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A study to evaluate inter-rater reliability, intra-rater reliability and concurrent validity of the fullerton advanced balance scale for assessing balance in patients with chronic stroke

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Abstract
Background: The Fullerton Advanced Balance (FAB) Scale is recognized for its accuracy and dependability in evaluating balance among elderly individuals. Unlike the Berg Balance Scale (BBS), it minimizes ceiling effects and emphasizes dynamic balance. Additionally, it offers more precise scoring compared to the Mini-BESTest, while being less time-consuming.
Purpose: To determine inter-rater and intra-rater reliability and concurrent validity of Fullerton Advanced Balance scale in patient with chronic stroke.
Method: A group of 55 individuals diagnosed with chronic stroke participated. The FAB Scale was administered by two trained evaluators within a span of three days. Its validity was measured by correlating results from the FAB with scores from the BBS and Mini-BESTest.
Results: Intra-class correlation coefficients (ICCs) were computed to evaluate reliability, while Spearman's rank correlation was used for assessing concurrent validity. The FAB Scale demonstrated excellent reliability (ICC: intra-rater = 0.975, inter-rater = 0.966) and strong correlation with Mini-BESTest ($\rho = 0.882$) and BBS ($\rho = 0.856$).
Conclusion: The FAB scale is a valid and reliable tool to assess balance in patients with chronic stroke.

Keywords: Cerebrovascular accident, postural control, psychometric properties

Introduction

Stroke is a leading cause of death globally and one of the primary reasons for long-term disability in adults. It significantly impacts individuals' physical, emotional, and social well-being [1]. The abrupt start of clinical indications showing localised or global brain dysfunction lasting more than 24 hours or leading to death, with no explanation other than a vascular origin, is what the World Health Organisation defines as a stroke [2]. One of the main causes of death and disability in India is stroke [3]. (3) Stroke is a serious public health issue in India. According to estimates from a number of population-based studies, prevalence rates as of the 2012 data ranged between 334 and 424 per 100,000 in urban populations and between 84 and 262 per 100,000 in rural areas. Rehabilitation is necessary for about 60% of stroke survivors [3]. This necessitates the development of advanced, affordable diagnostic and therapeutic strategies that can enhance recovery, shorten hospital stays, and improve overall quality of life. Common symptoms experienced post-stroke include headache, dizziness, speech difficulties, weakness, impaired activities of daily living (ADLs), and balance or coordination issues [4]. Balance impairments, in particular, can hinder mobility and increase the risk of falls [5]. These impairments arise from complex neurological dysfunctions and can be evaluated using both observational clinical scales and laboratory-based methods. Clinical assessments are often categorized by the postural control level they target: static, dynamic, or functional [6]. Although they have various drawbacks, the Berg Balance Scale (BBS) and the Mini-Balance Evaluation Systems Test (Mini-BESTest) are two of the most used clinical instruments used to evaluate balance in stroke survivors.

BERG Balance Scale (BBS)

The Berg Balance Scale (BBS) is a widely used clinical tool known for its strong reliability, validity, and sensitivity to changes in balance abilities among stroke patients [7].

This 14-item scale evaluates both static and dynamic balance through functional movement tasks such as transitioning from sitting to standing, unsupported standing, transferring between surfaces, standing with feet together, standing with eyes closed, single-leg stance, tandem stance, reaching, retrieving objects from the floor, rotating, and turning in place. Each activity is rated on a scale from 0 to 4, where 0 indicates the task cannot be completed, and 4 signifies independent and safe completion. The total score ranges from 0 to 56 and is interpreted as follows: severe balance impairment, acceptable balance, or good balance [8].

Mini – Balance Evaluation Systems Test (Mini – BESTest)
The Mini-BESTest is a condensed version of the Balance Evaluation Systems Test (BESTest) and serves as a comprehensive measure of balance in individuals with chronic stroke. It comprises 14 items that target distinct aspects of balance control, including anticipatory postural adjustments, reactive postural control, sensory orientation, and dynamic gait. Tasks include sit-to-stand transitions, rising onto toes, single-leg standing, stepping reactions, and walking with head turns. Each item is rated on a 3-point ordinal scale from 0 to 2, yielding a maximum total score of 28. Higher scores represent better balance capability [9].

Fullerton Advance Balance Scale (FAB)
The Fullerton Advanced Balance (FAB) Scale was created to assess varying degrees of balance difficulties in independently living older adults and to evaluate multiple systems influencing postural control [10]. The scale includes 10 items that require a combination of static and dynamic control, sensory integration, and anticipatory and reactive balance strategies [11]. Test activities include standing with feet together and eyes closed, reaching forward, turning 360°, stepping over obstacles, tandem walking, standing on foam with eyes closed, standing on one leg, two-footed jumping, walking while turning the head, and reactive postural control. Each task is scored on a 0–4 scale, allowing for a maximum score of 40 points [12]. It is a valid and reliable measure in older adults and Parkinson's disease populations, but less studied in stroke [13]. The psychometric properties of FAB scale have not been evaluated in stroke population.
Compared to BBS, the FAB includes more dynamic and functional balance tasks with minimal ceiling effects. Its 5-point scoring system also provides more nuanced detection of changes than the Mini-BESTest [11].
Therefore, the purpose of this study is to evaluate Inter – Rater and Intra – Rater Reliability and Concurrent validity of the FAB scale to assess balance in patients with chronic stroke.

Methodology
Participants
55 individuals with a chronic stroke diagnosis were selected for analysis out of the 105 patients that were screened. A total of 50 subjects were needed for the current study, but taking into account the dropout rate, which was estimated to be 5–10%, a total of 55 subjects were included in the study. The sample size was determined assuming the reliability value of the intra-class correlation coefficient, or R, was 0.80 or greater with a 95% confidence interval [14]. The study included 55 chronic stroke patients who met the following inclusion requirements: Age range: 35–65 years; diagnosis of cerebral haemorrhage or cerebral infraction with stable medical conditions; chronic stroke (delayed for more than 6 months); first unilateral hemisphere stroke; minimum mental scale score of 24; and ability to walk with or without assistance. Patients having any other systemic condition other than stroke that affects balance and using any medications that causes dizziness or impaired balance were excluded from the study. The study was initiated after obtaining clearance from the "Institutional Ethics Committee".
All patients had given written consent before participating in the study. Demographic data and history of each patient was noted. A thorough practice of entire procedure was done by the researcher and the other rater on few chronic stroke patients, till the procedure was perfected before starting the study.

Fig 1: Equipment used

Intra-rater reliability
Following an explanation of the process, each participant completed the FAB activities, which were graded by the same rater on Days 1 and 3.

Inter-Rater Reliability
By using a qualified second rater to score independently from rater 1, inter-rater reliability was evaluated. Rater 2's recording sheets were completely distinct from those used by Rater 1. To address any bias, care was taken to ensure that the two raters were properly blinded to one another.

Concurrent Validity
The FAB scale was correlated with the BBS and Mini-BESTest in order to evaluate the concurrent validity. The FAB scale, Mini-BESTest, and BBS tests were administered to each subject in the same order. After evaluating each scale, the patients were given ten minutes of rest so they could complete each activity in the same physical state.

Data Analysis
The data analysis in this study involved several statistical procedures conducted using the SPSS software (version 20.0). Descriptive statistics, reliability analyses, and concurrent validity assessments were performed. The results were considered significant if the p-value was less than 0.05 and the confidence interval (CI) satisfied the 95% criterion.

Descriptive Statistics: Descriptive statistics were computed for age, duration of stroke, and Mini-Mental State Examination (MMSE) scores of the 54 patients with chronic stroke included in the study. The mean and standard deviation (SD) were calculated for each variable. The data presented in Table 1 were used for the descriptive analysis.

Table 1: Descriptive statistics for all the patients

	N	Min	Max	Mean	Std. Deviation
Age (years)	54	31	60	51.22	8.527
Duration of stroke (in months)	54	6	72	17.20	15.317
MMSE score	54	24	29	26.63	1.846
FAB (rater 1, day 1)	54	1	37	15.98	9.700
FAB (rater 1, day 3)	54	1	38	15.85	9.098
FAB (rater2)	54	1	38	16.02	9.112
BBS	54	14	56	39.57	9.687
Mini-BESTest	54	1	26	14.48	6.118

Reliability Analyses

Both intra-rater and inter-rater reliability were assessed in order to evaluate the measurement's dependability. While inter-rater reliability evaluates the agreement between measures made by several raters, intra-rater reliability describes the consistency of measurements made by the same rater on various occasions. The intra-class correlation coefficient (ICC) for each item on the Fullerton Advance Balance (FAB) scale and the overall FAB score were used to evaluate intra-rater and inter-rater reliability. The ICC values were calculated, and the corresponding lower and upper confidence intervals (CIs) were determined. The ICC values were interpreted based on established guidelines to assess the reliability as poor, moderate, good, or excellent [15].

Agreement between raters was further examined using Bland-Altman limits of agreement analysis. The average mean of the measurements by rater 1 and rater 2 was plotted against the average difference between the measurements. The limits of agreement were drawn at M ± 1.96 SD, indicating the range within which the differences between measurements are expected to fall.

Standard error of measurement (SEM) and minimal detectable change (MDC) were calculated to estimate the variability in measurements and determine the smallest real difference. SEM represents the average variability of individual measurements around the true score, while MDC indicates the amount of change necessary to exceed the measurement error and reflect a genuine change.

Validity analysis

Concurrent validity was assessed by examining the correlation between the FAB scale scores and the scores of the Berg Balance Scale (BBS) and Mini-Balance Evaluation Systems Test (Mini-BESTest). The FAB, BBS, and Mini-BESTest are ordinal scales, and therefore, Spearman's rank correlation coefficient was used to determine the strength and direction of the correlations. The correlation coefficients were interpreted based on the guidelines for assessing the size of correlation coefficients [16].

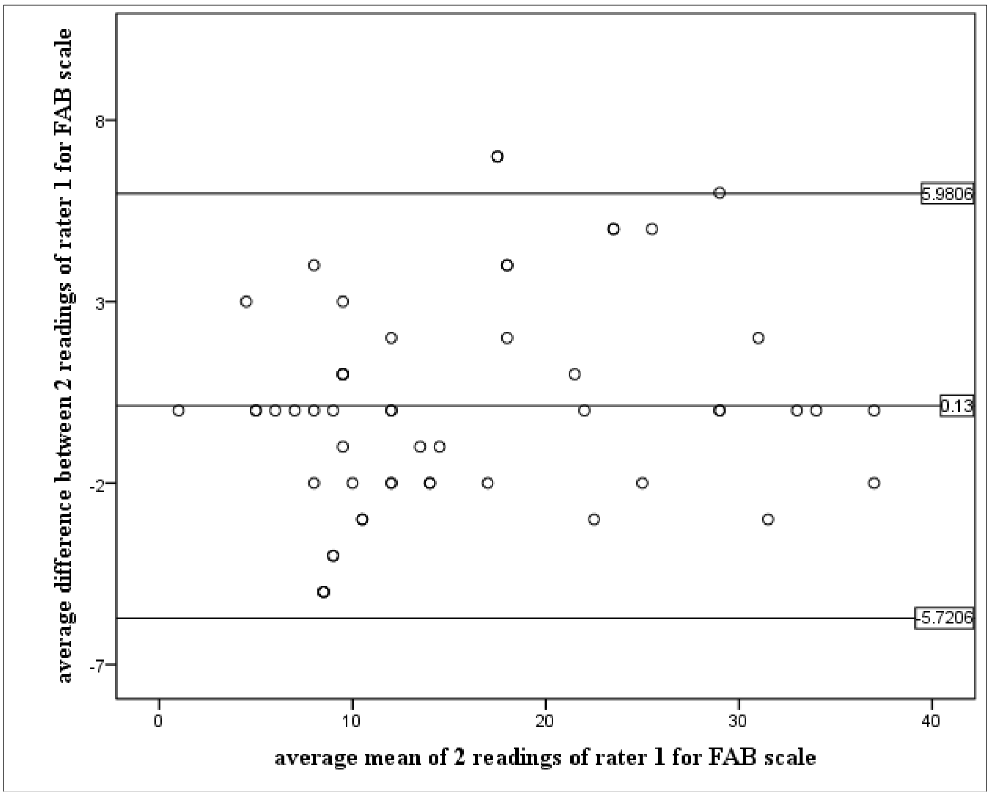
Result

The results of the data analysis indicated that the mean age of the participants was 51.22 years (SD = 8.527). The mean duration of stroke was 17.20 months (SD = 15.317). The mean MMSE score was 26.63 (SD = 1.846). In terms of gender distribution, out of the 54 patients with chronic stroke, 42 (77.8%) were male and 12 (22.2%) were female. The descriptive statistics presented in Table 1 provided the mean, minimum, maximum, and standard deviation for the FAB scale, BBS, and Mini-BESTest scores.

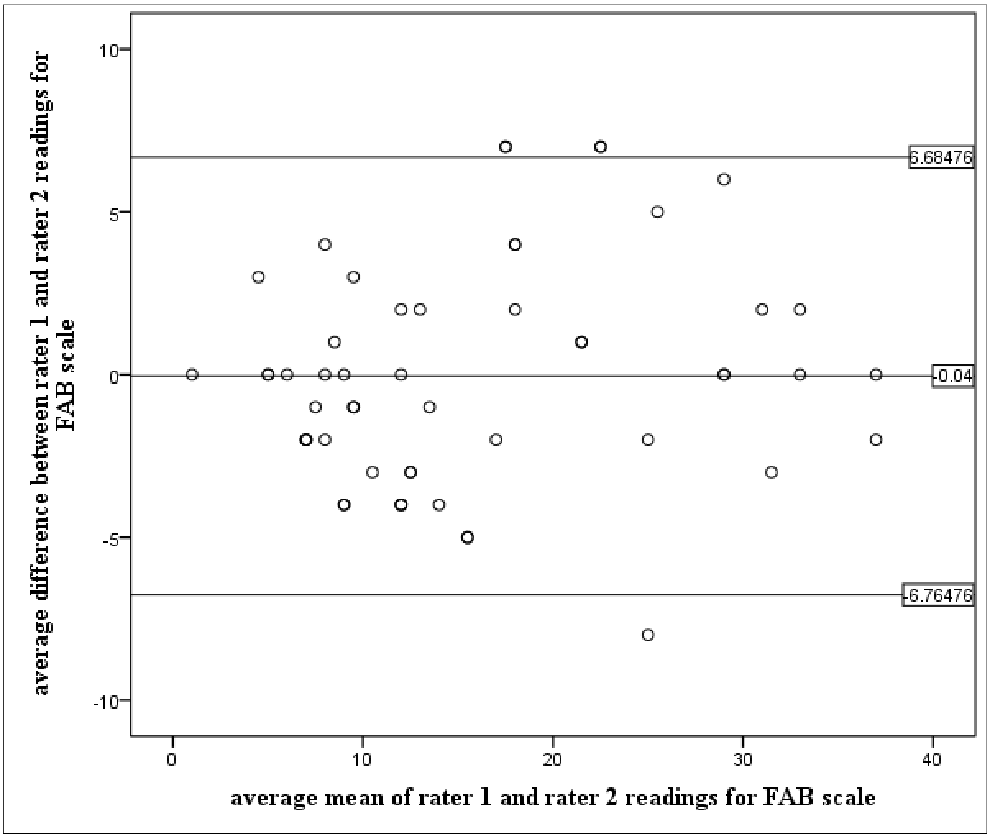
Table 2: Intra-class Correlation Coefficient (ICC) for the Intra – rater and Inter – rater reliability of FAB scale

	Intra - Rater			Inter – Rater		
	ICC	CI (lower)	CI (upper)	ICC	CI (lower)	CI (upper)
FAB Item-1	0.950	0.911	0.972	0.897	0.804	0.943
FAB Item-2	0.746	0.563	0.853	0.692	0.468	0.821
FAB Item-3	0.934	0.886	0.962	0.840	0.724	0.907
FAB Item-4	0.941	0.899	0.966	0.896	0.821	0.939
FAB Item-5	0.808	0.650	0.892	0.869	0.754	0.922
FAB Item-6	0.934	0.886	0.962	0.901	0.830	0.943
FAB Item-7	0.974	0.955	0.985	0.985	0.970	0.991
FAB Item-8	0.988	0.979	0.993	0.959	0.930	0.976
FAB Item-9	0.820	0.674	0.898	0.719	0.519	0.836
FAB Item-10	0.751	0.571	0.855	0.860	0.759	0.919
FAB total	0.975	0.956	0.985	0.966	0.942	0.980

The reliability analyses as shown in Table 2 revealed high ICC values for most items of the FAB scale, indicating good to excellent reliability for intra-rater and inter-rater assessments. The ICC value for the total FAB score indicated excellent intra-rater and inter-rater reliability. The Bland-Altman limits of agreement analysis demonstrated excellent agreement between rater scores. The SEM values were calculated as 1.486 for intra-rater reliability and 1.734 for inter-rater reliability. The MDC values were determined as 4.118 for intra-rater reliability and 4.806 for inter-rater reliability.

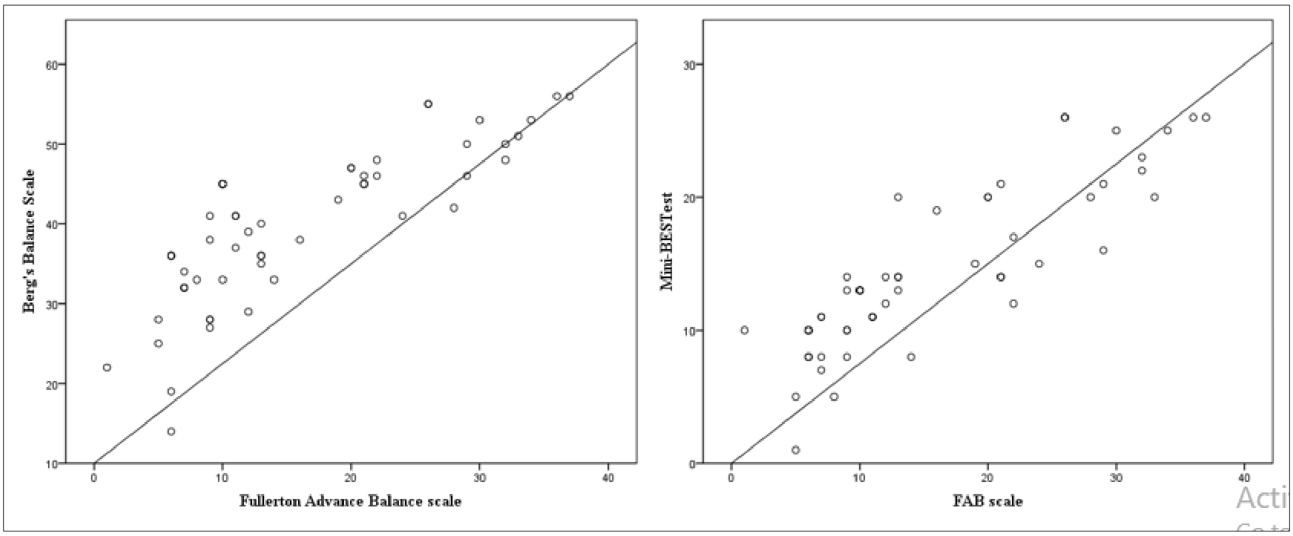


Graph 1: Bland Altman limit of agreement between 2 readings of rater 1



Graph 2: Bland Altman limit of agreement between rater 1 and rater 3

Concurrent validity analysis showed high positive correlations between the FAB scale scores and the scores of the BBS and Mini-BESTest. The Spearman's rank correlation coefficients indicated a significant and strong correlation between the FAB scale and both the BBS and Mini-BESTest.



Graph 3: Scatter plots for correlation of FAB with BBS and Mini-BESTest

These findings suggest that the FAB scale is a reliable and valid tool for assessing balance in patients with chronic stroke. The scale demonstrated good to excellent intra-rater and inter-rater reliability, as well as high concurrent validity with established balance measures.

Discussion

The purpose of this study was to test the Fullerton Advanced Balance (FAB) scale's concurrent validity, inter-rater reliability, and intra-rater reliability for evaluating balance in people who have had a chronic stroke. Of the 54 participants in the study, the majority were men (77.8%) as opposed to women (22.2%).

In terms of reliability, the FAB scale showed excellent consistency. Intra-rater reliability had an intraclass correlation coefficient (ICC) of 0.975, while inter-rater reliability was slightly lower but still excellent at 0.966. These values are comparable to those reported for other widely used balance assessment tools, such as the Berg Balance Scale (BBS) and the Mini-BESTest [17, 18]. These findings are consistent with earlier research by Debra J. Rose *et al*., who found similarly high reliability scores for the FAB scale in older adults living in the community (intra-rater ICC = 0.96, inter-rater ICC = 0.94–0.97). Likewise, a study by Christian Schlenstedt *et al*. involving individuals with idiopathic Parkinson's disease reported near-perfect intra- and inter-rater reliability (both ICC = 0.99) [11]. To further analyze reliability, the study also calculated the Standard Error of Measurement (SEM) and the Minimal Detectable Change at the 95% confidence level (MDC95). The SEM was 1.486 for intra-rater and 1.734 for inter-rater assessments, while the corresponding MDC95 values were 4.118 and 4.806. These metrics serve as useful benchmarks for interpreting changes in future studies using the FAB scale.

Regarding concurrent validity, the FAB scale showed strong positive correlations with the Mini-BESTest (Spearman's rho = 0.882) and the BBS (Spearman's rho = 0.856), confirming its validity in measuring balance in patients with chronic stroke [17, 18]. This study is notable as the first to establish concurrent validity for the FAB scale in this patient population. Comparable results were found by Schlenstedt *et al*. in Parkinson's patients, with high correlations between the FAB and both the Mini-BESTest (rho = 0.87) and the BBS (rho = 0.93) [11]. The FAB scale presents several practical advantages. It includes only 10 items-fewer than the 14 items in the Mini-BESTest and BBS-leading to a shorter administration time of approximately 10 minutes. Although it requires more equipment, the items needed are inexpensive and easy to obtain. Furthermore, the test can be administered in smaller spaces, which may make it more suitable for home-based assessments [10].

Nonetheless, the study has limitations. It did not examine the sensitivity and specificity of the FAB scale, which are important psychometric properties. Additionally, the findings apply only to adults aged 35–65 with chronic stroke, so results may not generalize to younger or older populations. In summary, the study supports the FAB scale as a reliable and valid tool for evaluating balance in individuals with chronic stroke. It offers advantages in terms of efficiency and detailed scoring. Future studies should examine its applicability across different stroke populations and explore other psychometric aspects like sensitivity and specificity.

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