest reliability. It was preferred to collect data with a same evaluator in order to avoid the inter-rater variability error rate between the evaluations. The patient was evaluated at one time of the day for test and retest.

Sample size calculation

According to the Lexell and Downham[18] 30−50 participants should be included in the reliability studies. Considering this recommendation, defining the reliability of 3MBWT, 41 stroke individuals were reached in our study.

Evaluations

3-meter backward walk test

The distance of 3 meters was measured and marked with a black tape. The participants were asked to align their heels with the black tape. The individuals were asked to walk backward as soon as possible with the command "walk" and to stop when they reached 3 meters. Meanwhile, the elapsed time was recorded in seconds. The individuals were allowed to look back if they wanted. The person making the assessment walked backward with the individual to provide safety and prevent the fall risk. The evaluation was made three times, and the average time was recorded.[16] Since more neuromuscular control and proprioceptive sensation is required during back walking, the feeling of insecurity in stroke individuals causes fear of falling. Therefore, the therapist performing the test should be about half a meter behind the patient during the test to guide the patient's walking speed and ensure safety.

The Berg Balance Scale was designed for the quantitative evaluation of balance and determining the fall risk,

and it was preferred because it evaluates individuals' ability to maintain their balance while carrying out functional activities. The BBS consists of 14 items aiming at the direct observation of maintaining body balance during the realization of performance. Each item is scored between 0 and 4, based on the patient's ability to meet test-specific time and distance requirements. In the test, which is made difficult by reducing the supporting ground, 4 points indicate the ability to complete the task independently, while 0 points indicate the inability to start the task. The test measures the level of dependence and/or independence during positions, e.g., standing up without sitting, standing with feet adjacent, standing in the tandem position, staying in balance on one leg, and evaluates the person's ability to change his/her position. In accordance with the scores acquired from the said test, the cases are divided into groups as "high fall risk (0−20 points)", "moderate fall risk (21−40 points)", "low fall risk (41−56 points)". Fifty-six, which is the highest score, is accepted to show the best balance.[19] The Turkish validity and reliability study of the scale was performed by Şahin et al.[20]

The Timed Up and Go test is applied to assess patients' balance and fall risk. A standard chair was utilized for the test. First of all, the patient was asked to sit by leaning against the chair. The patient was then asked to stand up, walk with regular steps at a predetermined distance of 3 meters, return at the end of 3 meters, and sit in the chair. The patient's walking time during the test was recorded by a stopwatch in seconds. The test was repeated three times, and the average value was recorded.[21]

Statistical analysis

Data analysis was conducted using the SPSS 23.0 (SPSS Inc., Chicago, Illinois, USA) program. The Kolmogorov-Smirnov test was used to check the normality of the distribution of variables.

Reliability

The Cronbach's alpha reliability coefficient and test-retest reliability and intra-class correlation coefficient (ICC) were utilized for internal consistency in reliability analyses. The ICC coefficient was considered as weak if it was smaller than 0.40, as below moderate if it was between 0.40-0.59, as moderate if it was between 0.60-0.74, as good if it was between 0.75-0.89, and as very good if it was greater than 0.90.[22]

Validity

Concurrent validity analysis was used to investigate the validity of the 3MBWT in stroke individuals. For convergent validity, the relationship between the BBS and TUG was evaluated with the Spearman correlation test. Spearman correlation analysis was performed by controlling the effect of age. Dancey and Reidy's classification was used to decide on the strength of the correlation: 0.00 indicates no correlation, 0.001−0.29 low-level correlation, 0.30-0.70 moderate-level correlation, 0.71-0.99 high-level correlation, and 1.00 indicates the perfect correlation.[23]

Standard error of measurement (SEM) and minimal detectable change (MDC)

SEM is an estimate of random variation that occurs in data without any real changes. It can be calculated from MDC and SEM with 95% accuracy. The MDC value is defined as the minimum amount of change that must be observed in the data, either as a group or individually. In our study, the SEM and MDC values were computed for the 3MBWT. It was calculated using the following formula: $MDC95\% = 1.96 * SEM * \sqrt{2}$; $SEM = SD\sqrt{(1-ICC)}$.

Results

This study included a total of 41 stroke patients [age 59 (35−78) years]. The sociodemographic and clinical data of the participants are presented in Table 1. Test-retest reliability: The average of the first measurement of the 3MBWT was calculated as 15.45 ± 8.91s, and the second

Table 1. *Socio-demographic characteristics of the participants.*

	Participants
Gender	
Female, n (%)	13 (31.7)
Male, n (%)	28 (78.3)
Age, (years), median (minimum-maximum)	59 (35-78)
BMI, (kg/m^2), median (minimum-maximum)	27.48 (17.92-42.24)
Stroke duration(month)	3 (1-132)
Stroke Type, n (%)	
Hemorrhagic	22 (53.7)
Ischemic	19 (46.3)
Dominant side, n (%)	
Right	37 (90.2)
Left	4 (9.8)
Affected side n (%)	
Right	17 (41.5)
Left	24 (58.5)
Falling history **n (%)**	
Nonfaller	22 (53.7.7)
Fallers	19 (46.3)
3MBWT (second), median (minimum-maximum)	13.91 (5.40-41.77)
BBS score, median (minimum-maximum)	46.50 (14-56)
TUG (second), median (minimum-maximum)	17.01 (7.30-53.33)

n: participant; %: percentage; BMI: Body Mass Index; 3MBWT, 3-m backward walk test; BBS: Berg Balance Scale; TUG: Timed Up and Go Test

Table 2. *The relative (ICC coefficient) and absolute (SEM and SRD95) reliability of the 3MBWT.*

First trial (mean SD)	Second trial (mean SD)	Difference (mean SD)	ICC (2, 1) 95% CI	SEM	$MDC_{95\%}$
15.45 ± 8.91	15.55 ± 9.39	0.11 ± 2.27	0.985	1.11	1.57

3MBWT, 3-m backward walk test; CI, confidence interval; ICC, intraclass correlation coefficient; SD, standard deviation; SEM, standard error of measurement with a 95% CI; $MDC_{95\%}$: Minimum Detectable Change at 95% of Confidence Interval

measurement was calculated as 15.55 ± 9.39 s. In accordance with the correlation analysis conducted, a very high correlation (r = 0.974) was determined between the first measurement of the test and the second measurement repeated one day apart (Table 2).

Cronbach's alpha coefficient was found to be 0.985 (excellent). For intra-rater agreement, the ICC values in the individual test were 0.985 (95% CI; 0.973−0.992 (excellent agreement). While for the 3MBWT, the SEM value was 1.11 s, the MDC value was found to be 1.57 s.

Concurrent validity

A moderate correlation was revealed between the 3 m-backward walking speed and BBS (r: -0.691, p: 0.001) and TUG (r: 0.849, p: 0.001). (Table 3).

Discussion

As a result of our study, the 3MBWT was observed to be valid and reliable in stroke individuals. In academic studies and clinical applications, to evaluate the effectiveness of an application, test result measurements should be valid, reliable, and sensitive to changes in the patient's condition. Our study has contributed significantly to the literature in terms of determining the validity and reliability of the 3MBWT in stroke individuals.

Motor control disorders and, consequently, losses experienced in independence in functional activities are the most common symptoms of stroke. Walking is the most important functional activity for stroke patients. Accordingly, most of the physical therapy period of a stroke patient is spent on the walking ability. The primary treatment goal for stroke patients is to improve walking, and to gain back the normal walking ability is important.[24] Although it is stated that 60% of individuals after stroke can walk independently in daily life activities according to the Functional Independence Scale and Barthel Index, their disability continues since their independence in social activities is affected. Due to permanent deficits that occur in balance and postural control, falls at a rate of 73% occur in stroke individuals with mild and moderate disorders. It has been reported that this decrease in functional independence and muscle strength and the disruption in balance cause an increase in the incidence of falling and fear of falling, and this also causes a decrease in the level of physical activity, and this situation continues as a vicious circle.[25] According to the literature, the backward walk function is also affected in stroke individuals. Since balance and self-efficacy are also affected, their evaluation and the addition of backward walk training to physiotherapy and rehabilitation programs have been emphasized to be important.[26,27] After the stroke, individuals fall not only during a forward walk but also during returning or transferring, both of which usually require a step back.[28]

Table 3. *Correlation Coefficients Between 3MBWT and BBS, TUG.*

	BBS	TUG
3MBWT	r = 0.691 p = 0.001	r = -0.849 p = 0.001

3MBWT: 3-m backward walk test; BBS: Berg Balance Scale; TUG: Timed Up and Go Test.

Common performance-based functional measures that have been related to functional ability, balance, and fall prediction primarily assess forward walking and the ability to turn around. Nevertheless, backward walking is apparently more difficult and requires an increased reliance on neuromuscular control, proprioception, and protective reflexes.[15]

While walking backward, there is no environmental visual feedback and visual flow used to plan movement during forward walking. Due to the lack of visual information, much more sensory feedback is required to control the step order.[29] Backward walking is required to carry out tasks, e.g., backing up to a chair, opening up a door, or getting out of the way of a sudden obstacle. The said movement can be especially difficult for older individuals or individuals with neurological deficits.[30] Therefore, since backward walking requires more postural control, its evaluation in terms of dynamic balance and fall risk is important.[31] Since the ability to walk backward in stroke individuals is an important factor of mobility and functionality, deficits occurring in this function may be associated with the risk of falling backward. Thus, the evaluation of backward walking can be an important clinical tool [30].

Although the 3MBWT is a new test, it has been started to be used frequently in recent times.[16,32] In a study conducted on healthy older adults, the 3MBWT showed diagnostic accuracy similar to or better than the most frequently used measurements for the last year's falls. The 3MBWT was also found to distinguish between groups with a fall history in older individuals. People who walked faster than 3.0 seconds in the 3 MBWT were stated

to be less likely to report falls, and those who were slower than 4.5 seconds were reported to be very likely to report falls.[16] Carter et al.[33] reported that 3MBWT cutoff of 4.2 secondas was identified to be the most optimal for defining falls in Parkinson's disease. In our study, the first and second walking durations of stroke patients were recorded as 15.45 ± 8.91 and 15.55 ± 9.39, respectively. According to these results, we can think that stroke individuals are at a higher fall risk and have balance problems compared to healthy older individuals. Therefore, we think that the backward walking function should also be definitely evaluated in stroke individuals.

In the studies, the Berg Balance Scale, Functional Reach Test, Timed Up and Go Test, Mini Balance Evaluation Systems Test (Mini-BESTest), and Stroke Assessment of Fall Risk (SAFR) were observed to be frequently used as the scale of balance, fall risk and mobility in individuals with stroke.[11–14] The studies stated that the Berg Balance scale (ICC: 0.97),[34] functional reach test (ICC: 0.92),[35] and TUG test (ICC: 0.95)[36] have excellent intra-rater reliability in stroke individuals. In our study, the 3MBWT (ICC: 0.985) was also found to have excellent intra-rater reliability.

In our study, the Berg Balance Scale and TUG, which are also frequently used in the clinic, were used to test the validity of the 3MBWT. In accordance with the correlation analysis performed, a moderate correlation was revealed between the 3MBWT and BBS and TUG. We believe that we found a relationship since the BBS and TUG scales do not contain backward walking activity, but they contain returning activity.

At the APTA's 2020 Combined Sections Meeting (CSM) congress, papers examining the 3MBWT in neurological cases (in individuals with Parkinson's disease and stroke) were presented. One of these papers reported that the 3MBWT showed better diagnostic accuracy than other common tests for falls in the last one year in Parkinson's patients. Another paper reported that the 3MBWT was highly correlated with instrumented walkway (Gait RiTE) and had excellent validity in stroke individuals.[33,37]

The results obtained from the tests applied should also be meaningful for clinicians in order to use these tests in practice in the clinic. In the literature, Ünver et al.[32] reported the MDC value as 2.94 in the study in which they examined the reliability of the 3MBWT in patients with primary total knee arthroplasty. MDC values may vary depending on the population. The 3MBWT is very sensitive in stroke patients. Clinicians and researchers can check whether a change higher than the MDC value (1.57) occurs to assess whether there is a significant change in stroke patients' performance.

Limitations

Since the patients were difficult to follow up, we could not perform a re-evaluation after a long term (2 or 4 weeks). Moreover, the predictive validity for the 3MBWT was not evaluated in stroke patients. The cut-off value and MCID of 3MBWT can be determined in further studies.

Declaration of Competing Interest

None

Disclosure statement

No potential conflict of interest was reported by the authors.

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