Motor Function Cutoff Values for Independent Dressing in Stroke Patients

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MeSH TERMS
- activities of daily living
- motor skills
- postural balance
- ROC curve
- stroke

OBJECTIVE. This study established motor function cutoff values for dressing independence in inpatients with stroke.

METHODS. Ninety-eight first-time inpatients with stroke were divided into groups on the basis of independence level in dressing, and receiver operating characteristic curves were determined for balance, motor function of affected limbs, trunk function, motor function of unaffected upper limb, and cognitive function.

RESULTS. Area under the curve for the Berg Balance Scale (BBS) was highest for the different motor functions. In distinguishing independence group and supervision or less level group, the cutoff value for the BBS was 44 points (sensitivity = 85%, specificity = 93%). In distinguishing supervision or higher level group and dependence group, the cutoff value for the BBS was 32 points (sensitivity = 94%, specificity = 79%).

CONCLUSION. Balance was strongly correlated with the level of dressing independence, and cutoff values for the BBS were indicators of the balance required to reach independent and supervision levels of dressing.

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After stroke, various dysfunctions frequently influence independence in activities of daily living (ADLs). Motor function impairments in particular have a greater effect than perceptual and cognitive dysfunction on independence in ADLs (Mercier, Audet, Hébert, Rochette, & Dubois, 2001). Therefore, determining the relationship between motor function and ADLs is vital in designing rehabilitation programs aimed at improving ADLs. In people with stroke, the function of the affected upper limb (Mercier et al., 2001), affected lower limb (Fujita et al., 2015b), coordination of unaffected upper limb (Bjørneby & Reinvang, 1985), trunk function (Likhi, Jidesh, Kanagaraj, & George, 2013), and balance (Mercier et al., 2001) have been reported to be related to ADL independence.

Dressing is an ADL in which people with stroke have difficulties achieving independence. According to previous studies, 41% of people require assistance with dressing 1 mo after a stroke, and 36% continue to require assistance 2 yr poststroke (Edmans & Lincoln, 1990; Edmans, Towle, & Lincoln, 1991). Previous studies have revealed that motor function of the affected upper and lower limbs (Walker & Lincoln, 1991) and trunk function (Fujita et al., 2015a; Saito, Toshima, Nori, & Kimura, 2012) are involved in independence in dressing. However, few studies have examined the relationship of dressing and motor dysfunction (Walker & Walker, 2001). For instance, it is unclear whether the functions that have been reported to relate to ADL performance, such as unaffected upper-limb function and balance, influence dressing independence in patients with stroke.

Previous studies (Fujita et al., 2015a; Saito et al., 2012; Walker & Lincoln, 1991) that examined the relationship between motor function and dressing performance may be important in designing occupational therapy programs aimed at improving ADL performance. However, objective quantitative measurements are also needed to guide occupational therapists' clinical decision making related to ADL performance. For example, scores on the Berg Balance Scale (BBS; Berg, Wood-Dauphinee, & Williams, 1989) are strongly linked to fall risk (Berg et al., 1989), and a BBS score of 45 has been identified as a cutoff value for risk of falls in older adults (Berg, Wood-Dauphinee, Williams, & Maki, 1992; Bogle Thorbahn & Newton, 1996). This cutoff value is calculated by using a receiver operating characteristic (ROC) curve, which is widely accepted as a method for selecting an optimal cutoff point for normal or abnormal (e.g., persons with vs. those without a health condition; people who fall vs. those who do not; Akobeng, 2007). To determine cutoff values for independence with ADLs, application of an objective quantitative index, such as the ROC curve, to ADL studies is needed. Moreover, these cutoff values can be used to determine ambulation safety and assistive device prescription and as target goals for therapy intervention.

A previous study by Bjørneby and Reinvang (1985) reported that a time of 168 s to perform the grooved pegboard test with the unaffected upper limb was the cutoff value for ADL independence in stroke patients. However, to our knowledge, no report has yet determined the cutoff value for motor function required for dressing. Moreover, no report has examined cutoff values on the basis of detailed independence levels in ADLs, that is, independence, supervision, or assistance. These cutoff values for dressing independence must be clinically useful because they will be used as targets in rehabilitation aimed at improving dressing for inpatients on a rehabilitation hospital ward. Moreover, the cutoff values will become a reference for judging when these patients can safely dress themselves independently. The aim of this study was to establish motor function cutoff values for dressing independence in inpatients with stroke on a rehabilitation hospital ward.

Method

Participants

Participants were 98 inpatients with stroke (58 men and 40 women, 47 with right hemiplegia and 51 with left hemiplegia; mean age = 71.3 yr, standard deviation = 13.8) who were admitted and discharged from a rehabilitation hospital ward. The inclusion criteria were first stroke and unilateral supratentorial hemispheric lesion. Patients who were missing records for the assessments mentioned in the "Data Collection" section were excluded from the study.

All patients were provided with a standard stroke rehabilitation program by occupational, physical, and speech therapists, as required. The therapy focused on each patient's individual problems and included ADL training, arm activities, balance and gait training, and speech and cognitive training. Patients received therapy 7 days/wk, 2–3 hr/day on weekdays and Saturday and 1 hr on Sundays and national holidays. The average time between stroke and discharge was 94.4 days (standard deviation = 35.9). The ethical review boards of Northern Fukushima Medical Center (No. 56) and Tohoku Fukushi University (RS141201) approved this study.

Data Collection

This study was a retrospective secondary analysis of an existing database. We collected and analyzed data from medical records at discharge. The BBS was used to assess balance function. The Stroke Impairment Assessment Set (SIAS; Chino, Sonoda, Domen, Saitoh, & Kimura, 1994) items for motor function were used to assess motor function of the affected side, and SIAS items for trunk function were used to assess trunk function. The Simple Test for Evaluating Hand Function (STEF; Kaneko & Muraki, 1990) was used to assess the function of the unaffected upper limb. Cognitive function and dressing performance were assessed using the FIM® instrument (Hamilton & Granger, 1994; Uniform Data System for Medical Rehabilitation, 1990).

The BBS assesses balance function in older adults. It is composed of 14 items scored on a 5-point scale ranging from 0 (*unable to perform the task*) to 4 (*able to easily perform the task*). The maximum total score is 56 points. The reliability and validity of this scale for stroke patients have been confirmed (Berg, Wood-Dauphinee, & Williams, 1995).

The SIAS is used to comprehensively assess functions commonly impaired as a result of stroke. It is composed of 22 items classified into nine dysfunctions, and each item is rated on a 3- or 5-point scale. A total of 5 items were used in the present study to assess motor function of the affected side, including the hand-from-knee-to-mouth test and finger-function test for the upper limbs and the hip flexion test, knee extension test, and foot-pat test for the lower limbs. These items are scored on a scale ranging from 0 to 5 depending on performance, and a score is assigned as follows (Chino et al., 1994): If patient has no muscle contraction, a score of 0 is given. If the patient is able to

complete the task (e.g., bring hand on the affected side to mouth and flex and extend each digit) with clumsiness, a score of 3 is given. A score of 5 indicates that the patient can perform the task as smoothly as on the unaffected side.

Trunk function items included the abdominal muscle strength test and verticality test, which are scored on a scale ranging from 0 to 3. Abdominal muscle strength is evaluated as follows. The patient is seated in a 45° semireclining position in either a wheelchair or a high-back chair and asked to raise the shoulders off the back of the chair and assume a sitting position. A score of 0 indicates that the patient is unable to sit up, and a score of 2 indicates that the patient is able to achieve a sitting position despite pressure on the sternum by the examiner. If the patient is able to sit up against considerable resistance, a score of 3 is assigned. In the verticality test, a score of 0 is given if the patient cannot maintain a sitting position. A score of 2 indicates that the patient can sit vertically when reminded to do so. If the patient can sit vertically in a normal manner, a score of 3 is given (Chino et al., 1994). These tests have proven reliability and validity (Domen, 1995; Sonoda, 1995).

The STEF objectively determines motor ability of the upper limbs, particularly as related to the speed of movement. The test is composed of 10 subtests; scores are calculated by measuring the time it takes to move 10 objects of different sizes, shapes, weights, and materials. Standard values are assigned according to age group.

The FIM instrument assesses the level of independence in ADLs and is rated on a 7-point scale on the basis of the amount of assistance required. The present study used the dressing items (upper and lower garments) and cognitive domain items (expression, comprehension, problem solving, social interaction, and memory). The FIM's reliability has been confirmed in stroke patients (Fricke, Unsworth, & Worrell, 1993; Segal & Schall, 1994).

In this study, total scores for the SIAS knee-to-mouth test and finger-function test were used to assess motor function of the affected upper limb; the total scores for the SIAS hip flexion test, knee extension test, and foot-pat test were used to assess motor function of the affected lower limb; and the total scores for the SIAS verticality test and abdominal muscle strength test were used to assess trunk function. The lower score on the FIM for dressing the upper and lower body was used to assess the level of independence in dressing.

Procedures

Ninety-eight patients with stroke were divided into two groups according to their FIM score for dressing: an independence group with a score of ≥6 ($n = 53$) and a supervision or less level group with a score of ≤5 ($n = 45$). ROC curves were used to elucidate the relationship between the level of independence in dressing and motor and cognitive functions and to determine optimal cutoff values (Akobeng, 2007). The ROC curve can be used for three purposes: (1) to determine the cutoff point at which optimal sensitivity and specificity are achieved, (2) to assess the diagnostic accuracy of a test, and (3) to compare the usefulness of two or more diagnostic tests (Akobeng, 2007). The area under the ROC curve (AUC) was calculated; measures with an AUC of ≥.9 (high accuracy; Akobeng, 2007) were deemed useful indicators for determining independence level. Cutoff values were calculated using Youden's Index (Fluss, Faraggi, & Reiser, 2005).

This analysis was repeated with the participants divided into a supervision or higher level group with an FIM dressing score of ≥5 ($n = 64$) and a dependence group with an FIM dressing score of ≤4 ($n = 34$). In this study, the higher level of independence is positive on ROC curves.

To reduce the chance of error when using the cutoff value determined in this study, each motor and cognitive function was compared with respect to true-positive and false-positive cases or true-negative and false-negative cases using the Mann–Whitney U test and χ^2 test. *True positive* represents the case in which participants in the independence group or supervision or higher level group were correctly placed in their respective groups on the basis of the cutoff value. *False positive* represents the case in which participants in the supervision or less level group or dependence group were incorrectly placed in the independence or supervision or higher level group on the basis of the cutoff value, respectively. *True negative* represents the case in which participants in the supervision or less level group or dependence group were correctly placed in their respective groups on the basis of the cutoff value. *False negative* represents the case in which participants in the independence group or supervision or higher level group were incorrectly placed in the supervision or less level group or dependence groups on the basis of the cutoff value, respectively. Our analysis aimed to clarify the characteristics of patients who may easily be misjudged. The statistical software used was IBM SPSS Statistics (Version 22.0; IBM Corporation, Armonk, NY) and ROCKIT (Version 9B; University of Chicago, Chicago, IL). The level of significance was set at <5%.

Results

Scores on the FIM dressing item were 7 points for 37 participants (37.8%), 6 points for 16 participants (16.3%), 5 points for 11 participants (11.2%), 4 points for 6 participants (6.1%), 3 points for 2 participants (2.0%), 2 points for 7 participants (7.1%), and 1 point for 19

participants (19.4%). ROC curves for each function are shown in Figure 1. In the comparisons of the independence group and supervision or less level group, the area under the curve (AUC) was .95 for the BBS, .71 for motor function of the affected upper limb, .72 for motor function of the affected lower limb, .82 for trunk function, .82 for the STEF, and .85 for the FIM cognitive items. The cutoff value determined for these two groups on the BBS was 44 points (sensitivity = 85%, specificity = 93%).

In the comparisons of the supervision or higher level group and dependence group, the AUC was .92 for the BBS, .75 for motor function of the affected upper limb, .75 for motor function of the affected lower limb, .84 for trunk function, .80 for STEF, and .85 for the FIM cognitive items (Figure 1B). The cutoff value determined for these two groups on the BBS was 32 points (sensitivity = 94%, specificity = 79%).

When participants were discriminated according to a BBS score of 44 points, there were 45 true-positive cases, 3 false-positive cases, 42 true-negative cases, and 8 false-negative cases. No significant differences were found in motor and cognitive function scores between the true-positive and false-positive cases (Table 1). However, scores for trunk function ($p < .01$), STEF ($p < .05$), and FIM cognitive items ($p < .05$) were significantly lower in true-negative cases than in false-negative cases (Table 1).

When participants were discriminated according to a BBS of 32 points, there were 60 true-positive cases, 7 false-positive cases, 27 true-negative cases, and 4 false-negative cases. Scores for FIM cognitive items were significantly higher in true-positive cases than in false-positive cases, and scores for trunk function ($p < .05$) were significantly lower in true-negative cases than in false-negative cases (Table 2).

Discussion

Balance was strongly associated with independence level in dressing, and cutoff values based on the BBS have a very high discrimination power. The results revealed that BBS score was an important variable in the discrimination among independence, supervision, and dependence in dressing and suggest that balance is a more important function influencing dressing independence than motor and cognitive functions. Balance training may be effective in improving independence level in dressing.

In this study, a BBS score of 44 points was the cutoff value to discriminate dressing independence, and a BBS score of 32 points was the cutoff value to discriminate at least a supervision level of dressing independence. These values indicate the balance required for achieving either independence or supervision and will be targets for balance training aimed at improving dressing. In addition, occupational therapy practitioners can use these cutoff values as criteria in determining the level of assistance (e.g., supervision necessary) required by a patient on a rehabilitation hospital ward for dressing. For instance, patients with stroke who have a BBS score between 32 and 43 points must be able to dress themselves without assistance despite requiring supervision. However, these cutoff values should be adapted for patients with a high level of trunk function, unaffected upper-limb function, and unaffected cognition, as we discuss next, to avoid misjudgments. In addition, these cutoff values should be adapted for inpatients in a rehabilitation hospital setting.

To avoid errors in judging the level of dressing independence using the BBS cutoff values, we analyzed the characteristics of patients who may be easily misjudged.
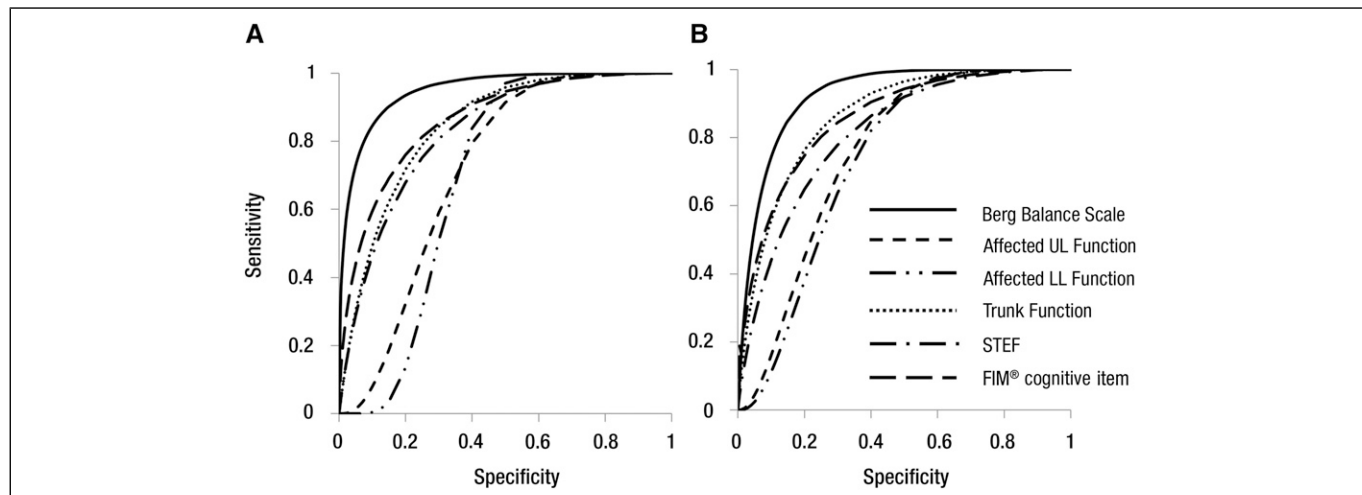
Figure 1. Receiver operating characteristic curves for each function. (A) Independence vs. Supervision or Less Level groups; (B) Independence–Supervision or Higher Level vs. Dependence groups.

Note. LL = lower limb; STEF = Simple Test for Evaluating Hand Function; UL = upper limb.

Table 1. Comparison Between True-Positive and False-Positive Cases or True-Negative and False-Negative Cases on Motor and Cognitive Functions on the Basis of a 44-Point BBS Cutoff Value

Characteristic	True Positive (n = 45), M (SD) or n (%)	False Positive (n = 3), M (SD) or n (%)	True Negative (n = 42), M (SD) or n (%)	False Negative (n = 8), M (SD) or n (%)
Age, yr	66.0 (14.0)	74.0 (14.2)	76.9 (12.1)	70.3 (10.5)
Men	31.0 (68.9)	1.0 (33.3)	22.0 (52.4)	4.0 (50.0)
Right-side hemiparesis	23.0 (51.1)	2.0 (66.7)	19.0 (45.2)	3.0 (37.5)
Time poststroke, day	82.3 (32.7)	95.7 (21.2)	104.5 (36.2)	108.5 (39.3)
BBS (0–56)	50.3 (26.6)	48.0 (17.4)	67.2 (31.4)	68.0 (34.0)
Affected UL function (0–10)	7.0 (2.5)	5.7 (2.1)	4.1 (3.8)	5.6 (3.0)
Affected LL function (0–15)	13.1 (2.3)	12.7 (2.1)	7.6 (5.7)	11.0 (2.9)
Trunk function (0–6)	5.6 (0.6)	5.7 (0.6)	3.8** (1.8)	5.5** (0.5)
STEF (0–100)	93.0 (6.3)	82.3 (23.7)	72.7* (22.3)	89.5* (9.7)
FIM® cognitive item (5–35)	32.1 (3.4)	24.0 (14.0)	22.1* (8.2)	29.6* (5.7)

Note. BBS = Berg Balance Scale; LL = lower limb; M = mean; SD = standard deviation; STEF = Simple Test for Evaluating Hand Function; UL = upper limb.
*$p \leq .05$. **$p \leq .01$.

Our results reveal that supervision may be unnecessary when patients have a high level of trunk function, unaffected upper-limb function, and unaffected cognition, even if their BBS score is <44 points. Similarly, our results suggest that patients may require assistance in dressing when they have deterioration in cognitive function, even when their BBS score is >32 points. Because a false positive (i.e., when patients who cannot dress themselves without supervision or assistance are judged as able to dress independently on the basis of cutoff values) may result in a falling accident, the need for supervision and assistance with dressing in a rehabilitation hospital ward should be carefully evaluated on the basis of a patient's BBS score and trunk and upper-limb function and cognition.

This study has some limitations. First, it was retrospective; it used chart review and only univariate analyses such as ROC curves and comparison between groups. Confounding factors may affect the results and generalizability. Second, this study did not evaluate perceptual disorders, which have been reported to affect dressing

independence (Walker & Lincoln, 1991). Third, the study participants were patients with stroke who received intensive rehabilitation at one specific facility. Therefore, generalization of this study's results may be limited. Further research is required. For instance, analysis of parameters including perceptual functions is necessary, using multivariate analysis to avoid bias. In addition, multisite trials are necessary to confirm the cutoff values determined in this study across multiple facilities.

Implications for Occupational Therapy Practice

The findings of this study have the following implications for clinical occupational therapy practice:

- Balance function is strongly associated with level of dressing independence, suggesting that balance training will be effective in improving independence level in dressing.
- BBS scores of 44 and 32 points are the criterion cutoff values of balance required to reach independent and

Table 2. Comparison Between True-Positive and False-Positive Cases or True-Negative and False-Negative Cases on Motor and Cognitive Functions on the Basis of a 32-Point BBS Cutoff Value

Characteristic	True Positive (n = 60), M (SD) or n (%)	False Positive (n = 7), M (SD) or n (%)	True Negative (n = 27), M (SD) or n (%)	False Negative (n = 4), M (SD) or %
Age, yr	68.2 (14.1)	72.1 (11.7)	77.9 (11.9)	70.5 (11.1)
Men	38.0 (63.3)	3.0 (42.9)	15.0 (55.6)	2.0 (50.0)
Right-side hemiparesis	31.0 (51.7)	5.0 (71.4)	10.0 (37.0)	1.0 (25.0)
Time poststroke, days	87.8 (35.6)	105.6 (31.3)	105.7 (37.4)	96.3 (17.5)
BBS (0–56)	54.5 (29.6)	60.3 (35.7)	69.1 (30.0)	53.8 (15.3)
Affected UL function (0–10)	6.7 (2.9)	4.7 (3.1)	3.4 (2.9)	6.3 (2.9)
Affected LL function (0–15)	12.6 (3.1)	11.7 (2.7)	6.2 (5.8)	8.5 (4.0)
Trunk function (0–6)	5.5 (0.6)	5.4 (0.5)	3.1* (1.8)	5.0* (1.4)
STEF (0–100)	91.1 (8.7)	86.1 (14.2)	66.3 (24.6)	85.8 (7.3)
FIM cognitive item (5–35)	31.3 (4.4)	24.1* (9.0)	20.0 (8.4)	24.3 (7.5)

Note. BBS = Berg Balance Scale; LL = lower limb; M = mean; SD = standard deviation; STEF = Simple Test for Evaluating Hand Function; UL = upper limb.
*$p \leq .05$. **$p \leq .01$.

supervision levels of dressing, respectively. These values should enable practitioners to target goals for balance training aimed at improving dressing and provide criteria for determining the level of assistance required for dressing rehabilitation hospital inpatients with stroke. However, these cutoff values should be adapted for patients with a high level of trunk function, unaffected upper-limb function, and no deterioration in cognition. ▲

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