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Original article

Relationship between post stroke duration and balance function necessary for performing activities of daily living independently in stroke patients on the convalescence rehabilitation wards

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ABSTRACT

Several previous studies have reported the balance cut-off value associated with activities of daily living independence in patients who suffered a stroke; however, the cut-off value may change over time post a stroke. If these cut-off values after the stroke are clarified according to the period, they will become more appropriate target values for rehabilitation. This retrospective observational study included 157 first-stroke patients. The area under the receiver operating characteristic curves were calculated using an independent/dependent group of activities of daily living items serving as dependent variables and the Berg balance scale scores serving as independent variables. Measurements were made at 1-, 2-, and 3-month after the stroke. Cutoff values were calculated if the receiver operating characteristic curves were >0.9. The Berg Balance Scale cutoff value for classifying the independence of toileting was 43 points at the 1-month, 42 points at the 2-month, and 39 points at the 3-month after stroke. The cutoff values for dressing was 44 points at the 1-month, 41 points at the 2-month, and 41 points at the 3-month after stroke. The cutoff values for stair-climbing ability were 53 points at the 2-month and 49 points at the 3-month after stroke. Our results indicated the cut-off values of balance associated with activities of daily living independence at each time point at 1, 2, and 3 months after the onset of stroke were clarified, and these are expected to help set the target value for rehabilitation considering the time post the onset of stroke in convalescence rehabilitation wards

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INTRODUCTION

Impaired balance is a well-characterized sequela associated with stroke[1)], and there are several investigations showing a strong association of the impaired balance of these patients with their independence and ability to perform activities of daily living (ADLs) [1-6)]. The analysis of individual ADLs has also demonstrated an association between balance and the ability to use the toilet[7)], get dressed [8,9)], groom [10,11)], and climb/descend stairs[12)], and the cutoff

values of balance required for independence in these ADLs have been reported [7,9,10,12]. The cutoff values of balance related to independence in ADLs can be used as a target value for rehabilitation.

It has been suggested that the association between physical function and ADLs may change throughout the rehabilitation process. For example, Fujita et al.[13] reported that factors related to independence in the dressing of stroke patients change at the time of admission and discharge from the convalescent rehabilitation ward. This is likely due to changes in the mental and physical faculties required for ADLs via the learning of compensatory means such as single hand techniques during the rehabilitation process[13]. Therefore, regarding the relationships mentioned above between ADLs and balance, there is a possibility that the presence or absence of the association between the two as well as the cutoff values required for independence may change after the initial onset of stroke. To our knowledge, there have been no investigations into the association between ADLs and physical functions, including balance in stroke patients from time-post stroke viewpoint. Clarifying these points will strengthen our understanding of a rehabilitation program that takes the poststroke period into account. In other words, cut-off values could become more valid and will be useful indicators when setting a target value for rehabilitation, especially in patients with advanced schedule of hospital discharge. The purpose of this study was to clarify the relationship between ADLs and balance in stroke patients and calculate the degree of balance function necessary for performing activities of daily living in an independent manner 1, 2, and 3 months after the stroke in the hospitalized patients at that time on convalescence rehabilitation wards.

Methods

The investigation utilized a retrospective observational study design. The subjects were 157 patients who met the inclusion criteria among the stroke patients admitted to the convalescent rehabilitation ward at Kita-Fukushima Medical Center in Japan. Inclusion criteria consisted of the following: (1) patients who were admitted and discharged between April 2011 and December 2017; (2) those who were diagnosed with first-time cerebral hemorrhage or cerebral infarction; (3) those with unilateral supratentorial lesions; (4) those without marked cognitive decline (scores of at least 21 points by the revised Hasegawa's dementia scale; HDS-R[14]; and (5) those with no missing data analysis items described later. This study, as will be described later, analyzed the assessment data at 1-, 2-, and 3-month post-stroke onset; however, patients assessed at least one time point among three time points were included as targets of analysis. It is because the study population is restricted to those who had not been discharged from the hospital 3 months after the stroke onset, and only severe patients are targeted if participants included only patients who were examined at all three time points (at 1, 2, and 3 months post-stroke onset). To avoid this problem, for example, participants in this study also included patients who were discharged before the 3-month time point and those who could not perform the 1-month evaluation because their admission was later than 1-month post-stroke onset. Therefore, the total subjects collected was 157; however, the sample size at each time point was 100 at 1-, 110 at 2-, and 75 at 3-month post the onset of stroke.

In general, all subjects received physical therapy, occupational therapy, and speech therapy, if necessary: 2–3 h per day on weekdays and Saturdays, and 1–2 h per day on Sundays and holidays. All procedures described herein were approved by the Ethics Review Boards of Kita-Fukushima Medical Center and Fukushima Medical University [No.72, 2020-081].

The relationship between independence in ADLs and balance at 1, 2, and 3 months after stroke onset was examined. We collected and analyzed the scores of toilet, dressing, grooming, and stairs items in the FIM® instrument [15], which have been reportedly strongly associated with balance [7-12]. As for dressing, the lower score on FIM® instrument for dressing the upper and lower body was adopted in this study. The Berg balance scale (BBS)[16] was used as an index of balance. Also, the patient's age, sex, paralysis side, stroke impairment assessment set (SIAS) [17], vitality index [18], and HDS-R were collected to grasp the subject's attribute and status of mental and physical functions. In this study, we considered the results evaluated during the period between 20 and 40 days from the onset of stroke as 1-month results, between 50 and 70 days as 2-month results, and between 80 and 100 days as 3-month results.

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To demonstrate the functional status of subjects at each of the 1-, 2-, and 3-month time points after stroke onset and the difference between these time points and add interpretation to the results of relationship between balance and ADL, analysis was performed by obtaining descriptive statistics of age, sex, paralysis side, FIM® instrument, SIAS, vitality index, and HDS-R, and Kruskal–Wallis or chi-square tests and multiple comparisons (Mann–Whitney test using Bonferroni correction or residual analysis) were performed to compare between the time points. Next, the receiver operating characteristic (ROC) analysis was performed. In the ROC analysis, the area under the ROC curve (AUC) was calculated with an independent/nonindependent group of each ADL item as dependent variables and scores of BBS as independent variables at each 1-, 2-, and 3-month time point after stroke onset. If AUC was 0.9 or higher (high accuracy), the cutoff values of BBS were calculated using Youden's index[19,20]. The significance level of all the tests was set at $P < 0.05$, and all statistical analysis was performed using SPSS Statistics 25.

RESULTS

The results of comparison of subjects' attributes, ADLs, and mental and physical functions between the three time point groups indicated that the motor function of the affected side lower limb was significantly lower in patients who were on the convalescence rehabilitation ward at 3-month post the stroke than those who were in the ward at 1-month after the stroke. However, there was no significant difference between the three time point groups in ADLs, motor function of the affected side upper limb, sensory function, trunk function, higher brain function, muscular strength of the unaffected side, motivation, cognitive function, or balance (Table 1).

The results of the ROC analysis are presented in Table 2. The optimum BBS cutoff value for classifying the independence or dependence of toileting was 43 at the 1-month time point, 42 at the 2-month time point, and 39 at the 3-month time point, and that for dressing was 44 at the 1-month time point, 41 at the 2-month time point, and 41 at the 3-month time point. The optimum BBS cutoff values for grooming were the same (i.e., 40) at both the 2-month and 3-month time points, but those for stair-climbing ability were 53 at the 2-month time point and 49 at the 3-month time point. The cutoff values were not calculated for the 1-month time point for grooming and stairs as AUC was below 0.9.

Table 1. Patients characteristics of the present study

	Time post-stroke			
	1 month (n=100)	2 month (n=110)	3 month (n=75)	Multiple comparison
Age, years	69.3 ± 14.2	69.5 ± 14.3	69.5 ± 13.7	n.s.
Men, %	60.0	55.5	60.0	n.s.
Right-side hemiplegia, %	45.0	42.7	46.7	n.s.
FIM® instrument				
Toileting score (range: 1–7)	5 (2–7)	5 (2–7)	5 (2–6)	n.s.
Independence (≥6 points), %	38.0	46.4	41.3	n.s.
6 points among independence [a], %	31.6	37.3	51.6	n.s.
Dressing (1–7)	5 (2–6.8)	6 (2–7)	5 (2–7)	n.s.
Independence (≥6 points), %	41.0	52.7	41.3	n.s.
6 points among independence [a], %	39.0	34.5	45.7	n.s.
Grooming (1–7)	5 (5–7)	5 (5–7)	5 (5–7)	n.s.
Independence (≥6 points), %	44.0	46.4	45.3	n.s.
6 points among independence [a], %	29.5	17.6	35.3	n.s.
Stairs (1–7)	1 (1–5)	3 (1–5)	1 (1–5)	n.s.
Independence (≥6 points), %	11.0	18.2	9.3	n.s.
6 points among independence [a], %	72.7	60.0	57.1	n.s.

(Continued)

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Table 1. (Continued)

	Time post-stroke			
	1 month (n=100)	2 month (n=110)	3 month (n=75)	Multiple comparison
SIAS motor function				
Knee-mouth test (0–5)	4 (2–5)	3.5 (1–5)	3 (1–4)	n.s.
Finger function test (0–5)	4 (1–5)	2.5 (1–5)	2 (1–4)	n.s.
Hip flexion test (0–5)	4.5 (3.3–5)	4 (3–5)	4 (2–5)	1 > 3*
Knee extension test (0–5)	5 (3–5)	4 (2–5)	4 (2–4)	1 > 3**
Foot pat test (0–5)	4 (3–5)	4 (1–5)	3 (1–4)	1 > 3*
SIAS sensory function				
U/L light touch (0–3)	3 (2–3)	3 (2–3)	3 (2–3)	n.s.
L/L light touch (0–3)	3 (2–3)	3 (2–3)	3 (1–3)	n.s.
U/L position sense (0–3)	3 (3–3)	3 (2–3)	3 (2–3)	n.s.
SIAS trunk function				
Vertically test (0–3)	3 (3–3)	3 (3–3)	3 (3–3)	n.s.
Abdominal strength (0–3)	2 (1–3)	2 (2–3)	3 (2–3)	n.s.
SIAS visuo-spatial perception (0–3)	3 (3–3)	3 (3–3)	3 (3–3)	n.s.
SIAS language (0–3)	3 (3–3)	3 (3–3)	3 (3–3)	n.s.
SIAS unaffected side function				
Grip strength (0–3)	2 (2–3)	2 (2–3)	2 (2–3)	n.s.
Knee extensor strength (0–3)	3 (3–3)	3 (3–3)	3 (3–3)	n.s.
Vitality index (0–10)	10 (8–10)	10 (9–10)	10 (9–10)	n.s.
Revised Hasegawa's dementia rating scale (0–30)	26.1 ± 2.6	26.4 ± 2.8	26.4 ± 2.9	n.s.
Berg Balance Scale (0–56)	35.5 ± 18.0	36.1 ± 19.2	34.4 ± 18.1	n.s.

Mean ± SD or % or Median (IQR)
Abbreviations: SIAS, stroke impairment assessment set; U/L, upper limb; L/L, lower limb
*p < 0.05 **p < 0.01
[a] Ratio of patients of FIM® 6 points among the independence group (score ≥6)

Table 2. Cut-off values with Berg balance scale for activities of daily living by time post-stroke

	AUC	Cut-off	Sensitivity (%)	Specificity (%)
Toileting				
1 month	0.91	43	89.5	77.4
2 month	0.96	42	96.1	88.1
3 month	0.93	39	96.8	75.0
Dressing				
1 month	0.92	44	87.8	83.1
2 month	0.95	41	89.7	84.6
3 month	0.92	41	85.7	82.5
Grooming				
1 month	< 0.90	-	-	-
2 month	0.93	40	96.1	78.0
3 month	0.92	40	91.2	80.5
Stairs				
1 month	< 0.90	-	-	-
2 month	0.94	53	90.0	90.0
3 month	0.96	49	100.0	82.4

Abbreviations: AUC, area under the curve

DISCUSSION

The present analysis first examined whether there was any difference in ADLs and mental and physical functions among the 1-, 2-, and 3-month time points. As a result, there was no statistically significant difference in the mental and physical functions of the subjects, including balance among the three time points, except for motor function of the lower limb of the affected side. However, this is not a result showing no rehabilitation effect. This may be because those whose severity was mild with good functions were likely to be discharged before the 2 or 3-month post-stroke time points and, therefore, the overall difference in mental and physical functions and ADLs among the three time points did not show a significant difference.

The AUC results from the ROC analysis confirmed that BBS has a very high discrimination ability to determine the possibility of independence in ADL items. Previous studies have already reported the discrimination ability of BBS in determining the possibility of independence in using the toilet[7], dressing alone[9], grooming[10], and using the stairs[12]. Our results support previous studies. In addition, the BBS cutoff values calculated in this study were very close to those calculated in previous investigations. For example, the BBS cutoff value for independence in using the toilet, including transferring oneself to the toilet, was 42 points[7], that for independence in dressing was 44 points[9], that for independence in grooming was 41 points[10], and that for independence in using the stairs was 54 points[12]. These results suggest that the cutoff values calculated in this study are reasonable.

Furthermore, this study clarified two points that have never been reported; one is BBS cut-off values have a very high discrimination ability in toileting and dressing regardless of the time from onset, and the other are cut-off values at 1-, 2-, and 3-month post-stroke onset were not similar in some ADLs. Especially, cut-off values were low at 2- or 3-month post-stroke onset as a general trend. This trend may be associated with motor and compensatory learning. In other words, our results suggest that patients who suffered from stroke can perform toileting, dressing, and stair climbing independently with low balance due to motor and compensatory learning through long-time rehabilitation even if their mental and physical functions remained unchanged. In fact, most mental and physical functions were not significantly different across three time points investigated in this study. In addition, although no significant difference was observed, the ratio of FIM 6 points (i.e., modified independence) in the independence group was highest among three time points in ADL items other than stairs. This result may reflect an increase in the number of patients who become independent by compensatory means, such as the use of tools at 3-month post-stroke onset. However, explaining the reason why the cut-off value has changed with the current data is difficult; therefore, further study is required.

The cut-off value calculated in this study seems to be a more reasonable target value because it considers the effects of time interval post the stroke onset (motor learning). Especially, it will be a useful indicator in patients who had been scheduled for hospital discharge in advance. For example, patients who are expected to be discharged at 2-month post-stroke onset and need to be independent of the toilet, the target is BBS 42 points, whereas patients hospitalized up to 3-month post the stroke onset, the target is BBS 39 points.

One potential limitation of this investigation is that only ADL independence scores were evaluated, with no evaluation of methods and procedures by which subjects carried out ADLs. Such changes in methods may be related to the cutoff balance values, and further investigation is warranted. Another potential limitation of this investigation is the targeted use of stroke inpatients during convalescent rehabilitation ward hospitalization. Therefore, different results may be obtained in studies on stroke patients living at home after being discharged from the hospital. Also, this study is not the longitudinal study in which the same subject was repeatedly measured, and subjects were limited to patients without cognitive dysfunction. In addition, our study was performed at a single facility. Therefore, whether similar findings can be obtained in studies at other facilities should also be confirmed for the generalization of the results. Furthermore, the BBS cutoff values in grooming and stair locomotion at the 1-month time point remain unclear. Finally, the small sample size is also a limitation of this study: the sample size at the 3-month time point after onset was 75. Hence, to obtain more reliable results, reanalysis on a larger sample size is necessary.

Conflict of Interest

The authors declare no conflict of interest.

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