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Original Article

Development of an independent ambulation rating chart for post-stroke hemiplegic patients in the recovery stage: at what level is patients free to walk within rehabilitation ward

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ABSTRACT

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Objective: This study aimed to identify subjective and objective assessment items to rate independent ambulation in hemiplegic patients, and to develop an effective independent ambulation rating chart.

Methods: Logistic regression analyses were conducted on subjective assessment items extracted from a questionnaire survey of 25 physical therapists and on objective assessment items using the Fugl-Meyer Assessment (FMA) to identify factors that influence independent ambulation in hemiplegic patients. The factors identified were used to construct an independent ambulation rating chart. Forty-five hemiplegic patients were assessed using the chart, and the concordance with the actual independence status was analyzed.

Results: Unsteadiness, distribution of attention, associated reaction, and balance subscale of FMA were identified as factors influencing independent ambulation. The results obtained from the rating chart constructed using the above factors showed high concordance with the actual independence status.

Conclusion: We developed a rating chart from analyzing independent ambulation factors. Since the rating chart assesses higher level brain functions and clinical context including self-management, good concordance with the actual independence status was obtained. The chart is useful for the rating of independence.

Key words: hemiplegic patients, gait, independent ambulation rating, kaifukuki rehabilitation ward

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Introduction

Regaining the walking ability is of paramount importance in hemiplegic patients, and is often the goal for rehabilitation programs. While physical therapists are actively involved in therapeutic interventions for these patients, we also charged with the responsibility to determine when the patients are capable of independent ambulation. The timing to determine the independent ambulation is important; starting too late will lead to excessive inhibition, while starting too early may cause falls. Due to this two-sided nature, determining independent ambulation has to be based on solid evidence.

In stroke patients, various factors for falls have been reported, including the ability to perform activities of daily living, status of incontinence, balance ability, severity of motor palsy, status of unilateral spatial neglect, use of diuretics, and use of antidepressant or sedatives [1−3]. In addition, a large number of risk assessment tools for falls in post-stroke hemiplegic patients have been developed, such as 10-m walking time [4], lower limb muscle strength evaluation [5], one-leg stance time [5], Berg balance scale (BBS) [6−9], functional reach test (FR) [10], timed up and go test (TUG) [11], cognitive function evaluations such as dual-task [6, 9, 12], and higher order brain function evaluations [2, 3, 13]. In some tools such as the BBS, FR, TUG, and 10-m walking time, cutoff values for independent ambulation have been set. Among them, the BSS is widely used clinically for the assessment of independent ambulation [7, 11, 14, 15]. However, these tools are not developed specifically for the determination of independent ambulation, and they only evaluate one aspect of walking [16]. Other tools for predictive estimation of falls use evaluation methods biased toward some physical functions or cognitive functions, and do not comprehensively address all the factors necessary for actual independent ambulation. Furthermore, studies on the risk factors for falling have reported that rather than physical function factors, complex tasks such as dressing are the strongest risk factor associated with falls [12], and that clinical observation is superior to fall risk assessment tools in predicting falls [17]. For tools such as functional independence measure (FIM) and functional ambulation category (FAC) that rate independence from the level of care needed, the criteria for assessment often depend on the subjective judgment of physical therapists and ward nurses [16]. However, the criteria for determining assistance/supervision to independence are ambiguous, because many factors affect the ability of subjective judgement of the staff. Therefore, there is a need to change the conventional methods of determining independent ambulation from only subjective judgement or from specific physical and cognitive functions, and to develop a check sheet for rating independence, which serves as universal criteria taking into account the essential points during evaluation in the clinical context and physical capability factors as background.

To develop the check sheet for rating independent ambulation, we performed three analyses in the present study. In part 1, we asked physical therapists to provide the reasons for determining that a particular patient was independent, and extracted the subjective factors associated with independent ambulation. In addition, as objective factors, we extracted factors affecting independent ambulation from various evaluations of mental and physical functions that improved after independent ambulation. In part 2, we further narrowed down the subjective and objective factors obtained from part 1, and constructed the Seiai independent walking ability rating chart (Seiai rating chart). In part 3, we compared the Seiai rating chart with BBS, currently the most widely used indicator for determining independent ambulation [7], to evaluate the usefulness of the Seiai rating chart. The aim of this study is to develop a clinically effective independent ambulation rating tool by the three step analyses.

Methods and Results

Part 1: Identification of factors for rating independent ambulation

1. Methods

Subjects were 63 patients who were able to walk independently inside the ward during the hospitalization period regardless of whether walking aid was used (Table 1). In our hospital, the approval of independent ambulation was determined by conference among the patient's attending staff members, judged by whether the patient can walk alone safely inside the ward (including toilet and dining room) during the day.

Table 1. Demographic and clinical data of subjects in part 1 (*n*=63).

Age (years)	65.6±12.7
Time from onset (days)	109.5±55.0
Gender: female/male (*n*)	28/35
Side of hemiplegia: left/right (*n*)	29/34
Disease: Stroke (*n*)	39
Brain hemorrhage (*n*)	24
Independent ambulation (*n*)	63

Data are expressed as number of patients (*n*) or mean ± standard deviation.

To identify the subjective factors for assessing the independency, a self-administered questionnaire survey was conducted in 25 physical therapists (mean working experience 7.2 ± 6.4 years) who attended the patient subjects, regarding the reasons for determining that a patient could walk independently. After organized the results into some categories, the categories that were responded by more than one respondent were retained as factors. From the retained factors, those that can be defined as an assessment index were further selected in a one-hour discussion participated by physical therapists and occupational therapists (4 members) who were executive staff of our hospital. In addition, we identified objective assessment indices of physical functions by the Fugl-Meyer assessment (FMA), the trunk control test (TCT), the 10-meter walking time, and FIM cognitive function score. Wilcoxon rank sign test was used to compare the scores before and after independent ambulation. Then, the factors influencing independent ambulation were analyzed by performing logistic regression analysis using the items that showed significant differences in the above analysis as independent variables and independent/dependence ambulation as dependent variable. To avoid multi-collinearity, correlation between factors was analyzed by Spearman rank correlation coefficient. When the correlation coefficient between independent variables was 0.8 or above, or −0.8 or above, the variable that had lower correlation with the dependent variable was excluded. This study was approved by the ethical committee of our hospital (approval number 13-088). Statistical analyses were performed using Free JSTAT version 13.0.

2. Results

Categorization of the reasons for judging independent ambulation is shown in Table 2. Among those items with multiple responses, unsteadiness during walking (57 responses), attention function (15 responses), and lower limb function of affected side (11 responses) occupied the top ranks, while associated reaction of upper limb, management of toilet time, and improvement of endurance were minor responses. From these results, 7 assessment items that had

Table 2. Results from questionnaire survey and categorization.

Results from questionnaire	No. of responses	Category
Can self-correct even when becoming unsteady during walking	15	Unsteadiness
Can open and close door without getting unsteady on the feet	13	
Getting less unsteady when changing direction	9	
Can stand up and sit on a chair in the day room	5	
Can pick up a cane	4	
Can change direction toward the affected side, with little wobbling	3	
Can self-correct wobbling even when stopping abruptly while walking	2	
Trunk wobbling decreases	2	
Unsteadiness when starting walking decreases	1	
Balance stably even when not using a cane	2	
Can walk backward without losing balance	1	
Can distribute attention to obstacle and multiple patients (especially when going in and out of a room)	9	Distribution of attention
Can pay attention to the surrounding	2	
Can walk stably even when being called by other patients	2	
Can walk without always looking at the feet	2	
No more catching of lower limb	8	Improvement of lower limb function
Improvement of back knee and knee buckling	3	
Can adjust the toilet time (no falling due to flustering)	1	Self-management
Can execute toilet movements safely	1	
Can manage the pouch by oneself	1	
Can wear device by oneself	4	
Improvement in walking endurance	4	Endurance
Achieved walking ability by one rank up	3	Achieve walking by one rank up
Can avoid person or object	2	Spatial perception
No more collision with the wall	1	
Associated reaction decreases	2	Associated reaction
Can understand and follow the free zone	1	Comprehension
Do not get loss inside the ward	1	Topographical orientation
Mental excitation decreases	1	Mental
Improvement of dizziness	1	Improvement of dizziness

multiple responses [(1) Unsteadiness: no unsteadiness during walking, or can self-correct even when unsteadiness occurs during walking; (2) Distribution of attention: can direct attention to other patients when walking in and out of a room; (3) Lower limb function: no tripping on the floor or knee collapse when walking, or can self-correct even if they occur; (4) Self-management: capable of wearing a device, toilet-related operations, and managing toilet time; (5) Endurance: capable of achieving walking task without resting; (6) Spatial perception: no collision with object, or can self-correct even it occurs; (7) Associated reaction: can execute movements without marked associated reaction in upper limb] were extracted.

The results of Wilcoxon signed rank test are shown in Table 3. The results of logistic regression analysis using the objective assessment indices with significant differences before and after independence as independent variables are shown in Table 4. Among the objective indices, the balance subscale of FMA was identified as the only significant factor affecting independent ambulation.

Part 2: Construction of the Seiai rating chart

1. Methods

To construct the Seiai rating chart, the items obtained from Part 1 were re-evaluated in other subjects, and logistic regression was performed to

Table 3. Results of Wilcoxon signed rank test before and after independence.

		Before independence	After independence	*p* Value
Fugl-Meyer Assessment	Upper extremity	46.4±18.5	47.6±18.3	0.0001
	Lower extremity	25.7± 4.9	26.5± 5.0	0.0000
	Balance	9.3± 1.6	10.3± 1.8	0.0000
	Sensation	19.0± 5.24	19.7± 5.28	0.0007
	Range of motion	38.7± 4.0	39.2± 3.8	0.0840
	Pain	42.3± 2.4	42.3± 2.21	0.8276
Trunk function	Trunk control test	88.2±13.8	92 ±12.3	0.0035
Walking ability	10-m walking time	19.2±13.4	16.3± 8.79	0.0012
FIM	total cognitive score	30.7± 4.7	31.2± 4.6	0.0853

Data are expressed as mean ± standard deviation.

Table 4. Results of logistic regression using before/after independence as dependent variable (Part 1).

		Estimate	*p* Value	Odds ratio
Fugl-Meyer Assessment	Upper extremity	−0.02	0.235	0.98
	Lower extremity	0.042	0.48	1.043
	Balance	0.389	0.004	1.475
	Sensation	−0.03	0.475	0.97
Trunk function	Trunk control test	0.017	0.336	1.017
Walking ability	Time	−0.018	0.457	0.982

further narrow down the factors and construct regression equations. Among the hemiplegic patients admitted to one of our rehabilitation wards (40 beds) during the six-month period, 93 patients with walking assistance level from light assistance to independence (independent ambulation 45 patients, non-independent ambulation 48 patients) were recruited in this study (Table 5). Walking dependence was rated by the attending physical therapists (mean working experience 5.4 ± 2.6 years). The task was walking from the bed to the toilet via the dining room, and then back to the bed. Assessment was done regardless of whether the patients were using walking aids. The 7 subjective assessment items identified from part 1 were used to rate whether the patient met the items during the walking task. In addition, the balance score in FMA was measured separately as the objective assessment item. For statistical analysis, first, the difference in each factor between the independent ambulation group and non-independent ambulation group was compared using chi-squared test. Then logistic regression was conducted using the factors showing significant differences in the above analysis as independent variables, and the independent ambulation level as the dependent variable. To avoid multi-collinearity, correlation between factors was analyzed by Spearman rank correlation coefficient. When the correlation coefficient between independent variables was 0.8 or above or −0.8 or above, the variable that had a lower correlation with the dependent variable was excluded.

Table 5. Demographic and clinical data of subjects in part 2 (*n*=93).

Age (years)	68.2±10.3
Time from onset (days)	102.0±50.0
Gender: female/male (*n*)	32/61
Side of hemiplegia: left/right (*n*)	46/47
Disease: Stroke (*n*)	58
Brain hemorrhage (*n*)	35
Independent ambulation (*n*)	45

Data are expressed as number of patients (*n*) or mean ± standard deviation.

2. Results

Chi-squared test detected significant differences ($p < 0.01$) between the independent ambulation group and non-independent ambulation group for all the seven subjective items. The correlation coefficients between factors are shown in Table 6. A high correlation was observed between (2) distribution of attention and (6) spatial perception (r=0.84) and between (2) distribution of attention and (4) self-management (r=0.80). To avoid multi-collinearity, (6) spatial perception and (4) self-management that had lower correlation with independent ambulation were

Table 6. Correlation coefficients between factors.

	Independence	Unsteadiness	Lower extremity	Associated reaction	Endurance	Spatial perception	Distribution of attention	Self-management	Balance	Lower extremity	Reaction time	MMSE	FAB
Independence	1.00												
Unsteadiness	0.78	1.00											
Lower extremity	0.68	0.75	1.00										
Associated reaction	0.66	0.62	0.76	1.00									
Endurance	0.66	0.73	0.75	0.71	1.00								
Spatial perception	0.67	0.71	0.66	0.62	0.79	1.00							
Distribution of attention	0.73	0.76	0.62	0.53	0.70	0.84	1.00						
Self-management	0.68	0.70	0.69	0.59	0.73	0.78	0.80	1.00					
Balance	0.78	0.61	0.59	0.55	0.55	0.48	0.56	0.62	1.00				
Lower extremity	0.52	0.39	0.51	0.53	0.51	0.37	0.39	0.43	0.63	1.00			
Reaction time	−0.21	0.01	0.28	0.18	0.30	0.03	−0.11	0.05	−0.26	−0.21	1.00		
MMSE	0.33	0.32	0.15	0.16	0.28	0.50	0.48	0.51	0.25	0.05	−0.47	1.00	
FAB	0.43	0.32	0.27	0.22	0.39	0.39	0.30	0.46	0.40	0.31	−0.48	0.54	1.00

Table 7. Results of logistic regression analysis using before/after independence as dependent variable (Part 2).

	Partial regression coefficient	Significance probability (*p*)	Odds ratio
Constant	−50.974	0.789	
Unsteadiness	11.352	0.934	85,109.43
Associated reaction	2.598	0.057	13.431
Distribution of attention	11.853	0.933	140,538.8
FMA (balance)	2.819	0.016	16.761
Discrimination rate	95.7		

Table 8. Demographic and clinical data of subjects in part 3 (*n*=45).

Age (years)	66.7±12.1
Time from onset (days)	139.8±88.7
Gender: female/male (*n*)	12/33
Side of hemiplegia (left/right)	16/29
Disease: Stroke (*n*)	24
Brain hemorrhage (*n*)	21
Independent ambulation (*n*)	16

Data are expressed as number of patients (*n*) or mean ± standard deviation.

excluded. Therefore, logistic regression analysis was conducted on the 6 subjective assessment items identified in part 1 and one objective assessment item (balance subscale in FMA). The logistic analysis identified (7) associated reaction and balance subscale in FMA as significant factors, with a discrimination rate of 89.3%. When (1) unsteadiness and (2) distribution of attention, which had high correlation of over 0.7 with independent ambulation and were the top ranking reasons for determining dependence in part I, were added to the above two factors, the discrimination rate became 95.7% (Table 7).

Part 3: Examination of the validity of the Seiai rating chart

1. Methods

Among the hemiplegic patients admitted to our three rehabilitation wards (116 beds) during the 6-month period between September 2012 and March 2013, 45 patients (independent ambulation 16 patients, non-independent ambulation 29 patients) who could be assessed using the Seiai rating chart (Figure 1) constructed in part 2 were recruited in this study (Table 8). Walking dependence was rated by the attending physical therapists (mean working experience 6.7 ± 5.8 years). Assessment was done regardless of whether the patient were using walking aids. Physical therapists who were not involved in parts 1 and 2 assessed the patients using the Seiai rating chart and the BBS. The concordance rates between the actual independence status at the time of assessment, the independence status determined by the Seiai rating chart, and the independence status determined by BSS (independence is defined by a score of 45 or above [18]) were calculated using κ coefficient. In addition, patients who were determined to be independent by the Seiai rating chart were followed for the occurrence of falls until the time of discharge.

2. Results

Table 9 shows the actual independence status and the results obtained using the Seiai rating chart and BBS in individual patients. Fourteen patients were determined to be independent by the Seiai rating chart constructed in part 2, and 7 patients were determined to be independent by BBS. Compared with the actual independence status, the Seiai rating chart (κ coefficient 0.95) showed higher concordance with the actual independence status than BBS (κ coefficient 0.72). Two patients who were actually independent were rated as non-independent by the Seiai rating chart, and 9 patients who were actually independent were rated as non-independent by BBS. Among these cases, a few had some problems with balance and were therefore rated as non-independent by the Seiai rating chart or BBS, but they were capable of walking cautiously and consequently were actually

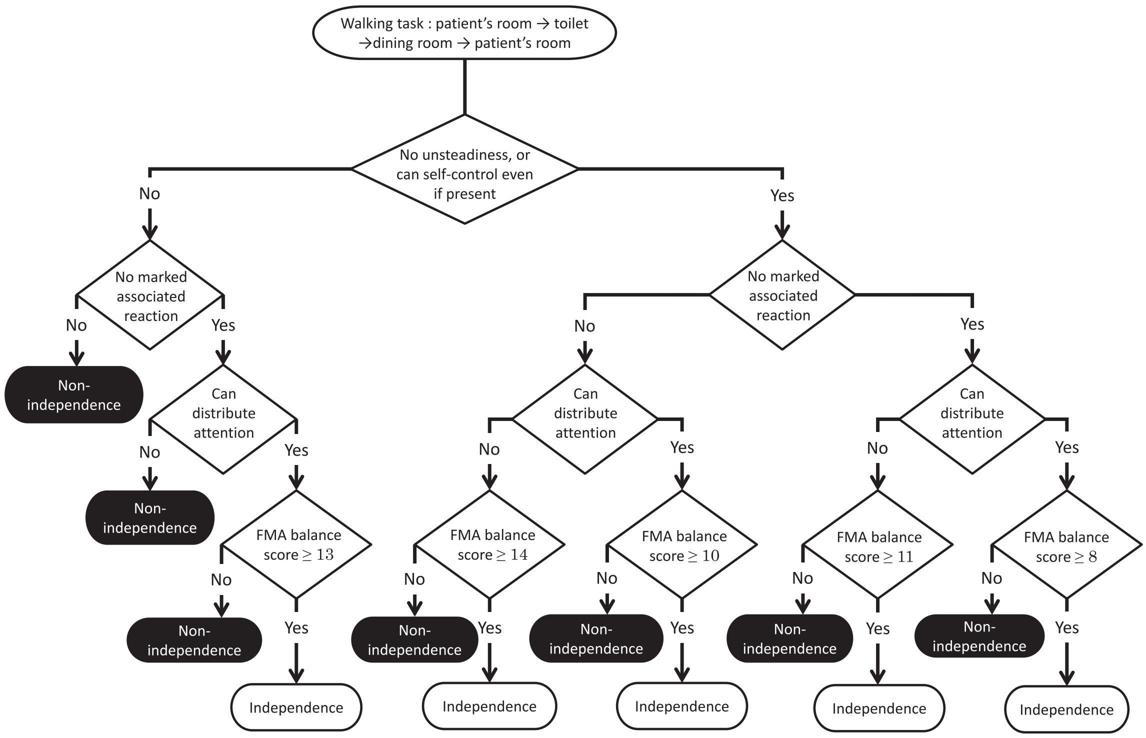

Figure 1. Seiai Independent walking ability Rating Chart (Seiai rating chart).

Table 9. Actual independence status and results from the two rating tools in individual patients.

Patient no.	Actual independence status	Seiai rating chart	BBS	
1	×	×	27	×
2	×	×	15	×
3	×	×	37	×
4	×	×	38	×
5	×	×	36	×
6	×	×	30	×
7	×	×	19	×
8	×	×	30	×
9	×	×	36	×
10	×	×	12	×
11	×	×	24	×
12	×	×	29	×
13	×	×	37	×
14	×	×	51	○
15	×	×	45	○
16	×	×	37	×
17	×	×	4	×
18	×	×	2	×
19	×	×	36	×
20	×	×	41	×
21	×	×	44	×
22	×	×	33	×
23	×	×	25	×
24	×	×	6	×
25	×	×	7	×
26	×	×	34	×
27	×	×	27	×
28	×	×	27	×
29	×	×	29	×
30	○	×	34	×
31	○	×	24	×
32	○	×	37	×
33	○	○	56	○
34	○	○	43	×
35	○	○	48	○
36	○	○	48	○
37	○	○	56	○
38	○	○	52	○
39	○	○	45	×
40	○	○	50	○
41	○	○	45	×
42	○	○	41	×
43	○	○	41	×
44	○	○	43	×
45	○	○	43	×

independent. None of the patients who were actually non-independent were rated as independent by the Seiai rating chart, while 2 patients who were actually non-independent were rated as independent by BBS. The reasons for being rated as independent by BBS but was in fact non-independent include the following: while there was no problem with balance, there were problems with instability while performing some applied movements or with paying attention to the surrounding.

Among patients who were rated as independent, none of them experienced falls until discharge.

Discussion

In rehabilitation wards, physical therapists often determine the functional walking ability in stroke patients from diversified viewpoint, and rarely evaluate only from the cutoff value of a specific assessment battery. However, since the working experience and technical level of physical therapists in rehabilitation ward vary considerably [19, 20] and the opportunity of information exchange among staff members has decreased due to the 365 days a year service, there is a need to develop valid criteria for determining independent ambulation. In order to construct an assessment chart as criteria for determining independent ambulation, we developed the tool in three steps based on actual assessment of independence. The actual assessments of independence in part 1 to part 2 were performed by mid-career physical therapists with mean working experience of around 5 years. Yoshino et al. [21] reported that 90% of the facilities responded that newly recruited physical therapists required training for less than three years. Takeuchi et al. [22] reported that 95% of medical accidents were caused by those with less than 5 years of experience. Based on these previous studies, the physical therapists with mean working experience of 5 years or above who rated independence in the present study should be able to make relatively valid judgement.

In part 2, the logistic regression analysis identified only the subjective indicator "appearance of associated reaction" and the objective indicator "balance ability of FMA" as independent factors. On the other hand, according to the questionnaire survey in part 1, "unsteadiness" and "distribution of attention" were frequently assessed for the determination of independence. In addition, assessing "appearance of associated reaction" and "balance ability of FMA" only cannot evaluate the effect of higher order brain function impairment common seen in stroke patients or the balance ability during unpredictable circumstances in applied tasks. Furthermore, "unsteadiness" and "distribution of attention" showed relatively high correlation with independence in part 2. When we added these two factors to the list, we obtained even higher discrimination rate.

Using the Seiai rating chart that was developed based on the above results, the concordance rate with the actual independence status was higher than using the BBS. BBS is a superior tool for assessing the balance ability in daily life, and the cutoff score for independent ambulation is 45 points. For hemiplegic patients, this score requires a high level of balance function. To compensate for such balance functions, hemiplegic patients make various compensatory movements to walk. In actual fact, these special balance functions are probably not required for independent ambulation. Furthermore, to rate independent ambulation, it is necessary to evaluate attention to the outside world and adaptive capability in actual environments. Indeed, the adaptive capability is the true balance ability in the broad sense. The rating chart developed in this study contains multiple assessments in the actual clinical context, such as the attention function, which may account for its high concordance with the actual independence status.

Since physical therapists cannot monitor patients' movements for 24 hours, the final determination of independent ambulation requires discussions among multiple disciplines. However, in such conference, the physical therapist should exhibit leadership and indicate the patient's problems and examining the intervention plan and the timing of independence. This rating chart would contribute to decide the functional walking ability in stroke patients.

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