

## ORIGINAL

# Relationship between Barthel Index scores during the acute phase of rehabilitation and subsequent ADL in stroke patients

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**Abstract :** The Barthel Index (BI) cannot be used to measure initial stroke severity or by extension, to stratify patients by severity in acute stroke trials because most patients are bedbound in the first few hours after stroke, either by their deficit or by medical directive. Our objectives were to clarify the threshold of acute BI for use in the prediction of subsequent independence in activities of daily living (ADL) and to assist in the definition of acute stroke rehabilitation goals. Subjects comprised 78 patients out of 191 inpatients admitted with acute stroke at our hospital during 2006-2007. The BI ADL score was divided into 2 ranges (BI $\geq$ 60 and $\leq$ 40), in a process similar to previous studies. During the acute period (from onset to approximately 3 weeks), all patients with a BI $\geq$ 40 could improve their ADL in 6 months. Patients with a BI $\leq$ 40 exhibited two ADL recovery outcomes (improved and no change) at 6 months. We also found that the skill level of basic activities related to standing was significant indicator of BI improvement ( $P < 0.001$ ). BI scores determined at approximately 3 weeks were reliable predictors of ADL disabilities at 6 months. *J. Med. Invest.* 57 : 81-88, February, 2010

**Keywords :** Barthel Index, stroke, acute rehabilitation, ADL

## INTRODUCTION

The Barthel Index (BI) (1) devised by Dorothea Barthel, RPT has been utilized since 1955. The BI is a simple and useful evaluation of a patient's

independence. It can be easily understood by those who work with patients ; it can be accurately and quickly scored by adhering to the definition of 10 items concerned with activities of daily living (ADL). The total score is not as significant or meaningful as the scores of individual items, since these indicate specific deficiencies.

The BI is a scale that measures 10 basic aspects of activity related to self-care and mobility. The normal score is 100, and lower scores indicate greater dependency. It has been widely used in clinical trials

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to measure patient outcomes. Clinically, the BI has proven to be valuable in discriminating between groups of patients (construct validity) and predicting outcome (predictive validity) (2-4). In clinical research performed by Granger et al., out of 117 stroke patients with BI scores of 0-40, 70% died or were living in long-term care facilities 6 months post-stroke. In contrast, 94% of 206 patients with BI scores of 81-100 were living in the community 6 months post-stroke. Furthermore, stroke patients who had scores  $\geq 60$  after rehabilitation were more likely to be active in their homes and communities, have more social interaction, and were more satisfied with life in general than those with scores  $\leq 60$  (3, 4).

In the setting of an acute stroke, the BI is not especially helpful, as it is highly susceptible to a "floor effect." Most patients, even those with a minor stroke, are bedbound in the first few hours after stroke, either because of their deficit or by medical directive (5, 6). Thus, all acute stroke patients will initially receive low scores. Consequently, the BI cannot be used to measure initial stroke severity or by extension, to stratify patients by severity in acute stroke trials.

In this study, our goal was to clarify the effectiveness of using the BI during acute rehabilitation after stroke and to determine whether the acute BI could be a helpful or meaningful prognosticator of eventual ADL levels for patients at other hospitals.

## METHODS

The total number of acute stroke inpatients admitted to our hospital during the time period 2006-2007 was 191 (102 cerebral infarction [CI], 56 cerebral hemorrhage [CH], 22 subarachnoid hemorrhage [SAH], 11 others). Out of these 191 inpatients, we selected 78 subjects who could be followed up after discharge to another hospital or home (42 CI, 25 CH, 7 SAH, 4 others). The characteristics of the study subjects are shown in Table 1-a and -b. Patients who were discharged from our hospital were

followed up for 6 months to evaluate their physical function.

Various assessments for stroke rehabilitation were used, in accordance with the Japan Guidelines for the Management of Stroke 2004 (7-9). Parameters used in these guidelines included consciousness, recovery stage of hemiplegia, muscle tonus (spasticity), impairment scale of motor function, basic activities, and activities of daily living (ADL). Consciousness was assessed using the Japan Coma Scale (JCS) and Glasgow Coma Scale (GCS). Brunnstrom staging was used to assess the recovery stages of hemiplegia. The modified Ashworth scale was used for evaluation of muscle tonus (spasticity). The stroke impairment assessment set (SIAS) was used for evaluation of integrated motor function. The BI was used to assess ADL. The Functional Independence Measure (FIM™) was used to assess cognitive function in this study. Additionally, we developed another assessment of motor function, a basic activities scale, which consisted of five items (turning over in bed, lying to sitting, holding sitting position, sitting to standing position, holding standing position). Scoring was similar to the BI and comprised three scoring grades (0±10/10, 10/10) : 10/10, Independent ; 5/10, With help from another person ;

Table 1-a. Characteristics of the subjects (n=78)

	Median (25 <sup>th</sup> -75 <sup>th</sup> percentile)
Age (y)	73.0 (64.0-79.0)
Gender (male/female)	46/32
Diagnosis (CI/CH/SAH/others)*	42/25/7/4
Body height (m)	1.64 (1.55-1.68)
Body weight (kg)	58.0 (52.2-67.1)
BMI (kg/m <sup>2</sup> )	23.7 (20.7-25.4)
Onset to admission	1.4 (1.0-2.7)
Span until initial assessments	4.0 (2.0-7.0)
Rehabilitation span	11.5 (3.0-17.8)
Admission to discharge**	17.0 (11.0-22.0)

\*cerebral infarction : CI, cerebral hemorrhage : CH, subarachnoid hemorrhage : SAH

\*\*Admission to discharge : acute period

Table 1-b. Characteristics of each diagnosis\* (N=78)

	CI	CH	SAH	Others
n(male/female)	42(26/16)	25 (14/8)	7(2/5)	4(2/2)
age**	76.0 (66.0-79.0)	70.0 (59.0-77.5)	70.0 (62.5-76.5)	71 (64.0-77.25)
BI (discharge)	50.0 (20.0-85)	10.0 (3.75-25.0)	20.0 (0.0-70.0)	80.0 (65.0-86.25)

\*cerebral infarction : CI, cerebral hemorrhage : CH, subarachnoid hemorrhage : SAH

\*\*age : median (25<sup>th</sup>-75<sup>th</sup> percentile)

0/10, Dependent. Inpatients were assessed twice after admission (on admission and at discharge).

The rehabilitation program consisted of individual training sessions of about 20-80 min duration in the basic activities mentioned above or in ADL items. The sessions were conducted 5 days a week by our rehabilitation staff, which consisted of a physical therapist [PT], an occupational therapist [OT] and a speech-language-hearing therapist [ST]. Nursing care was also included in the program.

For follow-up after discharge, we developed simplified acute stroke assessments and sent them along with the patients to other supportive hospitals. These assessments were collected at 3 and 6 months (10-12) after discharge. Patients who were discharged to home were interviewed by telephone regarding ADL.

#### *Statistical analysis*

1) Determination of arbitrary thresholds from the distribution of BI scores

We evaluated the BI during the acute period, at 3 months and at 6 months. ADL abilities, which were identified by the total score of BI items, were recorded and classified into three groups: Independent (BI score  $\geq 60$ ), with help (BI score 40-60), and dependent ( $\leq 40$ ). There were no patients with a score of independent on admission: hence, we arbitrarily set our thresholds at 40 and 60, since fewer than 50% of patients with a score threshold  $\leq 40$  were independent in very basic skills, such as feeding, grooming, and sphincter control, and because a score of 60 implies partial independence in ADL (2, 13). We also studied changes in BI scores (total and individual items) over time.

2) Differences between the arbitrary BI ranges

We enumerated our patients using the threshold scores of 40 and 60 on discharge as a meaningful expression of ADL abilities. The number (percentage) of patients with a score  $\geq 60$  was 27 (34.6%), with a score  $\leq 40$  was 44 (56.4%), and with a score between 40 and 60 was 7 (9.0%) on discharge from acute rehabilitation. Changes of BI were compared between the acute period, the score at discharge, and at 6 months post-discharge. The group with scores  $\leq 40$  was then divided into two more groups according to whether the BI significantly improved during the acute phase or showed no significant change or a decline. The result was two groups: Improved and no change. The number in the improved group was 28 and the number in the no change group was 16. Statistical significance of

group comparison was evaluated by unpaired t test. 3) Differences in BI item scores between two subgroups having a score  $\leq 40$

We evaluated the individual BI items on discharge to compare the differences between the improved 28 and no change 16 groups. The statistical significance of this group comparison was evaluated by unpaired t test.

4) Differences in acute stroke assessments on discharge between improved and no change

Acute stroke assessments on discharge were compared between the two subgroups with scores  $\leq 40$  to examine the determinants for improved or no change ADL function at 6 months. Statistical significance of group comparison was evaluated by the unpaired t test.

5) Predictors of BI in the acute phase

The acute rehabilitation program in our hospital utilizes basic activity training to improve ADL abilities. To identify the most effective training for improvement of ADL skills, multiple regression analysis was used to determine associations between BI scores and our basic activities evaluation scores during acute rehabilitation. The BI at discharge was used as the outcome variable, while basic activities scores were used as explanatory variables (age, sex, and scores of the basic activities items).

6) Predictors of ADL disabilities at 6 months.

We then examined whether the BI on discharge from the acute rehabilitation phase predicts ADL disabilities at 6 months. Multiple regression analysis was used to determine the associations between BI and stroke assessments in the acute rehabilitation phase. We used BI at 6 months as an outcome variable and the scores of acute stroke assessments as explanatory variables after adjustment for the effects of age and gender.

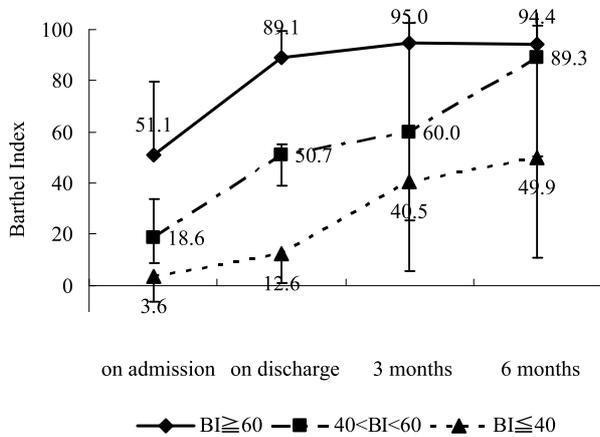
Statistical significance was defined as a *p* value of  $< 0.05$ . All of these analyses were carried out using Microsoft Excel software (Microsoft Corp, Redmond, WA, USA) add-on ekuseru-toukei 2006 version 1.42 (Social Survey Research Information Co., Ltd).

## RESULTS

### *1) Investigation for distribution of BI*

The mean BI increased with time, showing improvement in ADL skill level. Total mean BI ( $\pm$  standard deviation [SD]) was  $21.4 \pm 28.7$  on admission,  $42.5 \pm 37.4$  on discharge,  $57.9 \pm 37.8$  at 3

months, and  $67.3 \pm 37.2$  at 6 months. This pattern of improvement in BI was clearly different within each of the three score ranges (score  $\geq 60$ , 40-60, and  $\leq 40$ ) (Figure 1).



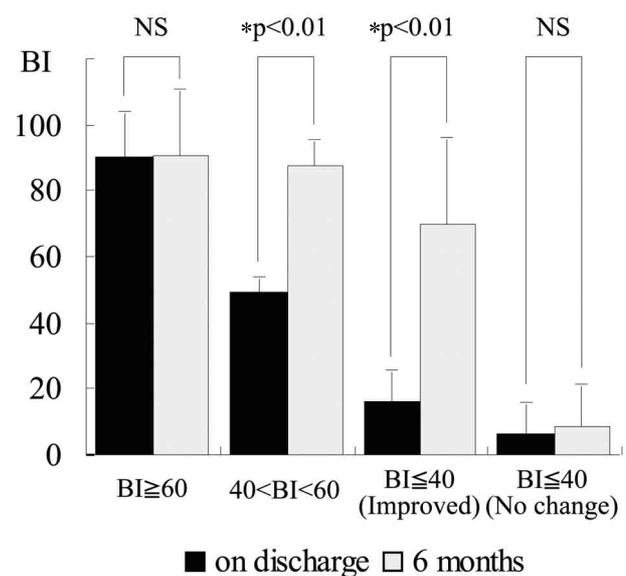
**Figure 1** N=78, BI changes in patients with different BI score ranges. Though all ranges changed for the better, patients with a BI  $\geq 40$  on discharge improved more than patients with a BI  $\leq 40$  after 6 months. Patients with a BI  $\geq 60$  on discharge maintained the same level of ADL at 6 months.

The upper range of the independent variable with a score  $\geq 60$  (27 patients) had no influence on ADL except for the controlled BI items grooming, bathing, and stair climbing. These three items showed lower scores during hospitalization or at home because these activities were “controlled” in the sense that they were limited by medical staff or the patient themselves to prevent accidents. The number of controlled items in the BI of patients with a total score  $\geq 60$  at the time the BI was given was as follows: For the grooming item, 0 (0%) were controlled on discharge, 2 (2.6%) were controlled at 3 months, and 3 (3.8%) were controlled at 6 months; for bathing items, 15 (19.2%) were controlled on discharge, 12 (15.4%) were controlled at 3 months, and 18 (23.0%) were controlled at 6 months; and for stair climbing, 7 (9.0%) were controlled at discharge, 4 (5.1%) were controlled at 3 months, and 3 (3.8%) were controlled at 6 months. The most controlled item was bathing, even for patients who were generally independent. Frequently, patients with a BI on discharge  $\leq 40$  (44 patients) had no items counted as independent. The BI scores of the subjects were not found to be a normal distribution. These threshold scores were considered arbitrary BI thresholds for determination of ADL independence or dependence. The rate of independence in patients with a score  $\leq 40$  was 0.0%, with the majority of patients

having difficulty with the transition from sitting to standing (56.9%). In this score range, the highest rates of complete dependence were for the BI items grooming, bathing, and stair climbing. However, 44 patients with a BI  $\leq 40$  improved their ADL scores at discharge approximately 3 weeks after stroke. After 6 months, 28 of these patients (63.6%) showed ADL score recovery compared with the score at discharge. With a score of 40-60 (7 patients), the rate of the independent and with help groups increased more than the dependent group. Patients with a BI  $\geq 60$  at discharge exhibited partial independence in their ADL in all activities except for the controlled BI items in the hospital or at home. These patients were nearly independent with regard to all BI items after 6 months (mean  $\pm$  SD :  $94.4 \pm 12.0$ ). The changes in patients with a BI score  $\geq 60$  differed from patients with a BI score  $\leq 40$ . For individual BI-scored items, three items-grooming, bathing, and stair climbing-were controlled during hospitalization by medical staff to prevent accidents, which was reflected in lower BI scores in all phases. On the other hand, no inpatients with a BI score  $\leq 40$  were independent for all items during acute rehabilitation.

## 2) Differences between patients with BI scores $\leq 40$ and $\geq 60$ of BI

Analysis of the arbitrary BI ranges is shown in Figure 2. The number of patients with a score  $\geq 60$



**Figure 2** N=78, mean  $\pm$  SD, the paired t test, \*P < 0.01. Score ranges were divided by BI on discharge: 27 (BI  $\geq 60$ ), 44 (BI  $\leq 40$ ), 7 (40 < BI < 60). The group of 44 patients (BI  $\leq 40$ ) consisted of 28 improved and 16 no change or declined in ADL skills.

was 27 (34.6%) and  $\leq 40$  was 44 (56.4%). Patients with a score  $\geq 60$  on discharge (mean score  $89.1 \pm 10.7$ ) did not show a statistically significant improvement at 6 months ( $94.4 \pm 12.0$ ,  $P=0.09$ ) using the unpaired t test. Their ADL abilities were maintained unchanged at a high level or improved slightly over 6 months. Patients with a score  $\leq 40$  on discharge showed two patterns of ADL recovery-either a statistically significant ADL improvement, or they showed no change or a decline. Of the patients with  $BI \leq 40$  (44), 28 of the 44 (63.6%) improved their scores at discharge (mean  $15.2 \pm 12.3$ ) to mean scores after 6 months of  $66.1 \pm 28.5$  ( $P < .0001$ ). Sixteen of 44 patients (36.4%) showed no significant change from discharge scores (mean  $11.2 \pm 10.6$ ) to mean scores at 6 months  $22.6 \pm 32.3$  ( $P=0.07$ ). One-third of stroke patients had not improved after 6 months.

There were 7 patients (9.0%) with BI scores at discharge in the 40-60 range. Their mean score was  $50.7 \pm 4.5$  on discharge and  $89.3 \pm 12.4$  at 6 months, which statistically showed a significant difference ( $P < .0001$ ). All of these patients improved their BI scores to exceed 60 at 6 months.

3) Differences of BI items between 2 groups with a score  $\leq 40$

Patients with a  $BI \leq 40$  showed an age difference

but no gender difference. The no change group was significantly older than the improved group. The age of the no change group (mean  $\pm$  SD) was  $75.9 \pm 11.6$  and the improved group mean was  $68.5 \pm 9.3$ , which showed a significant difference by unpaired t test ( $P=0.027$ ). The improved group included 16 males (36.3%) and 12 females (27.2%). The no change group included seven males (15.9%) and nine females (20.4%). The distribution of gender showed no significant difference ( $P=0.392$ ) by the  $\chi^2$  test between the two group.

Patients with a  $BI \leq 40$  on discharge who had no change in ADL abilities at 6 months were not significantly different with regard to the individual scores of BI items on discharge as shown. Change of BI scores in two groups of patients with  $BI \leq 40$  at discharge is shown in Figure 3.

4) Comparison of acute stroke assessments on discharge

Improved and no change of ADL disabilities at 6 months were compared with acute stroke assessments on discharge. The measurement of quadriceps muscle strength and grip (SIAS) were normally distributed. Others quantities did not have a normal distribution ; Age, range of motion of upper extremity (ROM of U/E ; SIAS), cognitive function (FIM<sup>TM</sup>), basic activity skills, and BI. The statistical

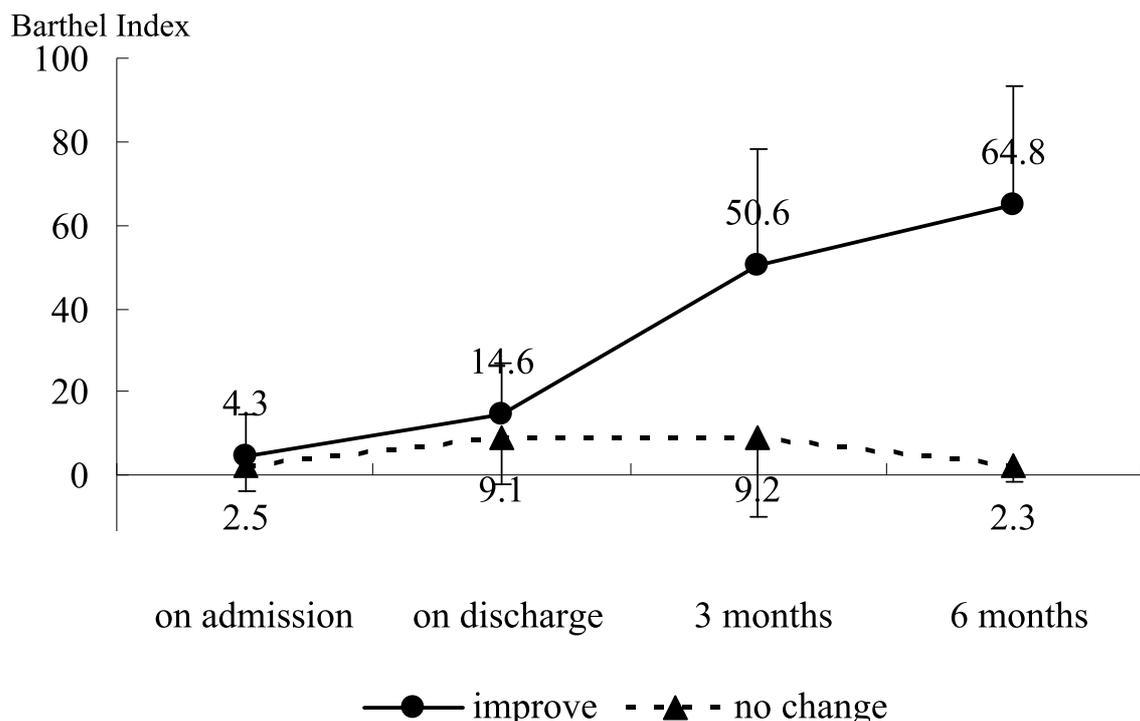


Figure. 3 N=44 (16 no change and 28 improve). Of patients with a  $BI \leq 40$ , two-thirds of patients could improved their ADL while one third of patients did not change.

significance of these acute stroke assessments is shown in Table 2. We found significant differences in age ( $P=0.032$ ), strength of the normal side of quadriceps ( $P=0.012$ ), grip ( $P=0.037$ ), cognitive function ( $P=0.016$ ), basic activity ( $P=0.009$ ), and BI score ( $P=0.017$ ). Patients with a  $BI \leq 40$  who improved at 6 months showed higher scores than the group that had no change during the acute period about 3 weeks after onset.

Table 2. Stroke assessments (Barthel Index [BI]  $\leq 40$ , on discharge)

	No change	Improved	P value
Age (y)	76.6 $\pm$ 11.5	68.5 $\pm$ 9.3	0.032**
Quadriceps (normal side)	1.3 $\pm$ 0.9	2.0 $\pm$ 0.8	0.012*
Grip (normal side)	6.2 $\pm$ 6.7	14.5 $\pm$ 8.2	0.003*
ROM (U/E)	2.4 $\pm$ 0.6	2.8 $\pm$ 0.5	0.037**
Cognitive Function (FIM)	12.8 $\pm$ 8.4	18.0 $\pm$ 6.7	0.016**
Basic activity skills	7.7 $\pm$ 8.1	17.1 $\pm$ 13.6	0.009**
BI score	5.7 $\pm$ 7.0	14.6 $\pm$ 12.4	0.017**

N=37; BI  $\leq 40$  (16 no change, 28 improve). \*unpaired t test. \*\*Welch's t test.

Muscle strength, ROM (Range of motion); SIAS score, U/E; upper extremity, Cognitive Function; FIM<sup>TM</sup> score. Stroke assessments in Table 2 showed that during acute rehabilitation, the improved subgroup (BI  $\leq 40$ ) had higher scores compared with the no change subgroup at 6 months during acute rehabilitation.

### 5) Predictor of BI during the acute phase

Multiple regression analysis showed that standing had an effect upon improvement of BI during the acute stroke rehabilitation period (Table 3). Probable determinants of BI in acute rehabilitation were the two basic activities of sitting to standing position ( $P < 0.001$ ) and holding the standing position ( $P = 0.001$ ). The other items could not significantly explain the BI. This result indicated that standing

Table 3. Basic activities and Barthel Index

	Parameter Estimate	Standard Error	P value
Age	0.24	1.00	0.092(NS)
Sex	3.01	3.33	0.369(NS)
Turn over in bed	1.00	1.00	0.318(NS)
Lie to sit position	0.33	1.04	0.749(NS)
Sit position hold	0.28	1.18	0.811(NS)
<b>Sit to stand position</b>	<b>3.86</b>	<b>1.07</b>	<b>0.0006(&lt;0.01)</b>
<b>Stand position hold</b>	<b>3.55</b>	<b>0.14</b>	<b>0.001(&lt;0.05)</b>

N=78, multiple regression analysis

Standing activities (bold) had effects on the BI scores at discharge during the acute stroke rehabilitation.

training could be very helpful during the period of acute rehabilitation.

### 6) Predictors of ADL disabilities at 6 months

Multiple regression analysis could not conclude that acute stroke assessments on discharge predicted improvement of physical function at 6 months.

## DISCUSSION

Mean days from admission to discharge was 18.3. Mean length of stay by type of stroke was follows: CI, 15.8 days; CH, 16.7 days; SAH, 35.4 days; and others 15.9 days. The BI, CI (51.3 $\pm$ 36.6) was significant higher than CH (21.5 $\pm$ 28.8) at discharge ( $P=0.001$ ). We assessed motor function and ADL skills in stroke inpatients twice (on admission to the stroke care unit and on discharge). Patients were followed up at 3 and 6 months after discharge using a similar but simpler stroke assessment instrument developed at our hospital. In this study, ADL disabilities at 6 months gave some information regarding the effectiveness of acute stroke rehabilitation (14).

The BI evaluated at the acute phase can be used to predict post-stroke rehabilitation progress (15, 16). Analysis of the BI reveals that an initial score (determined, on average, within 1 week after admission to the rehabilitation hospital)  $\geq 40$  defines a population with a greater proportion of home discharges and that patients with initial scores  $\geq 60$  have a shorter length of stay (17). Also, with a BI  $\leq 40$ , no patient had independent mobility skills, and fewer than 50% were independent in very basic skills, such as feeding, grooming and sphincter control. A score of 60 appears to be a pivotal score at which patients move from dependency to assisted independence (3, 18, 19).

In this study, the same BI thresholds (40 and 60) were found to be important in determining the ADL independence of stroke patients. Each recovery stage showed a similar in the acute phase. The scores  $\geq 60$  (34.6%) and  $\leq 40$  (56.4%) had a larger significance in the acute phase. Patients with a BI  $\geq 60$  had no dependences except for controlled items such as grooming, bathing, and stair climbing, and patients with BI score  $\leq 40$  had no independence in ADL, which led us to select these arbitrary scores for characterizing stroke patients. Patients with a BI score  $\geq 60$  could perform ADL activities with or

without someone's help in the hospital. Patients with BI  $\geq 60$  showed no significant change in ADL skill level between discharge and 6 months. That is, patients with a score  $\geq 60$  in the acute phase maintained their ADL abilities for 6 months. With a score  $\leq 40$ , the rate of dependence was still high, and patients had a high possibility of restricted ADL activities. All BI items on discharge were considered almost dependent in this score range, which needed more care. Patients with BI  $\leq 40$  had two recovery paths, a statistically significant improvement or no change at 6 months. The improved group showed a distinct recovery of ADL skills (BI  $\geq 60$ ) after 6 months, which means they could have partial independence in ADL. Another group showed a flat line for ADL recovery from acute phase to 6 months. About a third of stroke patients with a score  $\leq 40$  had not recovered for 6 months. Early recovery of ADL items by improved patients (BI  $\leq 40$ ) did not differ from patients in the no change group during the acute rehabilitation stage. Differences in acute stroke assessments factors such as age, cognitive function, muscle strength (quadriceps and grip with normal side), ROM of U/E, cognitive function, and basic activity skills could affect ADL recovery during acute rehabilitation (20-22).

Not only age but BI evaluated during the acute phase could be promising predictors of ADL disabilities at 6 months (23). The staff of the post-acute rehabilitation team could make use of the BI to better understand ADL problems in stroke patients, and simple physical assessments in the early stage could help us to successfully manage ADL recovery. In our hospital, basic activity training is routinely adopted as a strategy for rehabilitation training for stroke. Improved BI scores could confirm a higher level of ADL and help with an individual's physical recovery. To improve BI during the acute phase, standing (as a basic activity) could be very useful in ADL (BI) improvement as an indicator of training progression during this period. Basic activities are a necessary prologue before starting ADL acquisition process. The BI can then be helpful in the next stage after the achievement of basic activities. We also used an original assessment scale to measure the basic abilities before working on ADL. This scale consisted of five items that used three scoring grades from BI: Independent, with help, and dependent. Scoring was the same as the BI, and the total possible score was 50. This approach led to a more effective process for improving ADL skills. Specifically, we found that early standing position

exercises were important in improving the BI. Evaluating these basic activities in a detached, clinical manner could be also suitable to help identify the functional skill levels of inpatients (23).

## LIMITATIONS

There were several limitations to our study. Assessments during rehabilitation were not totally objective, instrumental measurements; they were dependent on people not equipment. Nevertheless, on comparing with results of previous studies, our results are reliable (24). In addition, the small number of clinical subjects included no controls (patients without rehabilitation training).

## CONCLUSION

Stroke patients with an early BI score  $\geq 40$  could be partially independent in their ADL at 6 months except for grooming, bathing, and stair climbing, implying a BI threshold for expected ADL recovery after stroke. Two-thirds of inpatients with a BI score  $\leq 40$  had a possibility of being partially independent in their ADL. The BI scores at approximately 3 weeks could predict ADL disabilities at 6 months.

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