doi: 10.2490/prm.20180015 Progress in Rehabilitation Medicine 2018; Vol. 3, 20180015

ORIGINAL ARTICLE

Reliability and Validity of the Japanese Version of the Mini-balance Evaluation Systems Test in Patients with Subacute Stroke

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Objective: The objective of the current study was to evaluate the reliability and validity of the Japanese version of the Mini-Balance Evaluation Systems Test (J-Mini-BESTest) in patients with subacute stroke. **Methods:** Eighteen patients who had suffered a first hemiplegic stroke (mean age, 59.1 ± 27.0 years) and had been admitted to convalescent rehabilitation wards were enrolled. The J-Mini-BESTest, the Berg Balance Scale (BBS), and the functional reach test (FRT) were used to assess balance. Four physical therapists (PTs) observed and scored the J-Mini-BESTest while another PT conducted the test. The interrater reliability of the J-Mini-BESTest was assessed using intraclass correlation coefficients (ICC[2,1]) for the total and section scores, and kappa statistics for each item. Internal consistency of the five raters was assessed using Cronbach's alpha. Concurrent validity of the J-Mini-BESTest was assessed against the BBS and FRT using Spearman's correlation coefficients. **Results:** The ICC[2,1] of the total and section scores were 0.90 (95% confidence interval: 0.81–0.95) and 0.63–0.85, respectively. Cronbach's alphas were 0.80–0.87. The kappa statistics were 0.47–1.00. The scores of the J-Mini-BESTest were significantly correlated with those of the BBS (rho=0.66, p=0.006) but not with those of the FRT (rho=–0.36, p=0.189). **Conclusion:** The J-Mini-BESTest showed excellent inter-rater reliability and internal consistency. Although the J-Mini-BESTest was not correlated with the FRT, it was significantly correlated with the BBS. The J-Mini-BESTest is a reliable and valid tool for evaluating dynamic balance in patients with subacute stroke.

Key words: balance; cerebrovascular disorders; hemiplegia; postural control; psychometric property

INTRODUCTION

Balance impairment is very common in patients with stroke and is related to dysmobility, decreased ability to carry out activities of daily living, and limited social participation. Because balance control involves many physiological systems, identifying the deficient systems responsible for poor balance control is critical for establishing appropriate intervention strategies for stroke rehabilitation. Balance assessment tools, such as the functional reach test (FRT)[1] and the Berg Balance Scale (BBS),[2] are well established in patients with stroke[3,4] and are widely used in clinical settings.

However, these instruments do not assess dynamic components of balance such as reactive postural control and dynamic gait. Furthermore, although these tests can be used to obtain total metrics and outcome measures, the specific systems that are impaired cannot be identified. In addition, although the BBS is known as the gold-standard test for patients with stroke,[3] floor and ceiling effects of the BBS have been described.[3,5,6] A more suitable measure without floor or ceiling effects would be beneficial in clinical settings.

In 2009, Horak et al. developed a comprehensive balance

Received: December 24, 2017, Accepted: June 14, 2018, Published online: July 6, 2018
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Table 1. Characteristics of the participants

Characteristics	
n	18
Sex, male/female	4/14
Age, years	59.9 ± 27.0
Days from stroke onset	37.5 ± 23.5
Type of stroke, infarction/hemorrhage	10/8
Paretic side, right/left	8/10
SIAS-motor	
Hip flexion test	4.67 ± 0.67
Knee extension test	4.61 ± 1.61
Foot pat test	4.44 ± 2.24
Number of participants using a walking aid	2 (11.1)
Number of participants using an ankle–foot orthosis	3 (16.7)

Values are reported as mean ± standard deviation or n (%).
SIAS, Stroke Impairment Assessment Set.

assessment tool, called the Balance Evaluation Systems Test (BESTest), based on systems theory.[7] BESTest, which consists of 27 items in 6 sections, is based on a theoretical understanding of balance control systems. It was expected to be useful for designing individualized strategies for balance impairment mitigation because it can potentially identify the affected balance-related system(s). The reliability and validity of BESTest in adults with or without balance deficits[7] and in patients with subacute stroke[8] have been established. However, BESTest takes about 30 min to complete, which may render it unfeasible in clinical settings.

A shorter version of BESTest, termed Mini-BESTest, which focuses on dynamic balance, has also been developed.[9] Mini-BESTest has shown good reliability and validity in patients with various conditions,[10] including individuals with Parkinson's disease,[11,12] in whom it has also been found to be a useful tool for predicting falls.[13,14] However, in the field of stroke, the Mini-BESTest has not been thoroughly studied, with reliability and validity evaluated only in patients with chronic stroke.[15,16] Clinically, the dynamic balance in patients with subacute stroke should be assessed in detail because the risk of falling is very high in these patients,[17,18] especially those with severe baseline disability.[18] As a result, establishing the psychometric properties of the Mini-BESTest for subacute stroke is considered to be clinically meaningful. Furthermore, although the Japanese version of the Mini-BESTest (J-Mini-BESTest) has been validated,[19] its reliability has not been evaluated. The aim of the present study was to determine the reliability and validity of the J-Mini-BESTest in patients with subacute stroke.

METHODS

Eighteen patients (mean age, 59.1 ± 27.0 years) who had experienced a hemiplegic stroke for the first time and were admitted to convalescent rehabilitation wards were enrolled using convenience sampling between February and October 2014 (**Table 1**). The inclusion criteria were the ability to follow three-step commands and to walk 6 m without physical assistance. The study adhered to the Declaration of Helsinki, and the protocol was approved by the institutional ethics committee (#84–2). Written informed consent was obtained from all participants.

The participants were assessed using three balance instruments within a period of 2 days: the J-Mini-BESTest, BBS, and FRT. All the assessments were conducted by registered physical therapists (PTs) who watched the training DVD provided by the developer of BESTest and were trained to perform balance assessments. The participants were monitored carefully by the assessors to prevent loss of balance and falls. While one PT (rater 1) conducted the J-Mini-BESTest, four PTs (raters 2–5) observed and assigned scores. The order of the instruments was counterbalanced among participants to eliminate the effect of order.

The Mini-BESTest consists of four sections corresponding to balance systems: anticipatory, reactive postural control, sensory orientation, and dynamic gait.[9] The test contains 14 items, each of which is scored from 0 to 2, with a higher score indicating better balance. The J-Mini-BESTest used in this study was translated according to the guidelines by Guillemin et al.[20] and validated in a sample of patients with

various pathological conditions.[19]

The FRT assesses the limit of stability during standing. The test measures the maximum distance of forward reach with the non-paretic hand.[1] Its interrater reliability and validity have been well established in stroke patients.[4,21] The participants were instructed to stand in the starting position with their shoulders at 90° of shoulder flexion. After a few practice runs to become familiar with the task, the participants were instructed to flex their shoulder to 90° and reach forward as far as possible without taking a step.[1] The maximum distance (cm) reached without loss of balance (reaching strategy was not controlled[1]; i.e., elevating the heels was allowed) was measured. Participants wearing an ankle–foot orthosis were allowed to use it during the test.

The BBS is a performance-based balance measure that consists of 14 tasks, including various static and dynamic balance tasks. Each item is scored on a 5-level ordinal scale, from 0 (worst performance) to 4 (best performance).[2] The total score ranges from 0 to 56, with a higher score indicating better balance. The internal consistency, reliability, and validity of the BBS are considered to be excellent in patients with stroke.[3]

Statistical analyses were performed using the STATA/SE 13.1 software package (StataCorp LP, College Station, TX, USA). Descriptive statistics of the instruments were examined to evaluate ceiling and/or floor effects. Skewness is a measure of asymmetry, and if the mean value is above the mode value in a distribution, it indicates a positive skewness. This means there is a tendency for scores to cluster at or towards the smaller end of the scale, thereby constituting a floor effect. Conversely, negative skewness indicates a ceiling effect. The scores from rater 1 were used for the descriptive statistics of the J-Mini BESTest. Interrater reliability of the J-Mini-BESTest was assessed using intraclass correlation coefficients (ICC[2,1]) for the total and section scores, and Fleiss's kappa statistics for each item. Internal consistency of the five raters was assessed using Cronbach's alpha. The concurrent validity of the J-Mini-BESTest versus the BBS and FRT was assessed based on the scores by rater 1 using Spearman's correlation coefficients. *P*-values less than 0.05 were considered to be statistically significant.

RESULTS

The distributions of the test results are shown in **Fig. 1.** The median scores for the J-Mini-BESTest, BBS, and FRT were 21, 54, and 26 cm, respectively (**Table 2**). The corresponding skewness values were −0.57, −2.09, and 0.93, respectively.

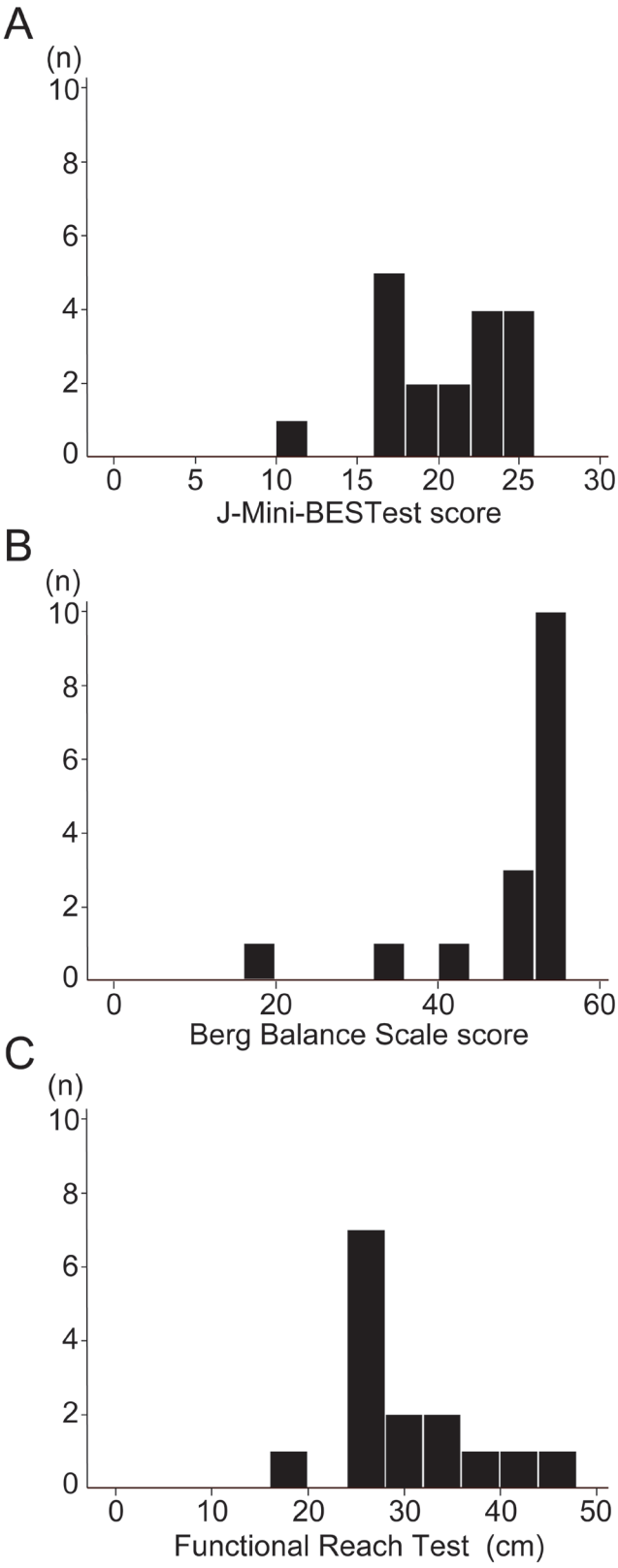

Fig. 1. Distributions of the results of the Japanese version of the Mini-Balance Evaluation Systems Test (J-Mini-BESTest) (A), the Berg Balance Scale (B), and the Functional Reach Test (C).

Table 2. Descriptive statistics of the Japanese version of the Mini-Balance Evaluation Systems Test (J-Mini-BESTest), Berg Balance Scale (BBS), and functional reach test (FRT)

	J-Mini-BESTest (score range, 0–28)	BBS (score range, 0–56)	FRT
n	18	16*	15*
Minimum	10	18	18
Maximum	26	56	47
Mean	20.2	49.8	29.5
Standard deviation	4.2	10.6	7.3
1st quartile	17	50	25
Median	21	54	26
3rd quartile	23	56	32
Number of participants with the minimum score	0 (0%)	0 (0%)	NA
Number of participants with the maximum score	0 (0%)	7 (43.8%)	NA
Skewness	–0.57	–2.09	0.93

*Data were missing for two participants for BBS and three participants for FRT. NA, not applicable.

Table 3. Intraclass correlation coefficients (ICC[2,1]) for the total and section scores of the Japanese version of the Mini-Balance Evaluation Systems Test

	ICC[2,1]	95% CI
Total score	0.90	0.81–0.95
Anticipatory	0.63	0.43–0.81
Reactive postural control	0.82	0.69–0.92
Sensory orientation	0.83	0.71–0.92
Dynamic gait	0.85	0.73–0.93

CI, confidence interval.

The ICC[2,1] was 0.90 (95% confidence interval: 0.81–0.95) for the J-Mini-BESTest total score and ranged from 0.63 to 0.85 for the section scores (**Table 3**). Cronbach's alpha ranged from 0.80 to 0.87. The kappa statistics ranged from 0.47 to 1.00 (average: 0.66) (**Table 4**). Spearman's correlation coefficients for the J-Mini-BESTest versus BBS and for the J-Mini-BESTest versus FRT were 0.66 (p=0.006) and −0.36 (p=0.189), respectively.

DISCUSSION

To the best of our knowledge, this is the first study to examine the reliability and validity of the J-Mini-BESTest in patients with subacute stroke. We found that the interrater reliability and internal consistency of this test are excellent. For internal consistency and interrater reliability, our findings are consistent with those of Tsang et al., who reported that the Mini-BESTest had excellent internal consistency (Cronbach's alpha=0.89–0.94) and interrater reliability (ICC[2,1]=0.96) in patients with chronic stroke.[15]

The kappa statistics for the J-Mini-BESTest items ranged from 0.47 to 1.00 in this study, with scores ≥0.99 obtained for items 1 (Sit to stand), 7 (Stance [feet together]; eyes open, firm surface), and 9 (Incline; eyes closed). The scores of all the raters were almost perfect for these items, and these results were likely influenced by the ease of the task (i.e., influenced by the ceiling effect). In contrast, the kappa statistics were relatively low for items 2 (Rise to toes), 5 (Compensatory stepping correction - backward), and 10 (Change in gait speed). For item 2 (Rise to toes), the raters had to judge whether the heel was at the maximum height. For item 10 (Change in gait speed), the raters had to determine the degree of the change in speed and gait stability. Consequently, the ratings were somewhat subjective, which might have resulted in differing scores. The task for item 5 (Compensatory stepping correction - backward) is relatively difficult to perform precisely in patients with stroke[22] and involves a certain risk of falling. It is possible that rater 1 offered more assistance

Table 4. Frequency of the scores given by the raters and kappa statistics for each task in the Japanese version of the Mini-Balance Evaluation Systems Test

Items	Rater 1			Rater 2			Rater 3			Rater 4			Rater 5			All raters			Kappa statistics
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	
Anticipatory																			
1. Sit to stand	0	0	18	0	0	18	0	0	18	0	0	18	0	0	18	0	0	90	1.00
2. Rise to toes	2	10	6	0	10	8	3	7	8	0	12	6	0	11	7	5	50	35	0.48
3. Stand on one leg	0	14	4	2	13	3	1	14	3	2	13	3	0	15	3	5	69	16	0.68
Reactive postural control																			
4. Compensatory stepping correction - forward	2	7	9	2	5	11	1	7	10	1	8	9	1	8	9	7	35	48	0.55
5. Compensatory stepping correction - backward	4	9	5	6	5	7	7	6	5	5	9	4	4	10	4	26	39	25	0.47
6. Compensatory stepping correction - lateral	5	8	5	4	9	5	5	8	5	3	10	5	3	9	6	20	44	26	0.61
Sensory orientation																			
7. Stance (feet together); eyes open, firm surface	0	0	18	0	0	18	0	0	18	0	0	18	0	0	18	0	0	90	1.00
8. Stance (feet together); eyes closed, foam surface	0	8	10	1	9	8	0	8	10	1	7	10	0	8	10	2	40	48	0.83
9. Incline, eyes closed	0	0	18	0	0	18	0	0	18	0	1	17	0	0	18	0	1	89	0.99
Dynamic gait																			
10. Change in gait speed	1	4	13	0	4	14	0	4	14	0	3	15	0	4	14	1	19	70	0.49
11. Walk with head turned - horizontal	2	6	10	0	6	12	0	7	11	1	4	13	1	4	13	4	27	59	0.52
12. Walk with pivot turns	1	8	9	2	8	8	2	7	9	3	9	6	2	7	9	10	39	41	0.59
13. Step over obstacles	2	6	10	1	6	11	2	7	9	2	7	9	2	7	9	9	33	48	0.56
14. Timed Up and Go with dual task	6	10	2	6	10	2	5	10	3	5	12	1	5	10	3	27	52	11	0.52

Each row contains the numbers of participants who received scores of 0, 1, and 2 from each rater for each item.

than necessary to the patients because of safety concerns, which might have made it difficult to judge whether patients would have fallen if not supported and the number of steps needed to recover.

With regard to concurrent validity, the J-Mini-BESTest scores were moderately correlated with those of BBS, and the correlation was statistically significant. However, Spearman's rho between the J-Mini-BESTest and FRT was not statistically significant. These findings are somewhat different from previous validation studies in patients with chronic stroke in which there were weaker but significant correlations between the Mini-BESTest and FRT.[15,16]

The main focus of the Mini-BESTest is the assessment of dynamic balance. During the development of the Mini-BESTest, section II (Stability Limit), which included FRT, appeared to be independent of the construct of dynamic balance according to Rasch analysis. Consequently, FRT and nine other items were excluded from the original BESTest to create a one-dimensional instrument in which all the items measure a single underlying dimension.[9] This could explain the relatively weak correlations between the FRT and J-Mini-BESTest scores found in previous studies and the lack of significant correlation between the two measures in the present study. The disagreement between previous studies and the present study in terms of the statistical significance between the Mini-BESTest and FRT might have two possible causes. First, the limited sample size of our study compared with the previous study.[15] Second, we studied inpatients with subacute stroke, in contrast to the previous studies that recruited participants with chronic stroke more than 6 months from onset.[15,16] It can be hypothesized that some patients might be fearful of the maximal reaching task while standing during the subacute phase, because they may not have fully adapted to their novel internal environments. The psychological aspects, rather than balance itself, could have easily affect the results of tests such as the FRT (a single-item test) in contrast with the Mini-BESTest and BBS tests, which are more comprehensive instruments consisting of multiple tasks. To eliminate this potential issue, a further study with multiple testing of the FRT is needed.

The maximum score was achieved by 43% of the participants in the BBS test, but none of the participants in the J-Mini-BESTest attained the maximum score. Unlike the BBS, the J-Mini-BESTest includes tasks requiring dynamic balance, such as walking tasks. All participants in the study were able to walk at least a short distance without physical assistance. Therefore, the ceiling effect was more prominent in the case of BBS.

There are several limitations to this study. First, because the sample was small and the participants were able to walk at least a short distance without physical assistance, the generalizability of the findings might be limited. Second, variability associated with the J-Mini-BESTest procedures could not be assessed because, to minimize the burden on the participants, we used observation to score the test and assess the reliability.

In conclusion, the J-Mini-BESTest demonstrated excellent inter-rater reliability and internal consistency. Although the J-Mini-BESTest was not correlated with the FRT, a measure of the limit of stability, the test was significantly correlated with the BBS, a comprehensive balance measure including dynamic balance tasks. These findings suggest that the J-Mini-BESTest is a reliable and valid tool for evaluating dynamic balance in patients with subacute stroke who can walk without physical assistance.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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