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Concordance and discordance between measured and perceived balance and the effect on gait speed and falls following stroke

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Abstract

Objective—To ascertain the existence of discordance between perceived and measured balance in persons with stroke and to examine the impact on walking speed and falls.

Design—A secondary analysis of a phase three, multicentered randomized controlled trial examining walking recovery following stroke.

Subjects—A total of 352 participants from the Locomotor Experience Applied Post-Stroke (LEAPS) trial.

Methods—Participants were categorized into four groups: two concordant and two discordant groups in relation to measured and perceived balance. Number and percentage of individuals with concordance and discordance were evaluated at two and 12 months. Walking speed and fall incidence between groups were examined.

Main measures—Perceived balance was measured by the Activity-specific Balance Confidence scale, measured balance was determined by the Berg Balance Scale and gait speed was measured by the 10-meter walk test.

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Authors' Note

Interested readers may access the data used in this article by contacting NINDS for publically released data of the LEAPS trial.

Conflict of interest

The authors declare that there is no conflict of interest.

Contributors

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Results—Discordance was present for 35.8% of participants at two months post-stroke with no statistically significant change in proportion at 12 months. Discordant participants with high perceived balance and low measured balance walked 0.09 m/s faster at two months than participants with concordant low perceived and measured balance ($p < 0.05$). Discordant participants with low perceived balance and high measured balance walked 0.15 m/s slower than those that were concordant with high perceived and measured balance ($p \leq 0.0001$) at 12 months. Concordant participants with high perceived and measured balance walked fastest and had fewer falls.

Conclusions—Discordance existed between perceived and measured balance in one-third of individuals at two and 12 months post-stroke. Perceived balance impacted gait speed but not fall incidence.

Keywords

Balance confidence; balance; falls; gait; stroke

Introduction

Balance disability affects more than 80% of patients post-stroke¹ with falls occurring in 40%–70% of stroke survivors within the first year.^{2,3} Of those who fall, 36% experience multiple or injurious falls.⁴

Balance performance and functional ability are strongly associated with perceived balance in community dwelling older adults.^{5,6} Individuals with stroke have lower confidence for performing tasks without falling than older adults without stroke.^{7,8} Individuals with stroke that have lower perceived balance are also more likely to have diminished physical capacity and reduced independence with activities of daily living (ADL) than those with higher perceived balance.⁹

Balance can impact a person's ability to walk. In fact, perceived balance may be as important as measured balance when predicting gait performance. Perceived balance in community dwelling elders can influence gait velocity,¹⁰ whereby individuals with higher perceived balance demonstrated faster gait speeds.¹⁰ Similarly, following stroke, low perceived balance has been shown to accompany greater walking impairments.⁹ Fear of falling and falls are strongly associated and can lead to restrictions in physical activities.¹¹ Therefore, a person's perceived balance ability may affect fall risk and gait speed.

Discordance occurs when a mismatch exists between an individual's perceived balance and his/her measured balance ability. For example, a person might perceive their balance as impaired but perform well on measured balance tests, or conversely, a person might perceive their balance as unimpaired but perform poorly on measured balance tests. In contrast, concordance reflects a match between perceived balance and measured balance.

In the older adult population, discordance has been observed between perceived balance and measured balance scores.^{12,13} Perceived balance was observed to be discordant with fall risk and gait speed in a study of older women with low bone mass.¹² However, the existence of

discordance and its association with functional mobility deficits, particularly gait speed and falls, has not been established in patients post-stroke. Therefore, the purpose of this article is to ascertain the existence of discordance between perceived balance and measured balance performance in persons with stroke and to explore its impact on walking speed and falls.

Methods

Data from 352 participants who participated in the Locomotor Experience Applied Post-Stroke (LEAPS),¹⁴ phase three, multisite, randomized controlled trial was utilized to conduct this secondary analysis. Inclusion criteria for the trial were: unilateral stroke with resultant paresis within 45 days of enrollment, the ability to walk 10 feet with no more than one-person assist for balance but not extremity advancement, walking speed of <0.8 m/s and the ability to follow a three-step command.^{14,15} Inclusion in this secondary analysis required a complete data for the Activities-Specific Balance Confidence Scale and Berg Balance Scale at two and 12 months post-stroke, resulting in exclusion of 56 participants from the original trial. Ethics review boards at each participating facility approved the trial protocol and all study participants were informed of the trial procedures and provided written consent.

Balance and gait speed assessments

Participants were assessed utilizing the following standardized assessments at two and 12 months post stroke: Activities-Specific Balance Confidence Scale,¹⁶ Berg Balance Scale¹⁷ and 10-meter walk test.¹⁸ Assessments were conducted by evaluators who were trained according to standardized protocols and blinded to participant randomization allocation.¹⁵

For the purpose of this study, a cutoff score of ≤ 42 on the Berg Balance Scale was used to define low measured balance. A score of ≤ 42 on the Berg Balance Scale has been shown to be a predictor for multiple or injurious falls in individuals with stroke.⁴ A cutoff score of $\leq 66\%$ on the Activities-Specific Balance Confidence Scale was used to define low perceived balance based on work by Lajoie and Gallagher¹⁹ in the elderly community-dwelling population. In their study, scores less than 67% on the Activities-Specific Balance Confidence Scale had 84.4% sensitivity and 87.5% specificity for predicting falls in the geriatric population.¹⁹ In a previous study, Myers et al.⁶ reported that scores of <49% on the Activities-Specific Balance Confidence Scale corresponded with lower measures of mobility, balance performance and self-paced walking speeds in older adults. Given that both of these studies were conducted in the geriatric population, and no cutoff on the Activities-Specific Balance Scale has been established in the stroke population, a follow-up analysis was conducted using a 49% cutoff score to identify any differences in study results based on a 66% or 49% cutoff for defining low perceived balance.

Fall incidence was monitored between two and 12 months post-stroke, utilizing falls calendars submitted monthly by participants and follow-up phone calls.⁴ A fall was defined as a person ending up on the floor, whether from a standing, seated or horizontal position, when it was unexpected.¹⁵

Data analysis

For this study, participants were categorized into four groups based on their Activities-Specific Balance Confidence Scale score and Berg Balance Scale scores: (1) low Activities-Specific Balance Confidence Scale/low Berg Balance Scale (concordant); (2) high Activities-Specific Balance Confidence Scale/low Berg Balance Scale (discordant); (3) high Activities-Specific Balance Confidence Scale/high Berg Balance Scale (concordant); (4) low Activities-Specific Balance Confidence Scale/high Berg Balance Scale (discordant). Number and percentage of participants with concordance and discordance were evaluated at two and 12 months post-stroke. McNemar's test was used to assess whether discordance rates were the same between two months and 12 months post-stroke; and whether the rates in each discordant/concordant group changed. A two sample *t*-test was used to compare gait speed between each pair of the concordant and discordant groups. In addition, a chi-squared test was used to evaluate whether the four groups had differences in fall frequency, followed by post-hoc pairwise comparisons. A multiple regression analysis was conducted to determine the association between the Activities-Specific Balance Confidence Scale, Berg Balance Scale and their interactions on gait speed at two months and 12 months, respectively. For all procedures, statistical significance was set at $p < 0.05$. All statistical analyses were conducted using SAS® version 9.3 (SAS Institute, Cary, North Carolina).

Results

Table 1 shows overall demographics of the cohort for this analysis ($n = 352$) and the original LEAPS cohort ($n = 408$). Figure 1 presents a scatterplot of the perceived balance and measured balance scores at two and 12 months post-stroke, and the number and percentage of participants with concordance and discordance. There was no significant difference in concordance/discordance between two and 12 months post-stroke ($p = 0.87$), however, the percentage of participants in concordant Group 3 (high Activities-Specific Balance Confidence Scale/high Berg Balance Scale) nearly tripled, while the percentage of people in Group 1 (low ABC/low BBS) nearly halved by 12 months post-stroke (13.9% to 39.2% $p < 0.0001$ and 50.3% to 25.9% $p < 0.0001$, respectively).

Table 2 displays the gait speed of concordant and discordant participants at two and 12 months. Concordant participants in Group 1 (low Activities-Specific Balance Confidence Scale/low Berg Balance Scale) walked the slowest, while concordant participants in Group 3 (high Activities-Specific Balance Confidence Scale/high Berg Balance Scale) walked the fastest at both time points. At two months, discordant participants in Group 2 (high Activities-Specific Balance Confidence Scale/low Berg Balance Scale) walked 0.09 m/s faster than concordant participants in Group 1 (low Activities-Specific Balance Confidence Scale/low Berg Balance Scale) ($p = 0.03$). At 12 months, discordant participants in Group 4 (low Activities-Specific Balance Confidence Scale/high Berg Balance Scale) walked 0.15 m/s slower than concordant participants in Group 3 (high Activities-Specific Balance Confidence Scale/high Berg Balance Scale) ($p \leq 0.0001$).

Mean Berg Balance Scale scores ($\pm$ standard deviation) were 36.6 ± 13.7 at two months and 44.0 ± 11.1 at 12 months with a 60% fall rate (one or multiple) between two and 12 months post-stroke. As demonstrated in Table 3, the four groups defined by the combinations of

Activities-Specific Balance Confidence Scale scores and Berg Balance Scale scores had significant differences in falls (overall $p < 0.0001$). Based on post-hoc pairwise comparisons, we found that among those with Low Activities-Specific Balance Confidence Scale scores, participants with low Berg Balance Scale scores (Group 1) fell significantly more than participants with high Berg Balance Scale scores (Group 4) ($p = 0.0001$). Among those with high Activities-Specific Balance Confidence Scale scores, the difference between low Berg Balance Scale scores and high Berg Balance Scale scores (Group 2 and Group 3) was similar in magnitude, but not statistically significant ($p = 0.199$). On the other hand, there was no significant difference based on Activities-Specific Balance Confidence Scale scores relative to whether the Berg Balance Scale scores were high or low ($p = 0.78$ and 0.33 , respectively). The secondary analysis using the cutoff score of ≤ 49 for the Activities-Specific Balance Confidence Scale produced similar overall results.

Additionally, a post-hoc regression analysis showed a significant interaction between Berg Balance Scale scores and Activities-Specific Balance Confidence Scale scores on gait speed at 12 months ($p = 0.0002$), but not at two months post-stroke ($p = 0.157$). Specifically, at 12 months, every standard deviation increase in the Activities-Specific Balance Confidence Scale (25.3 points) was associated with 0.04 m/s increase in walking speed for participants with an average Berg Balance Scale score (44 points); however, every standard deviation increase in the Activities-Specific Balance Confidence Scale score was associated with a 0.08 m/s increase in walking speed for participants whose Berg Balance Scale scores were 1 standard deviation higher (55 points). In terms of the effect of Berg Balance Scale scores, the interaction can be interpreted as: every standard deviation increase in Berg Balance Scale (11.1 points) was associated with 0.24 m/s increase in walking speed for participants with average Activities-Specific Balance Confidence Scale score (58 points); compared with every standard deviation increase in Berg Balance Scale associated with 0.28 m/s increase (increased by 0.04 m/s from 0.24 m/s) in walking speed for participants whose Activities-Specific Balance Confidence Scale score are 1 standard deviation higher (83 points). This finding is congruent with the findings of the concordant/discordant analysis.

Discussion

Like studies of older adults,^{12,13} discordance between perceived and measured balance was observed in individuals with stroke. The rate of discordance among our participants with stroke was much higher than the 20% reported for older adults.¹³ The higher rate of discordance may be related to stroke-specific impairments. Following stroke, individuals may be fearful owing to the sudden onset of impairments and therefore not trust their balance abilities. This could lead to a low perceived balance despite high measured balance and cause individuals to limit their engagement in functional activity. Conversely, individuals with stroke may lack insight into their sensory and motor deficits owing to cognitive impairment and have a higher perceived balance than their actual balance ability and be overly ambitious in their activities.

While it is clear that some participants shifted groups between two and 12 months, the mechanisms of those shifts were not investigated for the purpose of this study. For example, we did not assess the extent to which the increased number of individuals in Group 3 (high

Activities-Specific Balance Confidence Scale/high Berg Balance Scale) at 12 months was a result of individuals shifting from concordant Group 1 (low Activities-Specific Balance Confidence Scale/low Berg Balance Scale) or from one or both of the discordant groups. However, both perceived and measured balance increased over time for the cohort. Further research is needed to determine which individuals change groups and their distinguishing characteristics.

From this study, it appears insufficient to measure balance alone without establishing a patient's perceived balance. Participants with low perceived balance but high measured balance, walk significantly slower than those with high perceived and measured balance. Individuals with this type of discordance may not meet their functional potential. Objective balance measures may require supplementation with perception scales to determine if discordance exists. In the event of discordance, education and interventions may be required to address a patient's impaired perception and potentially self-limiting behaviors. A number of studies have investigated treatments for improving balance confidence in the elderly^{20,21} and stroke populations.²² From systematic reviews, circuit training improved balance confidence as well as functional measures following stroke, while exercise and Tai Chi were effective for older adults.^{20–22}

Based on Berg Balance Scale scores, participants in this study were at risk for falls. Contrary to expectations, participants with inflated perceived balance and low measured balance did not fall most often. Rather, higher perceived balance was associated with reduced falls compared with those with low perceived and low measured balance. Therefore, measured balance appears to be more closely associated with fall rate than perceived balance among those with low measured balance. The rate of falls for both groups substantiates the need for diligence in fall education and prevention.

Although the Berg Balance Scale score has been associated with falls in this study, this study may be limited by the scope of the items on the Berg Balance Scale. The Berg Balance Scale lacks tests of the dynamic aspects of mobility related to falls. It primarily tests non-mobility-related tasks and anticipatory postural control. Both anticipatory and reactive balance responses are linked with falls.^{23,24} The neural mechanisms involved with anticipatory postural reactions that require motor planning may differ from reactive postural control and may be affected differently after stroke. The Activities-Specific Balance Confidence Scale, on the contrary, is a self-report scale of perceived balance during function tasks that require both anticipatory and reactive postural control. The two measures may lack congruency. Clinically, both anticipatory and reactive postural control mechanisms may need to be examined and may be more associated with fall risk.

The primary purpose of this article was to determine the existence of discordance between perceived and measured balance. Therefore, this study did not examine the influence of treatment group assignment in the LEAPS trial (early/late body weight supported treadmill training vs. intensive home exercise program) on perceived balance or measured balance. Although this is a potential limitation, the LEAPS study found no significant difference in gait speed between groups at 12 months post-stroke.¹⁴ In relation to falls, the slowest walkers in the early treadmill group had significantly more falls.⁴

In conclusion, discordance exists between balance perception and balance performance in about one-third of individuals in the first year post-stroke, which is a higher rate than in healthy older adults. Objective balance performance tests may be helpful when used in conjunction with perceived balance assessments for individuals with stroke. Perceived balance appears to impact gait speed but not fall incidence.

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Clinical message

- Measured balance differs from perceived balance about one-third of the time following stroke.
- Higher perception of balance is associated with faster gait speed.
- Falls are more closely associated with measured balance than perceived balance.

Figure 1.

Concordance and discordance between perceived balance (ABC) and measured balance (BBS) at two months and 12 months post-stroke. Clockwise, bottom left is the Concordant Group 1, top left is Discordant Group 2, top right is Concordant Group 3 and bottom right Discordant Group 4.

ABC: Activities-Specific Balance Confidence Scale.

Table 1Demographics comparison between the current cohort ($n = 352$) and the entire LEAPS population ($n = 408$).

Variables		All LEAPS participants ($n = 408$)	Having ABC and BBS at 2 & 12 months ($n = 352$)
Male gender – No. (%)		224 (54.9%)	196 (55.7%)
Age at stroke onset – years		62.0 $\pm$ 12.7	61.6 $\pm$ 12.7
Race – No. (%)	Asian	54 (13.2%)	44 (12.5%)
	Black or African-American	90 (22.1%)	79 (22.4%)
	White	236 (57.8%)	203 (57.7%)
	Other	28 (6.9%)	26 (7.4%)
Ethnicity – No. (%)	Hispanic or Latino	63 (15.4%)	55 (15.6%)
	Non-Hispanic or Latino	345 (84.6%)	297 (84.4%)
Stroke characteristics	Time since stroke to randomization – days	63.8 $\pm$ 8.5	63.4 $\pm$ 8.5
	Left hemiparesis – No. (%)	182 (44.6%)	160 (45.5%)
	Right hemiparesis – No. (%)	226 (55.4%)	192 (54.5%)
Stroke type based on CT/MRI – No. (%)	Large vessel	162 (39.7%)	140 (39.8%)
	Lacune	128 (31.4%)	114 (32.4%)
	Hemorrhage	70 (17.2%)	61 (17.3%)
	Undefined	48 (11.8%)	37 (10.5%)
Stroke severity (Modified Rankin Scale) – No. (%)	Rankin 0–1	2 (0.5%)	2 (0.6%)
	Rankin 2	54 (13.2%)	49 (13.9%)
	Rankin 3	172 (42.2%)	153 (43.5%)
	Rankin 4	180 (44.1%)	148 (42.0%)
Comorbidities – No. (%)	Cardiovascular	109 (26.8%)	96 (27.4%)
	Hypertension	331 (81.5%)	283 (80.9%)
	Peripheral vascular disease	37 (9.1%)	30 (8.6%)
	COPD	26 (6.4%)	18 (5.1%)
	Arthritis/other musculoskeletal	146 (36.0%)	120 (34.3%)
	Diabetes	141 (34.7%)	117 (33.4%)
Depression (PHQ-9 $\geq$ 10)		67 (16.4%)	54 (15.3%)
Mini-Mental Status Examination (MMSE, range = 0–30)		25.9 $\pm$ 3.7	25.9 $\pm$ 3.7
Severity according to gait speed	Severe (< 0.4 m/s)	218 (53.4%)	177 (50.3%)
	Moderate (0.4–0.8 m/s)	190 (46.6%)	175 (49.7%)

ABC: Activities-Specific Balance Confidence Scale; BBS: Berg Balance Scale; COPD: ; CT: computed tomography; LEAPS: Locomotor Experience Applied Post-Stroke; MRI: magnetic resonance imaging; PHQ: .

Table 2

Comparing gait speed (m/s) between concordant and discordant individuals at two-month baseline and 12-month follow-up.

	Low BBS (≤ 42)	High BBS (> 42)	<i>p</i> -value
<i>2-month baseline</i>			
High ABC (> 66)	<i>Discordant Group 2</i>	Concordant Group 3	
	0.36 $\pm$ 0.21	0.56 $\pm$ 0.14	<0.0001*
Low ABC (≤ 66)	Concordant Group 1	<i>Discordant Group 4</i>	
	0.27 $\pm$ 0.18	0.53 $\pm$ 0.17	<0.0001*
<i>p</i> -value	0.03*	0.247	
<i>12-month follow-up</i>			
High ABC (> 66)	<i>Discordant Group 2</i>	Concordant Group 3	
	0.45 $\pm$ 0.23	0.84 $\pm$ 0.24	<0.0001*
Low ABC (≤ 66)	Concordant Group 1	<i>Discordant Group 4</i>	
	0.34 $\pm$ 0.22	0.69 $\pm$ 0.25	<0.0001*
<i>p</i> -value	0.056	<0.0001*	

ABC: Activities-Specific Balance Confidence Scale; BBS: Berg Balance Scale.

Table 3

Number and percentage of falls by measured balance (BBS) and perceived balance (ABC) at 12 months.

	Low BBS (≤ 42)	High BBS (>42)	<i>p</i>-value (from chi-square test of equal fall rates)
High ABC (>66)	<i>Discordant (N = 27)</i> <i>Group 2</i> No falls: 10 (37.0%) 1 fall: 8 (29.6%) Multiple: 9 (33.3%)	<i>Concordant (N = 49)</i> <i>Group 3</i> No falls: 28 (57.1%) 1 fall: 12 (24.5%) Multiple: 9 (18.4%)	0.199
Low ABC (≤ 66)	<i>Concordant (N = 177)</i> <i>Group 1</i> No falls: 51 (28.8%) 1 fall: 40 (22.6%) Multiple: 86 (48.6%)	<i>Discordant (N = 99)</i> <i>Group 4</i> No falls: 52 (52.5%) 1 fall: 24 (24.2%) Multiple: 23 (23.3%)	0.0001*
<i>p</i> -value	0.33	0.78	$p < 0.0001$ (overall)

ABC: Activities-Specific Balance Confidence Scale; BBS: Berg Balance Scale.