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The Gaps between Capability ADL and Performance ADL of Stroke Patients in a Convalescent Rehabilitation Ward —Based on the Functional Independence Measure—

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Abstract. [Purpose] The purpose of this study was to clarify the structure of activities of daily living and their characteristics based on the relationship with their difficulty levels and the gaps between the actual activity level achieved in daily living (performance ADL) and the potential activity level that can be performed under supervision (capability ADL). [Subjects] The subjects of this study were 255 stroke patients. [Methods] Performance ADL and capability ADL were evaluated using the functional independence measure, and the scores were converted to an interval scale by Rasch analysis to compare item difficulty and gaps. [Results] Scores of performance ADL were lower than those of capability ADL. The gaps between capability ADL and performance ADL on admission had not decreased at the time of discharge. ADL items could be categorized into three difficulty levels of high, moderate and low by interval scales. Some ADL items tended to develop gaps, while others did not. The correlation between difficulty level and the gap was extremely low, and ADL items of higher difficulty did not always have greater gaps. [Conclusion] We confirmed that the improvement of capability ADL precedes that of performance ADL in the process of ADL improvement.
Key words: The gaps of ADL, FIM, Rasch analysis

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INTRODUCTION

Improvement of activities of daily living (ADL) of stroke patients is one of major aims of rehabilitation. It is especially important to know the structure and characteristics of ADL in order to efficiently improve ADL in rehabilitation in the convalescence phase.

Beginning in the late 1970s,Granger et al.[1)], Linacre et al.[2)], Chino et al.[3)], Niki[4)], Masakado et al.[5)], Tsuji et al.[6)] and Sonoda et al.[7)] conducted studies on the difficulty of ADL items for stroke patients using the Barthel Index or the functional independence measure (FIM). Following these studies, Ueda, Okawa and others[8–12)] from the early 1990s began reporting ADL gaps between the level of potential activity and the level of actual activity. These gaps are also observed in the process of ADL improvement in clinical settings. The level of potential activity is called the "capability ADL" and the actual level of activity is called the "performance ADL". This bimodal nature of ADL has been recognized as an important perspective for rehabilitation intervention. Regarding ADL gaps, Duncan et al.[13)] monitored the recovery of motor function of 104 stroke patients for 6 months and reported that there is a gap between the timing of functional recovery and ADL improvement. Kenbe et al.[14)], Oshima et al.[15)] and Tsumoto[16)] reported the status of gaps between "capability ADL" evaluated by physical therapists or occupational therapists and "performance ADL" evaluated by nurses, and on countermeasures. Morita et al.[17)] examined psychological factors and environmental factors that affect the ADL gap, and Toshima et al.[18)] evaluated the bimodal ADL assessment as a predictive indicator for prognosis.

Conventional scores for ADL evaluation are rated on an ordinal scale and the significance of adding them has been questioned[19)]. Regarding this, Granger et al.[20)], Wright[21)] and Fiedler et al.[22)] studied conversion of ADL difficulty levels into an interval scale using Rasch analysis[23)]. Rasch analysis was introduced to Japan by Sonoda et al.[24)] and

Chino et al.[25],Tsuji et al.[6,26],Yamada et al.[27] and Tokuhisa et al.[28] have published reports on Rasch analysis. However, there has been no comparative examinations of the potential activity level that can be performed under a specific environment (capability ADL) and the actual activity level achieved in daily living (performance ADL) of convalescent stroke patients at the times of admission and discharge by an identical evaluator. Also, there is no report that has comparatively examined the gaps using data converted to an interval scale. In this study, we evaluated capability ADL and performance ADL using FIM of stroke patients in a convalescent rehabilitation ward, converted the difficult levels of ADL items to interval scales, and examined the conditions of gap development.

SUBJECTS AND METHODS

Among 317 stroke patients who were hospitalized in a convalescent rehabilitation ward (42 beds) of a middle-sized hospital (265 beds) in Hyogo prefecture from April 2004 to March 2010 for a month or longer, 255 cases of stroke cases with supratentorial lesion (excluding subarachnoid hemorrhage) were included as subjects in this study. Cases with subtentorial lesions of the brainstem or cerebellum and subarachnoid hemorrhage present disability patterns different from those with supratentorial lesion[29].

At first, we investigated age, sex, diagnosis, days from the onset to hospitalization, length of stay in the ward, ADL independence levels in the month of admission to the ward and the month of discharge.

At our ward, physicians and therapists in charge present a "Rehabilitation general planning sheet" to patients and families and explain about the content and provision of personal information. Patients and families who consent are supposed to sign the specified section of this sheet. For information acquisition for this study, we obtained written consent from the medical institution. It was decided that the results of this study would be used as academic material and strict caution would be exercised so that no individual could be identified in publication.

ADL independence level was evaluated through capability ADL and performance ADL using FIM. FIM[30] consists of a total of 18 evaluation items including 13 motor items and 5 cognitive items. Each item is evaluated with a score from 1 to 7 based on the amount of required assistance. The total score ranges from 18 to 126, with higher scores indicating greater independence.

Performance ADL was evaluated by the therapists in charge. In order to confirm the ADL items that patients could actually perform in the ward, the therapists collected information about actual status from nurses and caregivers at the same time as observing patients in the ward, and determined the score. Capability ADL was scored by the therapists in charge based on the ADL items which patients could perform in the physical therapy room or the occupational therapy room. We hold regular training sessions in the hospital for evaluators to standardize and improve scoring techniques. Also, we recommend evaluators to actively participate in training sessions such as FIM seminars held outside the hospital.

In FIM, homogeneity between motor items and cognitive items is regarded to be low, and Heinenman et al.[31] reported the effectiveness of using the total score of the 13 motor FIM items to evaluate functional disability. In this study, we compared the motor FIM scores of capability ADL and performance ADL between admission and discharge.

In the analysis, we first determined item difficulty and the fit index based on the scores of capability ADL and performance ADL using Rasch analysis. Rasch analysis[23, 31–34] is a method for transforming the distance of scores into an interval scale through normalization of the relationship between the distribution of capability of the patients and the distribution of item difficulty. Item difficulty is expressed in Logits. Logits (log odds units) is the natural logarithm of the odds for success. A logit value of 0 indicates standard item difficulty, and the greater the value, the higher the difficulty of the ADL item. The fit index is used to estimate the goodness of fit of the patient data to the Rasch model. The fit index is expressed as the mean square fit statistics which is the ratio of the observed distribution to the expected distribution, and its ideal value is 1.0. In this study, information-weighted mean square fit statistics (infit) and outlier-sensitive mean square fit statistics (outfit) were used as fit indexes. When infit and outfit are 1.5 or higher, items are judged to poorly fit the Rasch model.

The rate of cases whose scores for capability ADL and performance ADL agreed with each other (agreement rate) was compared between at admission and at discharge by item. Besides, correlation between the item difficulty, the agreement rate was analyzed.

For Rasch analysis, Winsteps Version 3.65 was used. For general statistical analyses, SPSS18.0J was used. Willcoxon's signed rank sum test and Spearman's rank correlation coefficient (ρ) were used to test the difference between two groups and for correlation analysis, respectively. The significance level was 5%.

RESULTS

The 255 cases consisted of 117 males and 138 females. The average age was 73.5 ± 10.6 years. Diagnoses were made of cerebral infarction for 178 subjects (78 males and 100 females) and cerebral hemorrhage for 77 subjects (39 males and 38 females). The length from the onset to admission to convalescent rehabilitation ward was 45.9 ± 16.4 days (average ± standard deviation) and the length of stay was 110.2 ± 43.4 days. At admission, motor FIM scores of capability ADL and performance ADL were 43.0 ± 24.9 and 40.7 ± 24.4, respectively, while at discharge they were 53.0 ± 27.3 and 50.7 ± 27.5, respectively.

FIM scores of capability ADL and performance ADL are shown by item in Table 1. For all the items, performance ADL scores were lower than capability ADL scores with significant differences ($p<0.01$) both at admission and at discharge.

Item difficulties determined by Rasch analysis are shown in Table 2. Regarding capability ADL at admission, item

Table 1. Average Scores of Motor FIM 13 Items

ADL Items	Admission		Discharge	
	Capability ADL	Performance ADL	Capability ADL	Performance ADL
Eating	4.9 ± 2.2	4.7 ± 2.3*	5.3 ± 2.1	5.1 ± 2.3*
Grooming	4.0 ± 2.3	3.7 ± 2.3*	4.5 ± 2.3	4.3 ± 2.4*
Bathing	2.5 ± 2.2	2.3 ± 2.1*	3.3 ± 2.2	3.1 ± 2.3*
Dressing-Upper Body	3.6 ± 2.2	3.3 ± 2.3*	4.4 ± 2.3	4.1 ± 2.4*
Dressing-Lower Body	3.2 ± 2.3	3.0 ± 2.3*	3.9 ± 2.4	3.7 ± 2.5*
Toileting	3.3 ± 2.3	3.2 ± 2.3*	4.1 ± 2.4	4.0 ± 2.4*
Bladder Management	3.5 ± 2.6	3.5 ± 2.6*	4.3 ± 2.6	4.2 ± 2.7*
Bowel Management	3.7 ± 2.7	3.7 ± 2.7*	4.3 ± 2.7	4.3 ± 2.7*
Transfer-Walking or Wheelchair	3.9 ± 2.1	3.8 ± 2.1*	4.7 ± 2.1	4.6 ± 2.2*
Transfer-Toilet	3.5 ± 2.2	3.3 ± 2.3*	4.4 ± 2.3	4.3 ± 2.3*
Tub/Shower Transfer	2.0 ± 1.8	1.9 ± 1.7*	2.9 ± 2.2	2.9 ± 2.2*
Walking or Using Wheelchair	3.1 ± 2.1	3.0 ± 2.1*	4.2 ± 2.2	4.0 ± 2.3*
Stairs	1.9 ± 1.7	1.5 ± 1.4*	2.8 ± 2.2	2.2 ± 2.0*
Total	43.0 ± 24.9	40.7 ± 24.4	53.0 ± 27.3	50.7 ± 27.5

mean ± SD, * :$p<0.01$.

Table 2. Item Difficulty and Mean Square Fit Statistics(infit, outfit)

	Admission						Discharge					
	Capability ADL			Performance ADL			Capability ADL			Performance ADL		
	Item Difficulty	Infit	Outfit	Item Difficulty	Infit	Outfit	Item Difficulty	infit	outfit	Item Difficulty	infit	outfi
Eating	–1.62	0.92	0.89	–1.60	1.00	0.96	–1.72	1.36	1.06	–1.59	1.43	1.01
Grooming	–0.68	0.89	0.82	–0.62	0.83	0.76	–0.56	0.81	0.80	–0.48	0.80	0.75
Bathing	0.85	1.65	1.25	0.86	1.54	1.29	1.05	1.21	0.98	0.94	1.14	0.94
Dressing –Upper Body	–0.30	0.60	0.56	–0.21	0.63	0.55	–0.37	0.66	0.65	–0.26	0.65	0.60
Dressing –Lower Body	0.10	0.75	0.60	0.09	0.68	0.52	0.22	0.73	0.64	0.21	0.65	0.54
Toileting	–0.05	0.45	0.39	–0.08	0.50	0.41	–0.01	0.50	0.45	–0.14	0.51	0.46
Bladder Management	–0.28	1.75	1.61	–0.38	1.73	1.59	–0.29	1.94	1.74	–0.44	1.80	1.61
Bowel Management	–0.44	1.58	1.30	–0.58	1.42	1.20	–0.32	1.80	1.32	–0.5	1.65	1.18
Transfer –Walking or Wheelchair	–0.62	0.63	0.91	–0.70	0.68	0.99	–0.80	0.58	0.68	–0.84	0.57	0.72
Transfer –Toilet	–0.23	0.67	0.65	–0.25	0.63	0.61	–0.37	0.58	0.55	–0.46	0.54	0.51
Tub/Shower Transfer	1.52	1.64	1.07	1.37	1.46	0.92	1.57	1.20	1.01	1.32	1.20	1.05
Walking or Using Wheelchair	0.13	1.01	1.29	0.09	1.09	1.31	–0.14	0.86	1.10	–0.1	1.17	1.23
Stairs	1.62	1.86	1.18	2.03	2.54	2.12	1.74	1.72	1.75	2.33	2.50	2.58

Item Difficulty unit: logits.

difficulty (unit: logits) was high for three items of Stairs (1.62), Tub/shower transfer (1.52) and Bathing (0.85), low for Eating (–1.62) and in the range of -0.68 to 0.13 for the other 9 items. As for performance ADL at admission, item difficulty was also high for the 3 items of Stairs (2.03), Tub/shower transfer (1.37) and Bathing (0.86), low only for Eating (–1.60) and in the range of –0.70 to 0.09 for the other 9 items. A similar tendency was observed at discharge, and the 13 motor FIM items could be classified into 3 categories; high difficulty ADL items (Stairs, Tub/shower transfer and Bathing), moderate difficulty ADL items (Grooming, Dressing-upper body, Dressing-lower body, Toileting, Bladder management, Bowel management, Transfer-bed, Transfer-toilet and Walking) and low difficulty ADL items (Eating). Item difficulties of moderate difficulty ADL items were close to each other and ranks of difficulty of some of the items differed between capability ADL and performance ADL.

Table 3. Agreement rate of scores for capability ADL and performance ADL

ADL Items	Admission(%)	Discharge(%)
Eating	91.0	89.4
Grooming	85.1	89.0
Bathing	92.2	90.2
Dressing–Upper Body	80.0	80.8
Dressing–Lower Body	87.8	84.3
Toileting	88.6	93.3
Bladder Management	94.9	96.1
Bowel Management	96.1	98.4
Transfer–Walking or Wheelchair	91.0	92.5
Transfer–Toilet	89.0	91.0
Tub/Shower Transfer	93.7	95.7
Walking or Using Wheelchair	89.8	84.3
Stairs	87.5	78.0
Average	89.7	89.5

Fit indices exceeded 1.5 for the following items. At admission; infit of capability ADL: Bathing, Bladder management, Bowel management, Tub/shower transfer and Stairs; outfit of capability ADL: Bladder management; infit of performance ADL: Bathing, Bladder management and Stairs; and outfit of performance ADL: Bladder management and Stairs. At discharge; infit of capability ADL: Bladder management, Bowel management and Stairs; outfit of capability ADL: Bladder management and Stairs; infit of performance ADL: Bladder management, Bowel management and Stairs; and outfit of performance ADL: Bladder management and Stairs (Table 2).

Score agreement rates between capability ADL and performance ADL are shown in Table 3. At admission, agreement rate was high for Bowel management (96.1%), Bladder management (94.9%) and Tub/shower transfer (93.7%), while low for Dressing-upper body (80.0%), Grooming (85.1%), Stairs (87.5%) and Dressing-lower body (87.8%). Similarly at discharge, the rate was high for Bowel management (98.4%), Bladder management (96.1%) and Tub/shower transfer (95.7%), and low for Stairs (78.0%), Dressing-upper body (80.8%), Dressing-lower body (84.3%) and Walking or using wheelchair (84.3%). When the rates at admission and at discharge were compared, some became higher and others became lower at discharge. The agreement rates at discharge were not necessarily higher than those at admission. The average of the agreement rates of the 13 items was 89.7% at admission and 89.5% at discharge.

Correlations between item difficulty and agreement rate excluding the ADL items whose fit index exceeded 1.5 were $\rho = -0.119$ and $\rho = -0.097$ for capability ADL and performance ADL, respectively at admission and $\rho = 0.226$ and $\rho = 0.109$ for capability ADL and performance ADL, respectively at discharge, which were extremely low (Table 4).

DISCUSSION

The convalescent rehabilitation ward provides intensive rehabilitation training aiming at ADL improvement. In the process of ADL improvement, gaps develop between capability ADL and performance ADL and it is considered that the faster the capability ADL improves, the greater the gap tends to be[9]. FIM scores for capability ADL were significantly greater than those for performance ADL both at admission and at discharge for all the 13 FIM items, which clearly shows the bimodal nature of ADL.

Masakado et al.[5] analyzed ADL structure using the Barthel index and reported that ADL items whose independence levels tend to be improved easily includes Eating, Bowel management and Bladder management, and those whose independence level are difficult to be improved include Dressing, Walking, Stairs and Bathing. Niki[4] assessed movements for self-care by stroke patients and reported that low difficulty ADL items include Roll-over, Eating and Bladder continence, while high difficulty ADL items include Dressing and undressing, Indoor walking and Outdoor walking. Tsuji et al.[6] reported that motor items with high difficulty levels include Bowel management, Bladder management and Eating while those with low independence levels include Stairs, Bathing and Tub/shower transfer. Granger et al.[20] determined item difficulty by Rasch analysis and reported that Stairs, Tub/shower transfer and Walking or using wheelchair were the most difficult items and Eating and Grooming were the easiest ones. In the present study, the difficulty levels of Stairs, Bathing and Tub/shower transfer were also high and that of Eating was low. Regarding the ranking of ADL difficulty levels, similar results to previous studies were obtained.

Among ADL items of moderate difficulty, there was not much difference in the difficulty level. It suggests the possibility that ADL items may show recovery irrelevant to their ranking though in principle independence is achieved through ADL items of lower difficulty.

In the Rasch analysis, fit indices exceeded 1.5 for five ADL items. We could not find any homogeneity or orientation in the numerical variation of these ADL items, possibly because there were many cases who could not perform the ADL items even though they had reached the level to perform the ADL items, or because there were many cases who could perform the ADL items even though they had not reached the level to perform the ADL items. These

Table 4. Correlation between item difficulty and agreement rate

	Admission		Discharge	
	Capability ADL	Performance ADL	Capability ADL	Performance ADL
Spearman's rank correlation coefficient (ρ)	–0.119	–0.097	0.226	0.109
Significant probability (both sides)	0.779	0.789	0.531	0.763

ADL items may be the ones through which independence is achieved with the involvement of various factors, not only through improvement of functions. Also, the scoring method of FIM may be a factor. Heinenmann et al.[35] pointed out that the dual scoring method of "the amount of assistance" and "frequency of failure" would be one of the factors for the high fit index for Bladder management. Also, for Stairs, the higher fit index would be related to the fact that there are two kinds of scoring methods: "up and down 12-14 steps" and "up and down 4-6 steps".

Regarding development of the ADL gap, Kenbe et al.[14] evaluated 38 stroke patients and reported that gaps tended not to develop for Eating, Transfer-bed and Transfer-toilet while they tended to develop for Bathing, Dressing-upper body, Tub/shower transfer, Locomotion and Stairs. In their report, however, Sphincter control was not included in the evaluation items. Tsumoto et al.[16] reported that agreement rates were high for Roll-over, Eating, Bladder management and Bowel management while they were low for Indoor walking, Stairs and Outdoor walking. Comparing their results with those of the present study, there is high agreement for the item of Bladder management and low agreement for the items of Stairs, Dressing and Walking or using wheelchair.

Sphincter control, agreement between performance ADL and capability ADL was high. We consider that appropriate assistance was provided resulting in smaller gaps since the frequency of assistance for these items is high in daily life and information on the way of assistance is easily shared. In contrast, agreement rates for Stairs and Walking or using wheelchair were low. We consider that the large gap was generated as a result of risk management, in that patients who could practically perform these items were not allowed to do so in the ward in order to prevent falls or accidents. Dressing activity also tended to develop a gap. It would be because patients could perform this activity in the physical therapy room aware that it was an exercise, whereas in the ward it would have required more staff and a greater amount of assistance. This was also pointed out by Suzuki et al.[36]

In our study, the agreement rate for Tub/shower transfer was high and that for Grooming was low, which was inconsistent with previous studies. Instead, Tub/shower transfer, in particular, was reported as an ADL item with a low agreement rate by Tsumoto et al.[16] This disparity may be attributable to the differences in the management system and training system of the wards where the studies were conducted. In the ward where this study was conducted, physical therapists and occupational therapists collaborate and actively provide the training of bathing activities as an ADL intervention in the ward. Such efforts may have raised the agreement rate.

When agreement rates are compared between at admission and at discharge, some ADL items had higher agreement rates at discharge and others did not. The agreement rates were not necessarily higher at discharge than at admission. That means ADL gaps already existed at admission and remained at discharge without being eliminated. We do not consider that this reflects the treatment results of our ward. For example, there was a case who had a gap in Transfer-bed at admission. The ADL gap had been eliminated at discharge but the same case developed a gap in Walking. In other words, with the improvement of ADL capability, a gap developed in another ADL item of higher difficulty level. That means the improvement of capability ADL precedes that of performance ADL in the process of ADL improvement in stroke patients. Though ADL is used in the evaluation of the category of disability, capability ADL evaluates an aspect close to impairment while performance ADL evaluates an aspect close to handicap[24]. We consider that ADL gap could be confirmed based on the characteristics of the structure of impairments, disabilities and handicaps. In convalescent rehabilitation, it is necessary to detect gaps at the early stage by capability ADL evaluation, in addition to performance ADL evaluation. Actually, in the section of ADL evaluation of the "Rehabilitation General Planning Sheet"[37] which is utilized in medical facilities, there are columns for "daily life (in the ward) performance status: performing activities" and "capability at exercise: capable activities". We suppose that both the capability ADL and performance ADL are evaluated, and if there is any gap, a meeting would be held to discuss the reason.

Tsumoto et al.[16] reported low agreement rates for items of high difficulty in the categories of Mobility and Locomotion and concluded that difficulty levels of activities may affect agreement rates. Since our experience in the clinical setting was similar, we evaluated the correlation between ADL difficulty levels and agreement rates, but we did not find a correlation between higher ADL difficulty levels and lower the agreement rate.

In this study we examined structure and characteristics of ADL from the two viewpoints of ADL difficulty levels and ADL gaps. We consider it important for the provision of ADL training to know these characteristics of ADL. The results also suggest the importance of evaluation of capability ADL as well as evaluation of performance ADL. We intend to continue studying the ADL structure and characteristics of ADL gaps.

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