Usefulness of the Dual-Task Stepping Test to Determine the Independent Toileting Ability of Patients with Stroke Who Could Perform Stepping in a Seated Position

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Abstract: Introduction: This study aimed to identify the usefulness of the dual-task stepping test to determine the independent toileting ability of patients with stroke.

Method: Sixty-seven stroke in-patients who were able to perform stepping in a seated position were enrolled in the study and underwent the dual-task stepping test. The relationships of the test results with other assessments (Berg Balance Scale, Mini-Mental State Examination, and the Attentional Rating Scale) with toileting ability, and with factors affecting toileting ability were investigated by regression analysis.

Results: Patients with low dual-task performance tended to have poorer balance, attentional, and cognitive abilities. The results of the dual-task stepping test and rates of independent toileting were distributed as follows: severe dual-task disability, 15.6% (5/32); mild dual-task disability, 64.7% (11/17); and normal dual-task ability, 94.4% (17/18). The dual-task stepping test results revealed a significant relationship between dual-task disability and toileting ability ($p < 0.01$). Logistic regression analysis showed that the dual-task stepping test had the highest odds ratio for toileting ability ($p = 0.00$; odds ratio, 14.50).

Conclusion: The dual-task stepping test was useful for determining independent toileting ability. This assessment is rapid and does not require special equipment or infrastructure, and has the potential for wide application in clinical practice.

Keywords: stroke, toileting, dual-task, assessment, rehabilitation

Introduction

Independent toileting is an important activity of daily living (ADL) [1, 2]. For in-patients with stroke, independent toileting ability is essential for independent living because it is an activity that normally requires a standing position, and therefore, has a high risk for falls [3]. However, it is difficult to determine independence in this area owing to the number of components involved in toileting, such as motor function required to transfer between a toilet and a wheelchair, lower body dressing while standing, cognitive function required to control urination and defecation, and attention required to perform some of these functions simultaneously. The association between toileting ability and several rehabilitation evaluations have been reported, including the evaluation of motor function, Berg balance scale (BBS) [4], the Stroke Impairment Assessment (SIAS) [5], and the Functional Assessment for Control of the Trunk (FACT) [6]. Evaluations of cognitive function, such as the Mini-Mental State Examination (MMSE) [6],
hemispatial neglect [7], and aphasia [8] have also been included. The BBS score is a significant predictor for the independent performance of most activities of toileting [4]. BBS cannot be considered a strong predictor for toileting ability, because it does not relate to the ability to control urination and defecation, which is an essential component of toileting. By clinical experience, even a patient with good physical balance does not always have independent toileting ability. Therefore, to evaluate independence in toileting, it is important to assess motor, cognitive, and attention functions simultaneously.

In recent years, dual-tasking (performing a motor and cognitive task simultaneously) has attracted attention as an indicator of performance ability. Patients with stroke have decreased dual-task ability compared with that of healthy elderly [9, 10]. Also, independent walking and falls among patients with stroke are associated with changes in motor performance when a cognitive task is added, such as counting backward while walking or performing repetitive utterance tasks while sitting unsupported [11–18]. Therefore, it is important to assess motor performance ability during dual-task conditions. Although there are reports regarding dual-task ability and ADL [19–21], we are unaware of any reports that have investigated the role of dual-task assessment methods in determining the independent toileting ability of patients with stroke.

We previously investigated 55 patients with stroke and identified a relationship between toileting ability and the results of a dual-task assessment involving a cognitive task that was performed while the subject stepped in place in a seated position [22]. During this test, we observed the participants’ ability to perform the task in the seated position with a comfortable speed for 30 seconds. The evaluation was performed by using a simple calculation wherein the associations among variables were statistically evaluated. The results showed that while motor performance was poorer during the dual-task compared with during a single task, there was no change in cognitive performance. We found that independent evaluation of toileting ability using dual-task was possible with 93.8% probability and when using BBS probability was 74.2%. In our previous study, the assessment required a personal computer monitor and other equipment. Furthermore, it was challenging to find an assessment method that could be easily performed in clinical practice. Accordingly, there is a need for an easy-to-administer assessment in clinical conditions. Therefore, this study aimed to identify the usefulness of the dual-task stepping test to determine the independent toileting ability of patients with stroke who can perform stepping in a seated position.

### Subjects and Methods

**Subjects**

All patients were recruited from the 128 patients with stroke admitted to our hospital between January and December 2017. Exclusion criteria were as follows: patients were excluded if they were within 2 weeks of onset or when the onset of stroke was more than 6 months prior, history of brain injury, no ADL independence prior to onset, inability to follow simple verbal instructions, presence of pain that would affect the assessment, and instructions from the attending physician to restrict sitting up. Following exclusions, a total of 90 patients were enrolled. Among them, only those participants who could successfully step in place for 30 seconds while seated in a 40-cm-high chair were included in the study. Sixty-seven patients who were able to complete this task became the study subjects. The study subjects’ characteristics are shown in Table 1. All participants provided informed consent. This study was approved by the Ethics Committee of Showa University School of Health Sciences (approval number: 366). The study was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

| Subject characteristics (n = 67) |
|---------------------------------|
| Age (years) | 67.5 ± 13.5 |
| Sex | M/F 38/29 |
| Diagnosis | Cerebral infarction 42 |
| Infratral cranial hemorrhage | 16 |
| Subarachnoid hemorrhage | 9 |
| Disability | Right hemiplegia 23 |
| Left hemiplegia | 27 |
| No paralysis | 17 |
| Leg BRS | III 2 |
| IV | 5 |
| V | 23 |
| VI | 20 |
| Time since onset (days) | 57.9 ± 43.0 |
| Means of mobility | Ambulatory/wheelchair 31/36 |
| Toileting ability | Independent/assisted 33/34 |
| Attentional rating Scale (points) | 15.0 ± 16.4 |
| BBS (points) | 36.1 ± 16.0 |
| MMSE (points) | 23.3 ± 8.3 |
| FIM, total of motor items (points)* | 67 |
| FIM, total of cognitive items (points)* | (46.0–80.5) |
| * Median (interquartile range). |
| BBS, Berg balance scale; BRS, Brunnstrom’s recovery stage; F, female; FIM, Functional Independence Measure; M, male; MMSE, Mini Mental State Examination. |
Methods

Developing the Dual-Task Stepping Test

We developed, in the following order, the motor tasks, cognitive tasks, and the dual-task. The motor task included a common denominator for toileting that required the involvement of autokinetic movements of the lower limbs, including maintenance of balance, and could be performed in a seated position. These requirements would ensure testing of a wide range of subjects, including wheelchair users. Further, the task required a series of repeated motions to enable performance assessment, and performance assessment had to be simple and require minimal equipment. Consequently, the task that was selected was stepping in place for 30 seconds while seated in a 40-cm-high chair. This task was performed at a comfortable and constant pace and allowed for synkinesis. Stepping was also used as a motor task in a previous study [22] and had obtained highly valid results for an independent evaluation of toileting. To select the cognitive task, we aimed to create a task that included the following requirements: 1) requires a certain degree of effort, even by those who have maintained cognitive function, 2) allows for multiple repetitions of tasks with an identical level of difficulty to create a minimum learning effect, and 3) has reassessment reliability to provide an estimate of the patient’s independent toileting ability during hospitalization. Consequently, the task we selected was to have the subjects recall the components of the lunch they ate on the assessment day (or breakfast, if the assessment was performed before noon). For subjects who did not take their food orally, the task was to list the types of medications they were currently taking. The usefulness and validity of these cognitive tasks have been confirmed in a previous study [23]. The subject’s toileting ability assessment consists of dual-task: the motor task (stepping in place) and an cognitive task (to answer the lunch menu).

Data-gathering procedures

The subjects’ dual-task ability was assessed by the performance of the motor task under the dual-task conditions based on results that have been established in previous studies [22, 24]. The examiner assessed three signs: (1) stepping stopped for 1.0 second or longer midway through the task; (2) stepping did not stop, but the feet were not more than half of the foot lifts before subjects answered the question; and (3) irregular pace. Sign 1 was indicative of severe dual-task disability, and signs 2 and 3 indicated mild dual-task disability. An absence of these signs indicated normal dual-task ability. The assessment procedure started with the subject seated in a 40-cm-high chair in a quiet private room. Assessors were provided with a predetermined assessment form for the dual-task stepping test (Fig. 1). Assessors carefully read the assessment procedures to the subject who was seated in the assessment chair and then carried out the evaluation. A single time assessment was performed for each patient. Assessors did not know the toileting ability of the subject.

Methods of Analysis

1. Comparisons of the groups classified according to the results of the dual-task stepping test and each assessment

Data collected at the time of the evaluation included baseline data regarding age, sex, diagnosis, stroke-affected side, Brunnstrom’s recovery stage for the legs, time since the onset of stroke in days, means of mobility, toileting ability, and the total score of motor-related and cognitive-related items of the Functional Independence Measure (FIM), that were available from the subjects’ medical records. The toileting ability for individual patients was determined using three procedures: (1) ability assessment in the toileting training scene by a therapist, (2) nurse assessment of the performance of toileting within ward life, and (3) attending physician’s independent judgment of toileting ability following daily morning conferences. These procedures were identical for all subjects. Assessment methods used as part of data gathering included dual-task stepping test and BBS [25], MMSE [26], and attentional rating scale (ARS) [27], which are generally used in our clinic. The data from BBS, MMSE, and ARS were extracted from the hospital records of each research participant, classifying research subjects according to the dual-task stepping test. Comparisons of the groups classified (severe dual-task disability, mild dual-task disability, normal dual-task ability) basic information, and the different assessments were compared statistically.

Fisher’s exact test was used to compare the three dual-task stepping test groups (severe dual-task disability, mild dual-task disability, normal dual-task ability) and each assessment to examine concurrent validity. The findings were with regards to the dual-task stepping test groups and sex, diagnosis, side affected by stroke, and means of mobility. The Steel-Dwass test was used for comparisons between the dual-task stepping test groups and age, Attentional Rating Scale, BBS, and MMSE.

2. Relationship between the seated position dual-task stepping test and toileting ability

The standard for independent toileting was a score ≥ 6 on the FIM. Findings from the dual-task stepping test and the rates of independent toileting were statistically compared. The accuracy of the determination of
independent toileting was assessed using the dual-task stepping test classification (severe dual-task disability, mild dual-task disability, normal dual-task ability). Furthermore, the groups classified by the BBS (score ≤ 35, severe balance disability; 36–45, mild balance ability; and ≥ 46, normal balance) [28] and the rates of independent toileting were statistically compared.

Logistic regression analysis was performed using independent toileting ability or inability as the dependent variable. The independent variables were normal/low dual-task stepping test results (sign 1 not observed/observed), normal/low BBS score (cut-off, 46 points) [25], normal/low MMSE score (cut-off, 24 points) [26], young/old age (relative to 70 years), and normal/low Attentional Rating Scale score (cut-off, 0 points) [27]. Fisher’s exact test was used for comparing the relationships between dual-task stepping test groups or BBS and toileting ability. Logistic regression analysis was performed to identify factors determining independent toileting ability. The software used for this analysis was JMP Pro version 13, with statistical significance set to less than 5%.

**Results**

**Comparisons of the Groups Classified According to the Results of the Dual-Task Stepping Test and Each Assessment**

All 67 subjects willingly completed the cognitive and dual-task stepping tests. The classification of the groups according to the dual-task stepping test was as follows: 32 subjects had a severe dual-task disability, 17 had a mild dual-task disability, and 18 had a normal dual-task ability. There were no significant differences between the groups for sex, diagnosis, and side affected by stroke. There were significant differences between the groups regarding their means of mobility ($p < 0.01$). There was a significant correlation between the groups
regarding age; older patients demonstrated poorer dual-task performance compared to younger patients \( (p = 0.03) \). There were significant differences between groups regarding their BBS, MMSE, and the Attentional Rating Scale scores \( (p < 0.01) \). In conclusion, participants with poorer dual-task assessment scores tended to have poor motor, attentional, and cognitive functions and were of higher age (Table 2).

### Relationship Between the Dual-Task Stepping Test and Toileting Ability

The rates of independent toileting for the three groups were as follows: severe dual-task disability, 15.6% (5/32); mild dual-task disability, 64.7% (11/17); and normal dual-task ability, 94.4% (17/18). This relationship between the groups and toileting ability was statistically significant \( (p < 0.01) \). The rates of independent toileting for the groups classified by the BBS were as follows: severe balance disability, 24.1% (7/29); mild balance disability, 40.0% (6/15); and normal balance, 87.0% (20/23) \( (p < 0.01) \). The dual-task stepping test classification was more accurate than that of the BBS, and the rate of independent toileting in the group identified as having normal dual-task ability was very high (94.4%).

### Analysis of Toileting Ability Using Logistic Regression

The results of the logistic regression analysis with independent toileting ability or inability as the dependent variable revealed that the dual-task stepping test \( (p < 0.01) \), BBS \( (p = 0.01) \), and MMSE \( (p = 0.03) \) were significant indicators of toileting ability (Table 3). The odds ratio was 14.50 for the dual-task stepping test, 9.69 for BBS, and 9.25 for the MMSE, indicating that the dual-task stepping test was the strongest indicator of toileting ability.

### Discussion

Dual-task ability is assessed by the performance of a motor task under dual-task conditions. Woollacott et al. [24] reported that elderly persons tended to give priority to a cognitive problem under dual-task conditions, with the result that their motor performance was diminished by the secondary task. In our previous study involving the dual-task evaluation of in-patients with
Table 3 Logistic regression analysis with toileting ability as a dependent variable

|                      | Likelihood ratio (chi-square) | Odds ratio | p-value |
|----------------------|------------------------------|------------|---------|
| Age                  | 0.57                         | 1.94       | 0.45    |
| Dual-task stepping test | 11.61                        | 14.50      | < 0.01  |
| BBS                  | 7.28                         | 9.69       | 0.01    |
| MMSE                 | 5.57                         | 9.25       | 0.03    |
| Attentional Rating Scale | 0.40                         | 1.84       | 0.53    |

BBS, Berg balance scale; MMSE, Mini Mental State Examination

stroke, although there was a drop in motor performance under dual-task conditions, there was no change identified in cognitive performance [22]. In attempting to classify patients, we assumed that sign 1 (stopped stepping) represented a clear decrease in dual-task ability because the cognitive task of remembering the last meal caused a temporary but total loss of attention to the stepping activity, while sign 2 (feet were not more than half of the foot lifts before subjects answered the question) and sign 3 (irregularly pace) represented a milder decrease in dual-task ability because signs 2 and 3 indicated their reduced attention paid to stepping. Patients who did not have any of these signs had the normal dual-task ability because they were able to distribute their attention to both tasks adequately. This assessment involved simultaneous motor and cognitive tasks, and participants’ dual-task ability was assessed based on their motor performance. Because the elements of motor, cognitive, and attentional functions were involved from the beginning of the test, we predicted that all the tested functions would be reflected in the results. Following the classification of our subjects based on the results of the dual-task ability test, we found that the groups were significantly different for BBS, MMSE, and Attentional Rating Scale scores. This confirmed that our assessment could accurately test for motor, cognitive, and attentional functions, and provided criterion-related validity that our test was actually a dual-task assessment. Further, we also found significant differences in the mean ages between the groups. Our findings that aging reduces dual-task ability are consistent with previously published research [29–31].

In this study, we were able to assess dual-task that appealed to using physical and cognitive functions used simultaneously, which differs in the quality of movement when compared to walking or standing (commonly used motor tasks). There were three possible reasons for this. First, many of the study subjects required assistance with ADL and had a total score of 67.0 points for FIM motor items; therefore, they experienced a high degree of difficulty with movement even while seated and required an increased amount of attention to perform motor tasks. Second, we used a relatively difficult cognitive task of recalling the contents of the last meal, which may have created a high level of interference. Third, there are differences in the way the brain works when walking and when stepping in a seated position. Apart from the initiation of walking and changing directions, walking is performed subconsciously by central pattern generators of the spinal cord [32]. This involves minimal activation of the prefrontal area, where conscious decisions are made that require an additional amount of attention [33]. On the other hand, stepping while seated involves a high level of conscious activity during the lifting of the feet. Therefore, interference from the recall task, which requires activation of the prefrontal area, is expected to affect performance. For these reasons, the dual-task ability can be assessed even when an activity is performed in a seated position, supporting the relevance and applicability of the dual-task stepping test among patients with stroke who have physical impairments, including wheelchair users.

The results of this study demonstrated a relationship between dual-task assessment and toileting ability. Assessments related to toileting ability that included other evaluations, such as the BBS, have also been noted [4–8]. However, unlike our study, other studies have not reported a relationship between dual-task assessments. Dynamic standing is associated with an increase in body sway, activates the prefrontal area, and requires conscious postural control [34]. In this study, patients with stroke who had some physical disability needed a certain level of attention to maintain dynamic standing while their clothes were pulled down. To perform this function, they must also focus their conscious attention on other events, such as pulling their clothes down with one hand. Additionally, greater cognitive and attention functions are required to control urination and defecation. This may be why toileting ability was determined with higher accuracy by the dual-task assessment that included elements of motor, cognitive, and attentional functions, unlike the BBS, which is an assessment of motor function. Only this test was developed with the goal of reflecting the ability to simultaneously focus attention on two events while assessing motor, cognitive, and attentional functions; therefore, the extent of these disabilities was not controlled when the subjects were being selected. It is therefore difficult to determine whether the cause of low scores for the dual-task assessment was increased attention given to the action due to motor function impairment, increased attention given to the recall task due to decreased cognitive function, or impairment of the ability to properly divide one’s attention between two tasks. In all cases of disability, motor,
Toileting for persons who had a stroke can involve a high risk of falling. Generally, elaborate observations are necessary to judge independence in toileting. However, an evaluation can be easily divided into sections by observers. This assessment is significant for clinical practice because it can be used to evaluate toileting ability, and will be helpful when considering whether the independence level based on the dual-task ability is normal. In Japan, the level of toileting independence of an in-patient with stroke is often decided during a team conference. When team members insist that a patient with poor balance has toileting independence, they can use the results of this evaluation as objective evidence to support their judgment.

This study had some limitations. Interpretations of the results were limited to the subjects of the present study, and it was a single-center study; therefore, it lacked external validity. Additionally, the sample size was rather small. Only one measurement was performed, and the reassessment reliability was not studied. Additionally, the movements were not observed in the real toilet setting; therefore, whether patients were able to perform toileting activities is not known. Finally, it was difficult to obtain normative values for dual-task assessments.

**Conclusion**

Toileting ability of patients with stroke can be evaluated using a dual-task assessment. Our dual-task stepping test was useful for determining independent toileting ability. This study found that toileting ability was affected more than balance, attention, or cognitive functions by the dual-task stepping test, which has widespread use in clinical practice.

**Conflicts of interest**

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Acknowledgments**

We are sincerely grateful to everyone at the Occupational Therapy Department at Showa University Fujigaoka Rehabilitation Hospital who significantly helped with the implementation of this study.

**Abbreviations**

ADL, Activities of Daily Living  
BBS, Berg Balance Scale  
CPG, Central Pattern Generator  
FACT, Functional Assessment for Control of Trunk  
FIM, Functional Independence Measure  
MMSE, Mini Mental State Examination  
SIAS, Stroke Impairment Assessment

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