Research Report

Balance Disability After Stroke

Background and Purpose. Balance disability is common after stroke, but there is little detailed information about it. The aims of this study were to investigate the frequency of balance disability; to characterize different levels of disability; and to identify demographics, stroke pathology factors, and impairments associated with balance disability. **Subjects.** The subjects studied were 75 people with a first-time anterior circulation stroke; 37 subjects were men, the mean age was 71.5 years (SD=12.2), and 46 subjects (61%) had left hemiplegia. **Methods.** Prospective hospital-based cross-sectional surveys were carried out in 2 British National Health Service trusts. The subjects' stroke pathology, demographics, balance disability, function, and neurologic impairments were recorded in a single testing session 2 to 4 weeks after stroke. **Results.** A total of 83% of the subjects (n=62) had a balance disability; of these, 17 (27%) could sit but not stand, 25 (40%) could stand but not step, and 20 (33%) could step and walk but still had limited balance. Subjects with the most severe balance disability had more severe strokes, impairments, and disabilities. Weakness and sensation were associated with balance disability. Subject demographics, stroke pathology, and visuospatial neglect were not associated with balance disability. **Discussion and Conclusion.** Subjects with the most severe balance disability had the most severe strokes, impairments, and disabilities. Subject demographics, stroke pathology, and visuospatial neglect were not associated with balance disability. [Tyson SF, Hanley M, Chillala J, et al. Balance disability after stroke. *Phys Ther.* 2006;86:30–38.]

Key Words: *Balance; Cerebrovascular accident.*

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Stroke is the third most common cause of death in the Western Hemisphere and the most common cause of adult disability[1]; of the survivors, about 50% will have a significant long-term disability.[2] Balance problems are thought to be common after stroke, and they have been implicated in the poor recovery of activities of daily living (ADL) and mobility and an increased risk of falls.[3–6] Despite these data, there is little detailed information about balance problems. One factor that contributes to this lack of information is a lack of clarity in the language used to describe balance difficulties. The terms "balance," "balance reactions," "postural reactions," "postural control," "posture," and "equilibrium" are used interchangeably, but there are neither commonly accepted definitions for these terms nor any consistency in the way in which they are used. This problem hampers attempts to draw conclusions from the literature or to generalize the findings. Most studies have measured balance impairments (such as postural sway, weight distribution, or related parameters) rather than balance disability (the type of balance task that a subject can perform while maintaining an upright position, such as static or dynamic sitting or standing balance), each of which is reviewed below.

Studies of balance impairments consistently have shown that people with stroke have greater postural sway than age-matched volunteers who are healthy.[7–11] They also have altered weight distribution patterns, so that less weight is taken through the weak leg, and they have smaller excursions when moving their weight around the base of support, especially in the direction of the weaker leg. This pattern is seen in all aspects of balance—static, dynamic, or responses to external perturbations—and even in people with stroke with high levels of function, such as those who are ambulatory in the community.[12–22] The relationship between balance impairments (such as weight distribution or postural sway) and function, whether assessed by balance disability, mobility, or ADL, is less clear. Although some studies have shown that balance impairment measures are related to measures of activity,[15–17,22] other studies have, more frequently, failed to demonstrate a relationship.[8,20,23–30] There are a number of possible reasons for these findings. First, most studies involved small numbers of subjects drawn from a convenience sample with a narrow range of abilities (eg, people who are able to stand with their eyes closed[13,26] or stand on one leg,[13,30] or both[13]), so that the majority of patients with stroke were excluded. Selection of subjects with a narrow range of abilities may result in too small a range of performance to detect a relationship. No descriptive studies of balance impairments used power calculations to determine the number of subjects needed to detect a relationship; therefore, it is possible that there were simply too few subjects. Another possibility is that balance impairments are not related to balance disability or everyday function. This possibility is strengthened by the finding that, although balance disability and function improve during rehabilitation and with time after stroke, balance impairments do not.[8,27,30] This finding suggests either that balance impairments are not related to balance disability and function or that people are able to develop compensation strategies that enable them to become functionally effective despite their balance impairments.

There is even less literature about balance disability after stroke, although this problem, rather than balance impairments, is the focus of physical therapists' assessment and treatment plans.[31–33] The most consistent

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finding is that a lack of sitting balance in the acute stages after stroke is a robust indicator of a poor prognosis for recovery of independence in mobility or ADL.[34–39] The other consistent finding is a positive relationship between balance disability and other aspects of function, such as mobility, ADL, and falls.[22,27,30,35–43] However, variability in outcome measures and selection criteria hampers comparison and generalizability and prevents meta-analysis. To date, there have been no detailed descriptive studies of balance disability after stroke. We aimed to repair this deficiency by undertaking a cross-sectional survey of balance disability after stroke. The specific objectives were to assess the frequency of balance problems, to characterize different degrees of balance disability, and to identify the factors associated with balance disability.

In this study, *balance disability* was defined as the ability to maintain an upright position within the limits of stability or base of support.[44,45] This definition is operationalized in a newly developed measurement tool, the Brunel Balance Assessment (BBA)[46] (Appendix). There are already many measures of balance after stroke,[47–53] and it may be questioned why a new measure is needed. Although ordinal scales, such as the Berg Balance Scale[47] or the Rivermead Mobility Index,[48] are generally reliable and valid measures of balance disability, they are relatively unresponsive to change. Functional performance measures, such as the Forward Reach Test[49] or the 10-Meter Walk Test,[50] are generally reliable, valid, and sensitive but suitable for use only with people with a narrow range of abilities. For example, the Forward Reach Test is suitable only for people who can stand and reach unaided (ie, have dynamic standing balance) but whose standing balance is not within normal limits. Instrumented measures, such as force plates or postural sway monitors, measure balance impairments rather than disability. For a comprehensive review of balance measurement tools after stroke and their psychometric properties, see Tyson and DeSouza.[51–53] The BBA is a reliable, valid measure of balance disability after stroke, is suitable for people with a wide range of abilities (from supported sitting balance to an advanced skill such as changing the base of support in a single stance), and is sensitive to change.[46,54] It operationalizes the hierarchy of balance tasks (progressing from sitting to standing and stepping balance) that physical therapists use when assessing balance disability.[31] It combines a 12-point ordinal scale of balance disability with functional performance tests at each level of the ordinal scale. The ordinal scale is arranged into 3 subscales that also can be used individually (Appendix). The sitting balance scale scores 1 to 3 on the main scale, the standing balance scale scores 4 to 6, and the stepping scale scores 7 to 12. In this article, subjects who scored between 1 and 3 on the BBA are referred to as being in the sitting balance group, subjects who scored between 4 and 6 are referred to as being in the standing balance group, and subjects who scored between 7 and 12 are referred to as being in the stepping balance group. Full details of the BBA and how to use it can be found and downloaded from: www.healthcare.salford.ac.uk/crhpr/brunel-balance-assessment.htm.

Method

A prospective cross-sectional hospital-based survey of subjects who had a stroke and who were recruited from 2 British National Health Service trusts was undertaken. Successive subjects with hemiplegia after a first-time anterior circulation stroke were recruited and tested 2 to 4 weeks after the stroke if they were able to give informed consent and were well enough to participate. They were excluded if they had another mobility-limiting neurological condition (such as dementia or Parkinson disease) or bilateral weakness, because their mobility and balance disabilities would be different from those with hemiplegia alone.

Subjects

All people who had a stroke and were admitted to 2 large British National Health Service trusts (N=433) were screened over a 1-year period (January 2003–January 2004). Of these, 75 subjects were recruited. Of the excluded 358 subjects, 132 (37%) were too unwell to participate because they were drowsy or unconscious or had severe comorbidities, 87 (24%) were too aphasic or confused to give consent, 4 (1%) spoke insufficient English to give consent, 77 (21.5%) were discharged within 2 weeks, 49 (14%) had another neurologic condition, and 9 (2.5%) declined to participate.

Of the 75 subjects recruited, 46 (61%) had left hemiplegia and 66 (88%) had ischemic stroke. Twenty (27%) had a total anterior circulation stroke, 24 (32%) had a partial anterior circulation stroke, and 31 (41%) had a lacunar anterior circulation stroke. The mean time since the stroke was 21 days (SD=5). There were 37 men (49%), and the mean age was 71.5 years (SD=12.2, range=34–92). A total of 55 subjects (73%) had no previous disability. The median Motricity Index score was 74.5 (interquartile range=35.5–96), the median Rivermead Assessment of Sensorimotor Performance (RASP) score was 14 (interquartile range=10–18), the median BBA score was 6 (interquartile range=3–10), and the Barthel Index score was 12 (interquartile range=7–17). A total of 21 subjects (28%) had visuospatial neglect. Informed consent was obtained from all participants.

Procedure

Once informed consent was obtained, data were collected in a single measurement session at the hospital bedside or physical therapy treatment gym by 1 of 4 assessors (2 senior neurologic physical therapists and 2 geriatricians). The following data were obtained.

Demographics. Demographic details included age, sex, and prestroke disability (Rankin Scale[55]). The Rankin Scale is a widely used basic measure of disability that is based on mobility and has established reliability and validity for stroke.[55] In this study, it was used to classify prestroke disability. Scores are as follows: 0 indicates no symptoms, 1 indicates no significant disability despite symptoms, 2 indicates slight disability (able to look after own affairs but unable to carry out all previous activities), 3 indicates moderate disability (requires some help but able to walk without assistance), 4 indicates moderately severe disability (unable to walk or attend to bodily needs without assistance), and 5 indicates severe disability (bedridden).

Stroke pathology. Stroke pathology included stroke type (ischemic or hemorrhagic, as determined from computed tomography scan), location (left or right, as determined from computed tomography scan), and severity (Oxford Community Stroke Project [OCSP] classification[56]). The OCSP classification classifies the severity of stroke according to the location of the cerebral insult. It is reliable and valid and is a good prognostic indicator in terms of morbidity and mortality.[56] It is widely used in the United Kingdom to stratify patients for trials or for treatment. Anterior circulation strokes are classified as total (TACS), partial (PACS), or lacunar (LACS), according to the number of acute impairments on clinical examination.

Neurologic impairments. Neurologic impairments included neglect (as determined by the Star Cancellation Test and the Line Bisection Test[57]), weakness (Motricity Index[58–62]), and sensation (RASP[63]).

The Star Cancellation Test and the Line Bisection Test are part of the Behavioral Inattention Test, which has well-demonstrated reliability, validity, and sensitivity.[57] The Star Cancellation Test consists of an A4 (8.27- × 11.69-in) sheet of paper with large stars, small stars, letters, and short words randomly positioned across the page. The subject is asked to cross out the small stars. There are 54 small stars, and a cutoff point of 51 stars is used to determine the presence of neglect.[57] The Line Bisection Test consists of three 8-in lines across a page.[57] The subject is asked to estimate and mark the center of each line. A template is used to score the subject's mark according to how close it is to the true center of the line. The maximum score is 9, the minimum score is 0, and there is an impairment cutoff at 7.[57] In this study, a subject failing either test was noted to have neglect.

The Motricity Index is a well-established measure of hemiplegic limb strength. The average of the scores for the upper and lower limbs is taken to provide a total score for the hemiplegic side; the total score was used in this study. A score of 0 indicates complete paralysis, and a maximum score of 100 indicates complete recovery or no weakness. Test-retest reliability, intertester reliability, and validity for use with people with stroke have been established.[58–62]

The RASP is a measure designed to operationalize the clinical assessment of sensation in neurologic conditions.[63] Proprioception (joint movement and direction) and sensation to light touch (detection of touch and location) of the upper limb (hand, thumb, wrist, and elbow) and lower limb (foot and ankle) are measured.[63] The maximum score is 18. A score of 0 to 6 indicates severely impaired or absent sensation, a score of 7 to 12 indicates impaired sensation, and a score of 12 to 18 indicates mildly impaired or intact sensation. Reliability and validity have been described.[63]

Balance disability. Balance disability was evaluated with the BBA[46,54] (Appendix).

Function. Function (independence in ADL) was evaluated with the modified Barthel Index.[64] The Barthel Index is a widely used measure of independence in ADL. A score of 0 indicates total dependence, and a maximum score of 20 indicates independence in basic ADL. Reliability and validity for use with people with stroke have been demonstrated.[64]

Data Analysis

Descriptive statistics were used to describe the frequency of balance disability (objective 1). To characterize the different balance groups, Kruskal-Wallis tests were used to assess differences between the groups (sitting, standing, or stepping balance); to assess where the differences lie, individual Mann-Whitney *U* test comparisons (to compare sitting versus standing, sitting versus stepping, and standing versus stepping) were undertaken for the significant parameters (objective 2). To assess which factors affected balance disability, linear regression was used (objective 3). Data for demographics, stroke pathology, and impairments were entered into an individual linear regression model, with balance disability as the dependent variable. Then, to take into account colinearity, the significant factors were loaded into a multifactorial model. The severity of stroke was not entered into the linear regression model because it has obvious colinearity with impairments, as the presence of impairments is used in the OCSP classification.[56]

Table 1.
Kruskal-Wallis Test Comparisons to Identify Differences Among Balance Groups[a]

Parameter	Sitting (BBA Score=1–3) (n=17)	Standing (BBA Score=4–6) (n=25)	Stepping (BBA Score=7–11) (n=33)	P
Stroke pathology				
Side of stroke—no. (%) with left hemiplegia	11 (65)	14 (56)	21 (64)	.051
Type—no. (%) with infarcts	12 (70)	24 (96)	30 (91)	.000[b]
Stroke severity—no. (%) of TACS/PACS/LACS	9/8/0 (53/47/0)	7/9/9 (28/36/36)	4/7/22 (12/21/67)	.000[b]
Demographics				
Age (y)—median (IQR)	76.0 (68, 81.5)	75 (70, 80)	74 (61, 80)	.896
Sex—no. (%) of men	8 (47)	11 (44)	18 (54)	.908
Premorbid disability—no. (%) symptom free	11 (65)	21 (84)	23 (70)	.381
Neurologic impairments				
Neglect—no. (%) of subjects with neglect	11 (65)	4 (16)	6 (18)	.000[b]
Sensation—median (IQR)	10 (8, 14)	14 (8.5, 18)	18 (14, 18)	.000[b]
Weakness—median (IQR)	12.5 (1, 33.5)	55 (43.25, 89.5)	88 (76.5, 100)	.000[b]
Disability				
Independence in ADL—median (IQR)	6.5 (4.5, 10.75)	16 (12.5, 17)	18 (16.25, 19)	.000[b]

[a] BBA=Brunel Balance Assessment, which assesses balance disability. Stroke severity was assessed by the Oxford Community Stroke Project in which TACS=total anterior circulation stroke, PACS=partial anterior circulation stroke, and LACS=lacunar anterior circulation stroke. IQR=interquartile range. ADL=activities of daily living. Premorbid disability was evaluated with the Rankin Scale. Neglect was evaluated with the Star Cancellation Test and the Line Bisection Test. Sensation was evaluated with the Rivermead Assessment of Sensorimotor Performance. Weakness was evaluated with the Motricity Index. Independence in ADL was evaluated with the Barthel Index.
[b] Significant at $P<.05$.

Table 2.
Individual Mann-Whitney *U* Test Comparisons to Identify Where Differences Among Balance Groups Lie[a]

Parameter	Balance Group Comparison	P
Type of stroke	Sitting and standing	.022
	Sitting and stepping	.066
	Standing and stepping	.453
Severity of stroke	Sitting and standing	.014
	Sitting and stepping	.000
	Standing and stepping	.000
Neglect	Sitting and standing	.001
	Sitting and stepping	.001
	Standing and stepping	.829
Sensation	Sitting and standing	.137
	Sitting and stepping	.000
	Standing and stepping	.016
Weakness	Sitting and standing	.000
	Sitting and stepping	.000
	Standing and stepping	.001
Independence in ADL	Sitting and standing	.000
	Sitting and stepping	.000
	Standing and stepping	.000

[a] ADL=activities of daily living.

Results

Thirteen subjects (17%) scored the maximum of 12 on the BBA (step-ups without hand support) and could complete all of the balance tasks. Of the remaining 62 with balance disabilities, 17 (27%) could sit but not stand (BBA scores of 1–3), 25 (40%) could stand but not step and walk (scores of 4–6), and 20 (33%) could step but still had limited balance (scores of 7–11).

There was marked heterogeneity among subjects with different levels of balance ability (Tabs. 1 and 2). There were no differences in the demographic characteristics (age, sex, and previous disability) or the side of stroke for subjects with different levels of balance disability (sitting, standing, or stepping balance). Subjects in the sitting balance group had more severe neurologic impairments, disabilities, and strokes than subjects with limited standing or stepping balance. Conversely, subjects in the stepping balance group were less severely impaired and disabled and had milder strokes than subjects with limited sitting or standing balance. There were significant differences among the 3 groups for weakness, independence, and severity of stroke. More subjects in the sitting balance group had neglect and sustained a hemorrhage (rather than infarct) than subjects in the standing balance group or the stepping balance group (but there were no differences between the standing balance and stepping balance groups). Subjects in the sitting balance and standing balance groups had worse sensation than subjects in the stepping balance group (but there were no differences between the sitting balance and standing balance groups).

Individual linear regression modeling revealed that none of the demographic or stroke pathology factors (age, sex, premorbid disability, side of stroke, or stroke type) was associated with balance disability. All of the

Table 3.
Results of Individual Linear Regressions to Identify Which Factors Predict Balance Disability

Factor	P
Stroke pathology	
Side of stroke	.937
Type of stroke (infarct or hemorrhage)	.086
Demographics	
Age	.23
Sex	.365
Premorbid disability	.981
Neurologic impairments	
Neglect	.015[a]
Sensation	.0001[a]
Weakness	.0001[a]

[a] Significance was set at $P<.05$.

Table 4.
Multiple Regression of Significant Factors Identified in Table 3.

Adjusted R^2 Change=0.468	Partial Correlation Coefficient	Standardized Beta Coefficient	P
Neglect	−0.066	−0.034	.714
Sensation	−0.569	0.206	.036[a]
Weakness	−0.258	0.555	.000[a]

[a] Significance was set at $P<.05$.

impairments (weakness, sensation, and neglect) were significantly associated with balance disability (Tab. 3). When the significant factors (impairments) were entered into a multifactorial model, weakness and sensation emerged as being independently associated with balance disability, but neglect did not (Tab. 4). This model accounted for 47% of the variance.

Discussion and Conclusions

Although rehabilitation of balance and mobility often has been identified as an important goal of stroke rehabilitation, this is the first detailed descriptive study of balance disability after stroke. We found that more than 80% of subjects who had first-time strokes, who were admitted to the hospital, and who met the inclusion criteria had balance disability in the acute phase, with similar numbers of subjects having limited sitting balance, standing balance, and stepping balance. There were marked differences in the severity of stroke, impairments, and disability among subjects with different levels of balance ability. Subjects in the sitting balance group had more severe strokes and impairments and were more dependent than subjects in the standing balance and stepping balance groups, and subjects in the stepping balance group had milder strokes, less impairment, and greater independence than subjects in the other groups. Given the heterogeneity among subjects with different balance abilities, a measure of balance disability may be a useful predictive tool in the clinical setting and for use as a stratification tool for further research. Moreover, level of balance ability (sitting, standing, or stepping balance) is meaningful to clinicians, patients, and their relatives, and a robust measurement tool (BBA[46,54]) that is quick and easy to use has been developed.[46] Further studies including power calculations to ensure a sufficiently large sample are needed to further test the hypothesis that balance level in the acute stages could be a useful, meaningful prognostic indicator of recovery.

Three previous studies[26,40,65] considered which factors may be related to balance disability (as the outcome variable). All 3 studies used a correlational design, rather than the linear regression design used in the present study. Their findings broadly support the results of the present study. A significant positive correlation between strength or lower-limb control and balance disability was found in all 3 studies.[26,40,65] Niam et al[26] and Keenan et al[40] found a positive relationship between balance disability and sensation (as measured by ankle proprioception). As in the present study, Niam et al[26] and Bohannon[65] failed to find a relationship between age, sex, or side of stroke and balance disability.

It is important to know which factors influence a patient's balance abilities most strongly so that they can be targeted during rehabilitation. The present study has indicated that weakness and sensation have the most impact on balance. A surprising finding was that neglect was not associated with balance disability. Although neglect appeared to be significant when it was entered into an individual analysis, the apparent significance was lost when it was entered into a multifactorial model with other significant impairments. This finding indicates that neglect may be related to the severity of balance disability because it is associated with other impairments (weakness and sensory loss); therefore, people with neglect probably have poor balance because they also have severe weakness or sensory loss, or both, rather than because they have neglect per se. The case for this interpretation is strengthened when people who have neglect and mild weakness (Motricity Index score of <60) are compared with the rest of the sample. If the hypothesis was correct, then people with neglect and mild weakness would have a high balance score. When the data were examined, 7 subjects with neglect and mild weakness were identified. They had better balance scores than the rest of the group (BBA scores of 8.3 [SD=4.23] versus 6.4 [SD=3.5]). These differences did not reach statistical significance ($P<.216$ for the BBA), however, possibly because of the small number of people with neglect (n=21). Further studies with a power calculation to ensure that sufficient numbers are recruited to detect a difference, should one exist, are needed to investigate this issue.

Although the model that we developed to identify factors associated with balance disability in the acute stages accounted for 47% of the variance in balance disability, 53% of the variance still was unaccounted for. Future studies need to consider which other factors may affect balance disability. Spasticity was not included in the present study because of the lack of a robust measurement tool,[66,67] but many physical therapists believe this to be an important contributor to loss of balance and function after stroke.[33] Tests of eyesight and cognitive factors, such as speed of information processing, also could be considered, and more subtle measures of neglect or attention may shed more light on otherwise unexplained variance. The relationship between balance impairments and balance disability also needs to be clarified by including measures of balance impairments in future, more detailed studies.

Finally, we chose not to recruit subjects until 2 weeks after stroke. We did this to avoid the first week, when subjects may have been distressed, busy with investigations, or acutely ill or when, in a few cases, the diagnosis was unclear. This strategy was successful in that very few people declined to participate in the study (only 2%), and we did not recruit anyone who was subsequently found not to have had a stroke. However, it did mean that we failed to recruit some people (25%) who had had very mild strokes and who were discharged within 2 weeks of admission. Notwithstanding the above details, it must be emphasized that we included all people who were admitted to 2 trusts over the course of 1 year, who met the inclusion criteria, and who were willing to participate. We therefore believe that our findings have general relevance to the population of people with balance disability after first-time stroke.

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Appendix.
Brunel Balance Assessment[a]

Level of Balance	PerformanceTest
1. Static sitting balance with upper-limb support *Whether the subject can maintain a sitting position for 30 s with upper-limb support but without assistance from another person*	Timed for 30 s (yes/no)
2. Static sitting balance *How often the sound arm can be raised and lowered (to the subject's full range) in 15 s; minimum score to pass this level=3 lifts*	Arm raise
3. Dynamic sitting balance *Distance the subject can reach beyond arm's length; minimum score to pass this level=11 cm*	Forward reach
4. Static standing balance with upper-limb support *Whether the subject can maintain a standing position for 30 s with upper-limb support but without assistance from another person*	Timed for 30 s (yes/no)
5. Static standing balance *How often the sound arm can be raised and lowered (to the subject's full range) in 15 s; minimum score to pass this level=3 lifts*	Arm raise
6. Dynamic standing balance *Distance the subject can reach beyond arm's length; minimum score to pass this level=7 cm*	Forward reach
7. Static double stance (stride-standing) *Whether the subject can maintain stride-standing position for 30 s without holding onto or assistance from another person*	Timed for 30 s (yes/no)
8. Supported single stance *Time taken to walk 5 m with a walking stick; minimum score to pass this level=0.43 s*	Timed 5-m walk with an aid
9. Dynamic double stance (stride-standing) *How often the subject can transfer weight on and off the weak leg while in stride-standing position in 15 s; minimum score to pass this level=3 shifts*	Weight shift
10. Change of the base of support (between double stance and single stance) *Time taken to walk 5 m without a walking aid; minimum score to pass this level=0.7 s*	Timed 5-m walk without an aid
11. Maintaining static single stance *How often the subject can tap the sound leg on and off a 10-cm box in 15 s; minimum score to pass this level=2 taps*	Tap
12. Advanced change of the base of support *How often the subject can step up onto and off of a 10-cm box, leading with the weak leg; minimum score to pass this level=1 step-up*	Step-up

[a] The Brunel Balance Assessment is the copyrighted property of Sarah Tyson.