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Original Article

Discriminative and predictive validity of the short-form activities-specific balance confidence scale for predicting fall of stroke survivors

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Abstract. [Purpose] The present study aimed to investigate the discriminative validity of the short-form activities-specific balance confidence scale (ABC scale) in predicting falls, and its validity. [Subjects and Methods] 43 stroke survivors were identified as a group with a history of multiple falls (faller group) and a group without or with a history of one falls (non-faller group). The balance confidence was examined using the ABC scale and the short-form ABC scale. Functional abilities were examined with Fugl-Meyer assessment, sit-to-stand test, and Berg balance scale. [Results] The area under the curve of the ABC scale and the short-form ABC scale in predicting fall was>0.77. This result indicates that both examination tools have discriminative validity in predicting falls. Although both tools showed an identical predictable specificity of 72% in the non-faller and faller groups, the short-form ABC scale exhibited a predictable sensitivity of 86% in the faller group, which is higher than that of the ABC scale (71%). [Conclusion] Results of this study showed that the short-form ABC scale is an efficient clinical tool to evaluate and predict the balance confidence of stroke survivors.

Key words: Activities-specific balance confidence scale, Falls, Stroke

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INTRODUCTION

Fear of falling is a general phenomenon that occurs in survivors who have postural instability and abnormal gait pattern, which are exhibited by survivors with Parkinson's disease, frail elderly, and stroke survivors[1, 2)]. Accurate evaluation for fall prevention of such people is important but difficult to achieve. Dichotomous questions that ask 'yes/no' are particularly difficult to express the fear of falling accurately[3)], and they may cause people to deny fear of falling by answering 'no'[4)]. However, questions that ask about fear of falling can obtain through information on the loss of confidence resulting from a fall, fear of falling, and activity restriction in daily life to adapt to changing environment[5)].

Only a few tools are used to evaluate fear of falling. The Falls Efficacy Scale (FES) is employed to examine the fear of falling[6)], and the Activities-specific Balance Confidence scale (ABC scale) is used to examine balance confidence and fear of falling[7)]. The ABC scale is composed of 16 items on specific activities to examine psychological fear of falls and degrees of balance confidence on various tasks including activities of daily living[7)]. The ABC scale is a well-known examination tool for classifying elderly people residing in communities[8, 9)]. This tool is used to investigate the effect of intervention on fear of

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falling[10, 11] or to determine the relationship between factors related to balance and risks of fall[12–14]. Previous studies used the ABC scale to examine balance[15, 16]. However, this scale takes 10–20 min to administer because it is composed of 16 items[7].

A shortened version of the ABC scale has been developed, and the scale can be a convenient tool because it reduces examination time compared with the ABC scale[4]. Previous studies reported the validity and reliability of this scale to evaluate the balance confidence of elderly people residing in communities[17], patients with Parkinson's disease, elderly with gait disturbances, and healthy adults. The short-form ABC scale has discriminative validity to classify patients with Parkinson's disease, elderly with gait disturbances, and healthy adults[4].

Both the ABC scale and the short-form ABC scale exhibit reliability and construct validity for stroke survivors, and the short-form ABC scale has a similar characteristic with the ABC scale[9]. The cutoff value of the ABC scale to examine falls among stroke survivors is reported to be 81[18], however the discriminative validity of the short-form ABC scale remain unknown. Therefore, the present study aimed to investigate the discriminative validity of the short-form ABC scale in predicting falls, and its prediction. In addition, this study identified the correlation among the short-form ABC scale, number of fall, and function ability.

SUBJECTS AND METHODS

Hemiplegic stroke survivors were recruited from a hospital through advertisements. A total of 59 stroke survivors were recruited, and they were screened against the following inclusion criteria: chronic stroke patients who survived at least 6 months after onset, patients who have ability to ambulate for more than 10 cm without walking aides, patient with absence of lower motor neuron diseases or musculoskeletal problems, and patient with score of >24 points on the mini-mental state examination (MMSE). Among the 59 volunteers, 7 volunteers who did not meet the criteria were excluded. In addition, 4 volunteers were dropped out because of worsening health condition or discharge from the hospital during the research periods. Five volunteers were also excluded because of finding errors in their data. Finally, data were analyzed from a total 43 stroke survivors.

The purpose and procedure of the study was explained to all participants, and they signed informed consent forms. The study was approved by the Kyungnam University Institutional Review Board.

This study was a retrospective cross-sectional study. The general and medical information on age, gender, height, weight, medical diagnosis, more affected side, disease duration, and use of a walking aide of participants were collected from medical charts or brief interviews. Data on the number of falls within a year from the present were also collected from interviews with the participants or caregivers. The criteria for a fall was defined as an unexpected accident that occurred on a lower point along the ground, upon an object, or on the floor because of an unintended change in posture and not because of paresis, epilepsy, seizure, or momentary and overwhelming outside factors[19]. The participants were identified as a group without or with a history of one falls (non-faller group) and a group with a history of multiple falls (faller group).

After investigating the general and medical information and fall experiences, the balance confidence the participants were examined using the ABC scale and the short-form ABC scale. In addition, to examine functional ability, Fugl-Meyer Assessment (FMA), Sit-To-Stand test (STS), and Berg Balance Scale (BBS) were used. The FMA was used to examine motor recovery in the lower extremity of the affected side, the BBS for examining balance, and the STS for examining muscle strength in the lower extremity of the affected side.

General and medical characteristics and the number of falls of stroke survivors were collected by research assistants on the first day. All examinations including ABC scale and the short-form ABC scale, FMA, STS, and BBS were performed over a period of two days by two physical therapists who had more than 15 years of experience caring for neurological patients.

The ABC scale was developed to measure fear on fall and confidence level on activities of daily living. This tool is composed of 16 items. Confidence is measured on a scale from 0% (not confident at all) to 100% (completely confident)[7]. The total score is the sum of scores on each question. Total scores closer to 100 points indicate more balance confidence.

Statistical analysis was performed with SPSS 16.0 (IBM, Armonk, New York, USA). Descriptive statistics was used to analyze the general and medical characteristics of the participants. χ^2 test was performed to compare the gender, medical diagnosis, and affected side. Age, disease duration, number of falls, MMSE, ABC scale, short-form ABC scale, FMA, STS, and BBS were analyzed with independent t-test. Cohen's d was used to analyze the size of the effect between two groups[20]. Cohen d>0.8 indicates a large effect; 0.5–0.8, medium effect; and 0.2–0.4, small effect. The Spearman correlation coefficient among the ABC scale, short-form ABC scale, FMA, STS, and BBS was analyzed. The receiver operating characteristic (ROC) curve was used to investigate the discriminative validity in predicting fall of the ABC scale and short-form ABC scale. Odds ratio was calculated with logistic regression analysis that used cut-off values to predict validity. The statistical significant level was set at α=0.05.

RESULTS

The gender, age, medical diagnosis, disease duration, affected side, and MMSE between the non-faller group and faller group showed no significant differences. However, significant differences were observed in the number of falls, ABC scale, short-form ABC scale, and FMA. Although significant differences were not found in the STS and BBS, significant differences

Table 1. Characteristics of participants depending on fall experience and correlation among variables

	All (n=43)	Non-faller group (n=29)	Faller group (n=14)
Gender, male/female (n)	24/19	16/13	8/6
Age (years)	70.09 ± 9.96	69.55 ± 10.38	71.2 ± 9.3
Etiology, infarction/hemorrhage (n)	34/9	21/8	13/1
Affected side, left/right (n)	25/18	15/14	10/4
Stoke duration (months)	15.3 ± 6	15.4 ± 5.9	15.2 ± 6.3
The number of falls (n)	1.1 ± 0.9	0.6 ± 0.5	2.2 ± 0.43*
MMSE (score)	26.7 ± 2.4	27.1 ± 2.3	26 ± 2.4
ABC scale (score)	56.2 ± 19.7	62.4 ± 19.4	43.4 ± 13.7*
Short-form ABC scale (score)	46.6 ± 20.5	52.6 ± 20.6	34 ± 13.7*
FMA (score)	22.2 ± 2.8	22.8 ± 2.6	21 ± 2.9*
STS (second)	17.0 ± 6.8	16.0 ± 6.6	19.3 ± 6.9
BBS (score)	40 ± 4.3	40.6 ± 4.7	38.7 ± 2.8

The values are presented as mean (SD) or frequency (%).
Significant differences between two groups were presented as *p<0.05
MMSE: Mini Mental State Examination; ABC: Activities-specific Balance Confidence Scale; FMA: Fugl-Meyer Assessment; STS: Sit to Stand test; BBS: Berg Balance Scale

Table 2. Correlation among the number of falls, ABC scale, short-form ABC scale, FMA, STS, and BBS

	ABC scale	Short-form ABC scale
ABC scale (score)	1	0.96*
The number of falls (number)	−0.64*	−0.65*
FMA (score)	0.40*	0.42*
BBS (score)	0.39*	0.49*
STS (sec)	−0.40*	−0.44*

Significant differences were presented as *p<0.01.
MMSE: Mini Mental State Examination; ABC: Activities-specific Balance Confidence Scale; FMA: Fugl-Meyer Assessment; STS: Sit to Stand test; BBS: Berg Balance Scale

Table 3. Cut-off value for fall prediction, sensitivity, specificity, and PPV and NPV of the ABC scale and the short-form ABC scale

	Group	Screening criteria	AUC (95% CI)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
ABC scale	Non-faller group	≤49.84	0.77 (0.63–0.91)	10/14 (71)	21/29 (72)	10/18 (56)	21/25 (84)
Short-form ABC scale	vs. Fall group	≤45.42	0.78 (0.63–0.92)	12/14 (86)	21/29 (72)	12/20 (60)	21/23 (91)

ABC: Activities-specific Balance Confidence Scale; AUC: Area Under the Curve; CI: confidence interval; PPV: positive predictive value; NPV: negative predictive value

existed in effect sizes because the BBS and STS were d=0.45 and d=0.47, respectively (Table 1). The significance of spearman correlation coefficient among the number of falls (r=−0.6 to −0.65), ABC scale, short-form ABC scale (r=0.96), FMA (r=0.40 to 0.42), STS (r=−0.40 to −0.44), and BBS (r=0.39 to 0.49) is shown in Table 2.

The AUC of the ABC scale and the short-form ABC scale for fall prediction was 0.77–0.78 (95% CI: 0.63–0.92, p<0.004), which is an acceptable level. The specificity of the ABC scale were 72% and 86%, respectively. The PPV and the NPV of the Short-form ABC scale were 60% and 91%, respectively. Thus, the total score of the short-form ABC scale showed sufficient validity in predicting falls in stroke survivors, and it showed higher discriminative validity in predicting falls compared with the ABC-16 total score (Table 3).

Logistic regression analysis showed that the cut-off values of the ABC scale, general characteristics, FMA, STS, and BBS failed to predict falls as a significant variable, whereas that of the short-form ABC scale significantly predicted falls. For the total score of the short-form ABC scale, participants who had ≤45.42 points had 0.063 times of probability to experience

Table 4. Prediction validity of fall risk

	Regression coefficients	Standard error	Wald	Odd ratio	95% CI
Short-form ABC scale	−2.757	0.869	10.054	0.063	0.012–0.349

Independent variables: age, gender, height, weight, medical diagnosis, more affected side, disease duration, and MMMSE.
Dependent variable: Non-faller Group, Faller Group.
ABC: Activities-specific Balance Confidence Scale; CI: confidence interval

multiple falls compared with participants who had >45.42 points (Table 4).

DISCUSSION

The short-form ABC scale of stroke survivors was strongly correlated with the ABC scale (r=0.96). Such result indicates that the short-form ABC scale can be used as a valid examination tool for examining the balance confidence of stroke survivors. In previous studies were reported the relationship between the two variables[4]. The ABC scale based on elderly who reside in a community[17] and the short-form ABC scale showed significant relevance in four balance examinations including unipedal stance time, maximal step length, functional reach, and timed up and go (TUG). The results of previous studies support that the short-form ABC scale can examine balance confidence and balance ability.

The ABC scale and the short-form ABC scale showed significant relevance with the FMA (r=0.40–0.42) and BBS (r=0.39–0.49), which indicates that the short-form ABC scale can examine balance ability. The factors on function of selective and coordinated pelvic limb, which can be examined using the FMA and BBS, exhibited close relationship with balance confidence[22]. reported that the ABC scale is significantly correlated with the strength of lower extremity (r=0.30) in patients with Parkinson's disease. The result of STS, which can examine the strength of lower extremity and static balance ability, showed medium level of correlation with the ABC scale and the short-form ABC scale (r=−0.40 to −0.44)[9]. conducted a study based on stroke survivors and found that the ABC scale and the short-form ABC scale had significant relevance with BBS (r=0.42–0.49), TUG (r=−0.34 to −0.52), Barthel index (r=0.37–0.45), short-form health survey (r=0.60–0.56), and short-form ABC scale. In particular, they reported more significant relevance in examinations related to functional ability compared with the ABC scale. Such results also accord with the present findings. Thus, the short-form ABC scale is more potentially useful for determining the functional ability of stroke survivors compared with the ABC scale.

In the present study, both of the scales had a significant relevance with the number of falls (r=−0.64 to −0.65), and such result agrees with that of Mak MK et al[21]. The AUC of both scale was 0.77 over, and these examination tools have a discriminative validity in predicting falls[22]. Both scales, which were used to predict in fall and non-faller groups, showed identical specificities of 72%; however, the sensitivity of the short-form ABC scale was 86%, which was higher than that of the ABC scale (71%). In addition, the PPV, a probability to assess the fall group among survivors who had ≤45.42 of the short-form ABC scale, was 60%, and the NPV, a probability to examine the non-faller group among survivors who had>45.42 of the short-form ABC scale, was 91%. These results show that the short-form ABC scale had superior accuracy compared with the PPV (56%) and NPV (84%) of the ABC scale.

Although both examinations can be utilized as tools to predict balance ability and fall of stroke survivors, the short-form ABC scale was much more efficient in survivors over 70 years old compared with the ABC scale. However, the cut-off value of the short-form ABC scale for fall was not introduced in preceding studies and literature reviews. In the study by Salbach NM et al.[10], the scores of the BBS and the ABC scale of 35 stroke survivors were 44 points and 62 points, respectively. However, the scores of the BBS and the short-form ABC scale of 51 subjects were 40 points and 62 points, respectively. The results of the above mentioned study were similar to the present findings. The scores of the BBS, short-form ABC scale, and ABC scale of the participants in this study were 40 points, 46.57 points, and 56.22 points, respectively. However, the ABC scale score of the present study was relatively lower than that reported by Salback NM et al[10]. Such differences may not be attributed to the reliability of the examination tool but due to the characteristics of the participants.

The level of self-efficacy decreases based on individual tendencies, including increase in age, reduction of functional ability, reduction in mental function, and worsening health condition[4], however such characteristics are not confirmed in stroke survivors[10]. The balance ability of stroke survivors positively correlated with self-efficacy[23], however self-efficacy differs based on the disease period after stroke. According to van de Port IG et al.[24], approximately 21% of 205 stroke survivors may experience a decrease in functional status in 1–3 years after an attack, and the balance confidence may also decrease. Considering that the average age of the participants in this study was around 70 years old and the disease period was approximately 15 months, the balance confidence was low.

Botner reported[23] that the short form of the ABC scale correlated with the number of falls (r=−0.33) and the ABC scale (r=−0.17) exhibited no correlation with the number of falls. Investigations on the correlation between scale and fall support that the short-form ABC scale has higher discriminative validity compared with the ABC scale. In this study, the short-form ABC scale had higher discriminative validity in sensitivity, PPV, and NPV, which can predict a fall compared with the ABC

scale. In an odds ratio analysis, the short-form ABC scale appeared to be superior compared with the ABC scale.

Among the 16 items of the ABC scale, the items included in the short-form ABC scale (particularly items 13–16) focus on confined places to express balance confidence (e.g., crowded places, escalators, and frozen roads), as well as activities difficult to act and control posture[4]. Although the examination tool, which includes psychological items, is efficient for information collection, it requires minimum time for data management and interpretation of result[25]. Practitioners and researchers take a long time to examine using the tool, and errors can occur during data collection including measurement of errors. In addition, the examination value and the actual value differ because of the structural problems of the examination tools, and negative results on examination can be due to the reliability problem in subjects[26, 27].

Complete examination of a participant takes approximately 20 min. The short-form ABC scale can shorten approximately 50% of evaluation time compared with the ABC scale[4]. Examination time in clinical settings presents some limitations, and an accurate examination may not be established when the examination period is long, which makes the participants feel bored or allows intervention of other external factors[26, 27]. Thus, examination tools that require longer examination should establish identical scales by separating and reducing questions and not making the subjects feel tired or bored.

The scores of the ABC-16 scale and the short-form ABC scale for the non-faller group were 62.41 points and 52.61 points, respectively, and the scores of the ABC-16 scale and the short-form ABC scale were 43.40 points and 34.04 points, respectively. The short-form ABC scale showed that the differences between identical and opposing independent groups can be classified. The results of the study agree with those of proceeding studies[4, 7, 9, 17]. Thus, the 10 items of the ABC scale, which are not included in the short-form ABC scale, may be overstated because the standard deviation to express a balance confidence increases. Thus, the short-form ABC scale is an efficient tool that can be used to examine balance confidence and predict a fall compared with the ABC scale.

Although the number of falls within a year after stroke was investigated without possible errors, the potential to include the number of falls, which may deviate from the definition or standard of fall, and the collected data may be inaccurate[17, 28]. Therefore, a prospective study should be established in the future, and validity verification of the short-form ABC scale must be conducted by comparing with FES.

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