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PO Box 117
221 00 Lund
+46 46-222 00 00

The Reproducibility of Berg Balance Scale and the Single-Leg Stance in Chronic Stroke and the Relationship between the Two Tests

Ulla-Britt Flansbjer, RPT, PhD[1,2], Johanna Blom RPT[3] and Christina Brogårdh, RPT, PhD[1,2].

[1]Department of Rehabilitation Medicine, Skåne University Hospital, Lund, Sweden, [2]Department of Health Sciences, Lund University, Lund, Sweden and [3]Department of Neurology, Skåne University Hospital, Malmö, Sweden

Short title: Reproducibility of balance tests in chronic stroke

Corresponding author: Ulla-Britt Flansbjer, RPT, PhD, Department of Rehabilitation Medicine, Skåne University Hospital, SE-221 85 Lund, Sweden.
E-mail: ulla-britt.flansbjer@med.lu.se

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ABSTRACT

Objective: To assess the reproducibility of the Berg Balance Scale (BBS) and the Single-leg stance (SLS) and the validity of the SLS as an independent test of upright postural control in patients with chronic stroke

Design: An intra-rater test-retest reproducibility study. The BBS and the SLS were assessed twice, 7 days apart.

Setting: A university hospital

Participants: Fifty individuals; 6-46 months post-stroke.

Intervention: Not applicable

Main Outcome Measurements: The reproducibility of the BBS and the SLS was evaluated with intraclass correlation coefficient ($ICC_{2,1}$), the mean difference between the 2 test sessions ($\bar{d}$) with 95% confidence interval (95% CI), the standard error of measurement (the standard error of measurement [SEM]%), the smallest real difference (SRD%) and the Bland-Altman graphs. To assess validity of SLS, the relationship between the SLS and the BBS was analyzed by the Pearson correlation coefficient.

Results: The $ICC_{2,1}$ was 0.88 for the BBS and the $ICC_{2,1}$ values were 0.88 for the nonparetic limb and 0.92 for the paretic lower limb for the SLS. The smallest change that indicates a real improvement for a group of individuals, SEM%, was 3% for BBS, 15% for the nonparetic limb and 27% for the paretic limb for SLS. The smallest real difference for a single individual was 8% for BBS but was higher for SLS, at 42% for the nonparetic limb and 74% for the paretic limb. There was a significant relationships between the SLS and the BBS ($r= 0.65-0.79$; $p< .001$).

Conclusions: The BBS and the SLS are reproducible measurements in patients with chronic stroke, but only the BBS is sensitive enough to follow changes over time or after an intervention. The SLS is strongly related to the BBS and can be used as an independent test to measure upright postural control after a stroke.

Key words: Cerebrovascular Disorders; Postural Balance; Outcome Assessment; Validity of Results; Reproducibility of Results.

INTRODUCTION

Impaired balance is a common symptom after a stroke. Balance or postural control can be defined as the ability to maintain, achieve, or restore stability of posture or during activity [1]. Balance deficits after a stroke can be caused by lesions in the pons or the cerebellum, or as a consequence of hemiparesis, sensory impairment, reduced visual field, or cognitive deficits [1-3]. Individuals after a stroke have shown 4-5 times greater postural instability in both the frontal and sagittal planes compared with healthy age-matched individuals [3]. Reduced balance after stroke is associated with low ambulatory activity [4] and increased risk of falling [5].

Many assessment tools are used to evaluate balance, for example, the Berg Balance Scale (BBS), Functional Reach, Postural Assessment Scale for Stroke patients, Single-leg Stance (SLS) and Computerized Dynamic Posturography [2, 6-8]. The most common instrument to measure balance after stroke is the BBS, which has been shown to be a valid and reliable test of upright postural control in a variety of populations, including patients who have experienced a stroke [9-11]. The sensitivity to change has been assessed in the acute and/or subacute phase after a stroke [12] but is lacking in the chronic phase.

Another common balance test is the SLS (also called “one-leg standing”), frequently used for elderly populations. The test-retest reliability has been shown to be acceptable [13-15], even if the testing procedures vary in different studies [16]. The SLS is less time consuming than the BBS, which can be of importance for clinicians [6]. One-leg standing is included as one item in the BBS, and has been shown to have a good inter-item and item-to-total correlation in patients with an acute stroke [9]. However, the validity and reliability of the SLS as an independent test of upright postural control has not been assessed in patients who have experienced a stroke.

To be able to evaluate balance after a stroke, reliable and sensitive testing methods are essential. Reproducibility in clinical practice and medical research can be determined from measurements of the same individuals on 2 occasions, so-called test-retest reproducibility. To fully assess the reproducibility, several statistical methods are required, which cover both agreements between measurements, systematic changes in the mean, and measurement errors [17]. In addition, a measurement tool can be considered highly reliable, but may not be sufficiently sensitive to detect a real change over time or after an intervention.

The aim of this study was to evaluate (1)) the reproducibility of the BBS and SLS as balance tests in patients with chronic stroke and to define limits for the smallest change that indicates a real improvement, both for a group of individuals and for a single individual and

(2) the validity of the SLS as an independent test of upright postural control after a stroke by analyzing the relationship between the SLS and the BBS.

MATERIAL AND METHODS

Individuals

All participants were recruited from a database at a rehabilitation unit in a university hospital in the south of Sweden. Fifty community-dwelling individuals (38 men and 12 women; mean ± standard deviation [SD] age, 58 ± 6 years; range, 46-72 years; mean [± SD] time since stroke onset, 17 ± 9 months; range, 6-46 months) met the following inclusion criteria: (1) a minimum of 6 months post-stroke; (2) residual hemiparesis at discharge from primary rehabilitation; (3) able to understand both verbal and written information; (4) able to walk at least 300 meters with or without a unilateral assistive device; (5) able to stand without hand-held support; and (6) medically stable, with no other diseases that could significantly influenced muscle strength, gait performance or postural control. The clinical characteristics of the individuals are presented in Table 1. Before the first test session, all the individuals completed a questionnaire, which provided demographic and medical information. All individuals were checked by the responsible physician to fulfill the inclusion criteria and to be medically stable and therefore suitable to participate in the study. At the time of the assessments the individuals also participated in 2 other reliability studies of gait performance tests and knee muscles strength measurements [18, 19].

Insert Table 1 about here

Ethics Considerations

All the individuals were contacted by telephone, received verbal and written information about the study, and then gave their informed consent. The ethics research committee of Lund University, Lund, Sweden approved the study (LU 243-01).

Balance Tests

Each participant underwent the BBS and the SLS on 2 occasions. The BBS was tested before SLS at both test occasions. The BBS was performed by following the standard procedure [10]. The test is a 14-item scale, scored from 0 to 4; a score of 0 represents the inability to complete the task and a score of 4 represents independent item completion. The sum score of all 14 items (maximum score for the BBS, 56 points) was calculated and used in the analyses.

When the SLS was performed, the participants were instructed to stand on one leg, as long as possible, but not longer than 15 seconds, starting with the preferred leg. The SLS was timed when one foot was lifted from the floor until it touched the ground or the other leg; no hand-held support was allowed during the test. The SLS was repeated 3 times during each session, with the right and left foot alternately, and the mean times for the 3 trials were then determined. To avoid any learning effect the first trial of SLS was used to score the last item in BBS; one-leg standing on the preferred leg in the BBS is scored from 0 point (not able to lift one foot or need help not to fall) to 4 points (if able to stand on one leg at least 10 seconds).

Procedure

The individuals were tested in a rehabilitation unit in a university hospital on 2 occasions, 7 days apart, at the same time of the day. The participants were instructed not to change their normal physical activities between the 2 test occasions. One senior physiotherapist (U.-B.F.) did all assessments and has extensive experience from stroke rehabilitation and the tests used. The test protocols for BBS and SLS were carefully standardized. No verbal encouragement was given during the tests. Throughout each session, the individuals wore comfortable shoes and were allowed to use their common ankle-foot orthosis (n=7) but no other assistive devices. The total time for the 2 balance tests was approximately 45 minutes. After the first test session, the individuals received information about the second test session but were not informed about their results. A written summary and oral information about the test results were given after completion of the second test session. All individuals were provided transportation free of charge to and from the test site. The test procedure (ie, time interval between the test occasions, standardized protocols, verbal information during the tests) has previously been developed and used in 2 other studies in our research group [18, 19].

Data and statistical analyses

All 50 individuals completed the tests. The recorded variables, obtained from the 2 test sessions, were used in the analysis. Descriptive statistics (means and SD) were calculated for the BBS and the SLS. To determine the test-retest reproducibility for the BBS and the SLS, several statistical methods were applied [17, 20]. Agreement between measurements was analyzed by the intraclass correlation coefficients, ($ICC_{2,1}$) and the mean differences between the test sessions ($\bar{d}$) together with the 95% confidence intervals (CI) for $\bar{d}$ [21]. Measurement

errors were assessed by the standard error of measurement (SEM) and the SEM%. The SEM gives the measurement errors in absolute values and represents the limit for the smallest change that indicates a real change for a group of individuals. The SEM% is independent of the units of measurement and therefore more easily interpreted. The smallest real difference, (SRD) [22], which represents the limits for the smallest change that indicates a real change for a single individual, was calculated, together with an "error band" around the mean difference of the 2 measurements, $\bar{d}$. From the SRD, the SRD% was calculated, which represents the change in relative terms.

The Bland-Altman graphs were formed to give a visual interpretation of the data [23]. From each test session, the relationship between the SLS (the mean of the 3 trials from each lower limb) and the sum score of BBS was analyzed using the Pearson product moment correlation coefficient. All calculations were performed using the SPSS 18.0 Software for Windows (SPSS Inc, Chicago, IL). A significance level greater than .05 represented nonsignificance.

RESULTS

None of the participants reported any negative events between or during the 2 test sessions, which potentially could have influenced the results. The mean values from the 2 test sessions for the BBS and the SLS are presented in Table 2.

Insert Table 2 about here

Reproducibility

The reproducibility of the BBS and the SLS are presented in Table 3. The $ICC_{2,1}$ values were 0.88 for BBS and were 0.88 for the nonparetic lower limb and 0.92 for the paretic lower limb for the SLS. The $\bar{d}$ values were close to zero, and the widths of the 95% CI for $\bar{d}$ were narrow, which demonstrated a small distribution. A positive value of $\bar{d}$ was found for the BBS and for the SLS nonparetic lower limb, which means that the performance at the second test session was better than at the first ($p < .05$), which in turn indicates a learning effect. The SEM% was low for BBS (3%) but higher for the SLS (15% for the nonparetic and 27% for the paretic limb). The SRD% was also low for the BBS (8%) but higher for SLS (42% for the nonparetic limb and 74% for the paretic limb). From the Bland-Altman graphs (Figure 1), a systematic variation around the zero line was revealed. In general, there were more values above the zero

line than below for the BBS and for the SLS nonparetic lower limb, which illustrates the better performance at the second test session.

Insert Table 3 and Figure 1 about here

Validity

The relationship between the SLS and the BBS was determined by data from the 2 test sessions. The correlations between the SLS and the BBS were significant ($p < .001$) for both lower limbs at both test sessions. The *r* value for the nonparetic lower limb was .77 at the first occasion and .79 at the second occasion, and for the paretic lower limb .7 at the first occasion and .65 at the second occasion.

DISCUSSION

The main finding of this study is that although both the BBS and the SLS are reproducible measurements in patients with chronic stroke, only the BBS is sensitive enough to follow changes over time or after an intervention. Because there are strong relationships between the SLS and the BBS, the results indicate that the SLS could be used as an independent test of upright postural control in chronic stroke.

Reliable and sensible measurement tools are essential to be able to follow changes over time or after an intervention. To fully investigate the reproducibility of a test, several statistical methods were applied in this study. Hopkins [24] suggested that a sample size of at least 30 individuals should be considered in reliability studies, but a larger sample size gives safer results for a given population [25], and therefore a total of 50 individuals were recruited in this study. Furthermore, much attention was paid to the procedure of the test protocol. All conditions were as stable as possible: for example the same assessor, assessments at the same time of the day, and standardized instructions during the tests to reduces the possibility of errors. The tests were performed at the same weekday and at the same time of the day, and all individuals were told to live as usual in the meantime. The design used in this study was previously developed and used within our research group. For patients in a chronic phase after a stroke, no change in balance deficits would be expected within 1 week. Because no participants reported any negative events between or during the 2 test sessions and the protocol was strictly standardized, the change in balance could be considered as normal variations within the individuals.

The $ICC_{2,1}$ was chosen because it provides the basis for the calculations of the SEM. By following the guidelines of Shrout and Fleiss [21], an $ICC_{1,1}$ might, be the most correct equation. However, in practice, the values of the different ICCs are often more or less identical and it has been suggested that an $ICC_{2,1}$ can be used in most circumstances. The results from this study showed that the $ICC_{2,1}$ were high for both the BBS (0.88) and the SLS (0.88 and 0.92 for the non-paretic and paretic lower limb, respectively) with low measurement errors. Our results for BBS are comparable with the results from another reliability study of BBS in the early phase after a stroke with an $ICC_{2.1}$ of 0.92 for individuals able to stand without any support [12].

Even if the ICCs were high for both measurements, the variance differed, with low values for the BBS but higher values for the SLS, which yielded higher values for the SEM% and the SRD%, especially for the paretic leg. From a clinical point of view, only the SRD% values for the BBS (8%) were sufficiently small to detect real changes in balance for single individuals with chronic stroke; for example, for an individual with a sum score of 50 points for the BBS, a change of 4 points is needed to detect a real improvement. For an individual able to stand for 7 seconds on one leg, a real change in the SLS, would be at least 3 seconds for the non-paretic lower limb and 5 seconds for the paretic lower limb, which clearly illustrates the need for several statistical methods to fully assess the reliability of a measurement method.

The BBS was assessed before the SLS at both test session. Because one-leg standing is one item in the BBS, there could have been a learning effect from the BBS to the SLS. To avoid this learning effect, the last item of BBS was scored from the first trial of SLS which could be done because the instructions for the last item (one-leg standing) in BBS was similar to those used in the SLS and the time frame was longer for SLS (15 seconds compared to 10 seconds for BBS). A better performance during the second test session was found for both the BBS and the non-paretic lower limb of the SLS, which suggests a small learning effect, which also has been reported in gait performance after stroke [17]. Even though this learning effect was small, it has to be taken into account. Learning effects might be reduced if practice is allowed before the actual test procedure. However, when following the standardized protocol of the BBS, a practice before the assessment is not allowed. To reduce a possible learning effect of SLS, the participants were allowed to perform 3 trials and the mean values were used in the statistical analysis. Still, we found a better performance for SLS at the second test session than the first, but only for the nonparetic lower limb.

Limitations

In this population, the balance varied within the group, and these differences were also demonstrated by the need of assistive device for 18 of the 50 participants. All participants were well recovered, able to stand without support and to walk with or without an assistive device; however the result from this study are representative only for persons with mild-to-moderate disability after a stroke.

A problem with the SLS is that it has not been fully standardized. Leg selection, maximum times, opened or closed eyes, restrictions about the arms, and the number of trials vary [13, 16]. The design of SLS in this study was standardized before the assessments, with a maximum time of 15 seconds; the preferred leg was assessed first, with eyes opened; and aspects of security were highlighted so as not to cause any risk for the participants. In further studies the optimal standardization of the SLS in patients with chronic stroke should be addressed.

The results from this study could guide the clinicians to choose appropriate measurements when assessing balance in patients with chronic stroke. The BBS could be considered as the criterion standard test to measure balance in stroke; however the SLS is a less time-consuming balance test, does not require any special equipment or training and is performed on both the paretic and nonparetic lower limbs. Both assessments can be used in clinical settings but only BBS seems to be appropriate for follow-up evaluations after an intervention or over time.

CONCLUSIONS

The BBS and the SLS are reproducible measurement tools after stroke, but the SLS is less sensitive for measuring changes over time or after an intervention. There are strong relationships between the BBS and the SLS for both lower limbs which indicates that the SLS is a valid test of upright postural control for both lower limbs, in patients after a stroke and can be recommended as a test of balance in patients with chronic stroke.

REFERENCES

1. Pollock AS, Durward BR, Rowe PJ, Paul JP: What is balance? Clin Rehabil 2000;14:402-406.

2. de Oliveira CB, de Medeiros IR, Frota NA, Greters ME, Conforto AB: Balance control in hemiparetic stroke patients: main tools for evaluation. J Rehabil Res Dev 2008;45:1215-1226.

3. de Haart M, Geurts AC, Huidekoper SC, Fasotti L, van Limbeek J: Recovery of standing balance in postacute stroke patients: a rehabilitation cohort study. Arch Phys Med Rehabil 2004;85:886-895.

4. Michael KM, Allen JK, Macko RF: Reduced ambulatory activity after stroke: the role of balance, gait, and cardiovascular fitness. Arch Phys Med Rehabil 2005;86:1552-1556.

5. Lamb SE, Ferrucci L, Volapto S, Fried LP, Guralnik JM: Risk factors for falling in home-dwelling older women with stroke: the Women's Health and Aging Study. Stroke 2003;34:494-501.

6. Tyson SF, Connell LA: How to measure balance in clinical practice. A systematic review of the psychometrics and clinical utility of measures of balance activity for neurological conditions. Clin Rehabil 2009;23:824-840.

7. Lubetzky-Vilnai A, Kartin D: The effect of balance training on balance performance in individuals poststroke: a systematic review. J Neurol Phys Ther 2010;34:127-137.

8. Orr R, Raymond J, Fiatarone Singh M: Efficacy of progressive resistance training on balance performance in older adults : a systematic review of randomized controlled trials. Sports Med 2008;38:317-343.

9. Berg K, Wood-Dauphinee S, Williams JI: The Balance Scale: reliability assessment with elderly residents and patients with an acute stroke. Scand J Rehabil Med 1995;27:27-36.

10. Berg KO, Wood-Dauphinee SL, Williams JI, Maki B: Measuring balance in the elderly: validation of an instrument. Can J Public Health 1992;83 Suppl 2:S7-11.

11. Blum L, Korner-Bitensky N: Usefulness of the Berg Balance Scale in stroke rehabilitation: a systematic review. Phys Ther 2008;88:559-566.

12. Stevenson TJ, Garland SJ: Standing balance during internally produced perturbations in subjects with hemiplegia: validation of the balance scale. Arch Phys Med Rehabil 1996;77:656-662.

13. Michikawa T, Nishiwaki Y, Takebayashi T, Toyama Y: One-leg standing test for elderly populations. J Orthop Sci 2009;14:675-685.

14. Franchignoni F, Tesio L, Martino MT, Ricupero C: Reliability of four simple, quantitative tests of balance and mobility in healthy elderly females. Aging (Milano) 1998;10:26-31.

15. Giorgetti MM, Harris BA, Jette A: Reliability of clinical balance outcome measures in the elderly. Physiother Res Int 1998;3:274-283.

16. Bohannon RW: Single Limb Stance Times: A Descriptive Meta-Analysis of Data From Individuals at Least 60 Years of Age. Top Geriatr Rehabil 2006;22:70-77.

17. Lexell JE, Downham DY: How to Assess the Reliability of Measurements in Rehabilitation. Am J Phys Med Rehabil 2005;84:719-723.

18. Flansbjer U-B, Holmbäck AM, Downham D, Patten C, Lexell J: Reliability of gait performance tests in men and women with hemiparesis after stroke. J Rehabil Med 2005;37:75-82.

19. Flansbjer U-B, Holmbäck AM, Downham D, Lexell J: What change in isokinetic knee muscle strength can be detected in men and women after stroke? Clin Rehabil 2005;19:514-522.

20. Atkinson G, Nevill AM: Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. Sports Med 1998;26:217-238.

21. Shrout PE, Fleiss JL: Intraclass correlations: Uses in assessing rater reliability. Psychol Bull 1979;86:420-428.

22. Beckerman H, Roebroeck ME, Lankhorst GJ, Becher JG, Bezemer PD, Verbeek AL: Smallest real difference, a link between reproducibility and responsiveness. Qual Life Res 2001;10:571-578.

23. Bland JM, Altman DG: Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;1:307-310.

24. Hopkins WG: Measures of reliability in sports medicine and science. Sports Med 2000;30:1-15.

25. Donner A, Eliasziw M: Sample size requirements for reliability studies. Stat Med 1987;6:441-448.

LEGENDS

Figure 1

The differences between test sessions 2 and 1 (test 2 minus test 1) plotted against the means of the two test sessions for the Berg Balance Scale (BBS) and the Single-leg Stance (SLS) for the nonparetic and the paretic lower limb. From these Bland- Altman graphs, the systematic variation around the zero line was revealed, and shows the learning effect for the BBS and nonparetic lower limb in the SLS.

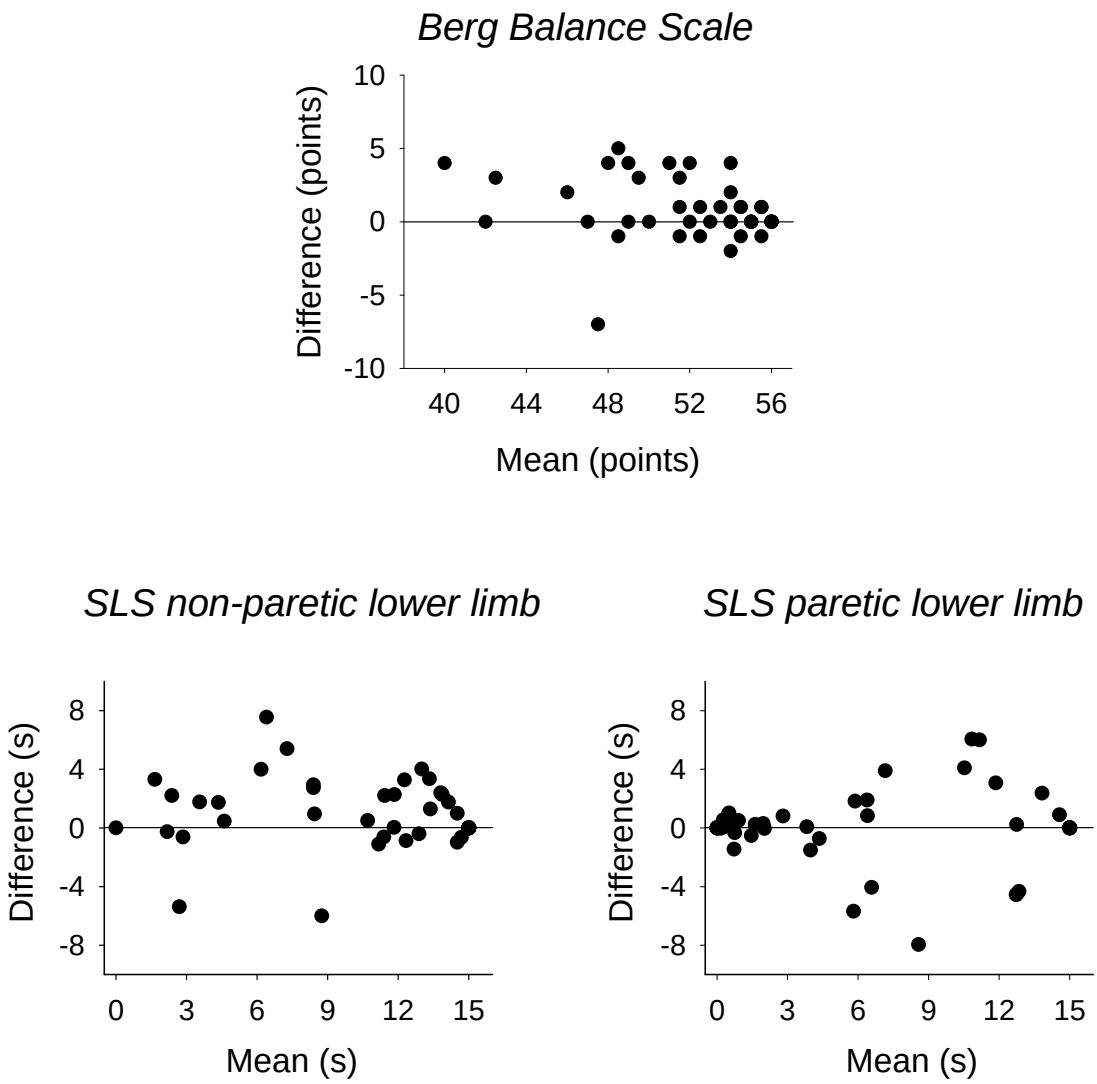
Berg Balance Scale
Difference (points)
10
5
0
-5
-10
40
44
48
52
56
Mean (points)
SLS non-paretic lower limb
Difference (s)
8
4
0
-4
-8
0
3
6
9
12
15
Mean (s)
SLS paretic lower limb
Difference (s)
8
4
0
-4
-8
0
3
6
9
12
15
Mean (s)

Figure 1

Table 1. Clinical characteristics of the 50 individuals post stroke.

Characteristics	**n (%)**
Type of stroke	
Ischemic	37 (74)
Hemorrhagic	13 (26)
Hemiparetic side	
Weakness in right side	20 (40)
Weakness in left side	30 (60)
Use of assistive device	
No walking aid	32 (64)
Walking aid	11 (22)
Ankle-foot orthosis and walking aid	7 (14)

Table 2. Berg Balance Scale and Single-leg stance results for 50 individuals after stroke.

Test	Test session 1 Mean ± SD	Test session 2 Mean ± SD
Berg Balance test, points	52 ± 4.3	52.7 ± 3.8
Single-leg stance, s		
Nonparetic	10.6 ± 5	11.5 ± 4.7
Paretic	6.6 ± 6	6.5 ± 6.1

Table 3. Reproducibility of the Berg Balance Scale and the Single-leg stance for the 50 individuals after stroke.

Test	$ICC_{2,1}$ (95% CI)	$\bar{d}$ (95% CI)	SEM	SEM%	SRD	95% SRD	SRD%
Berg Balance Scale, points	0.88 (0.80-0.93)	0.72 (0.15-1.29)	1.49	3	4.13	-3.41 to 4.85	8
Single-leg stance, s							
Nonparetic	0.88 (0.79-0.94)	0.82 (0.19-1.45)	1.66	15	4.59	-3.77 to 5.41	42
Paretic	0.92 (0.86-0.95)	-0.03 (-0.74-0.68)	1.76	27	4.87	-4.90 to 4.84	74

$ICC_{2.1}$ = intraclass correlation coefficient; CI = confidence interval; $\bar{d}$ = the mean differences between the test sessions; SEM = standard error of measurement; SRD = smallest real difference