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ORIGINAL REPORT

BALANCE ABILITY MEASURED WITH THE BERG BALANCE SCALE: A DETERMINANT OF FALL HISTORY IN COMMUNITY-DWELLING ADULTS WITH LEG AMPUTATION

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Objective: **Falls are common among adults with leg amputations and associated with balance confidence. But subjective confidence is not equivalent with physical ability. This multivariate analyses of community-dwelling adults with leg amputations examined relationships among individual characteristics, falls, balance ability and balance confidence.**
Design: **Cross-sectional study.**
Subjects/Patients: **Community-dwelling adults with leg amputations recruited from a support group and prosthetic clinic.**
Methods: **Subjects provided self-reported medical/fall history, prosthetic functional use, and Activities-specific Balance Confidence (ABC) questionnaire data. Balance ability was assessed with the Berg Balance Scale (BBS). Fall incidence was categorized as any fall (one or more) and recurrent falls (more than one). Multivariate logistic regression analyzed relationships within the two fall categories. Cross tabulations and ANOVA analyzed differences among subcategories.**
Results: **Fifty-four subjects (mean age 56.8) with various etiologies, amputation levels, and balance abilities participated. 53.7% had any fall; 25.9% had recurrent falls. Models for both fall categories correctly classified fall history in >70% of subjects with combinations of the variables ABC, BBS, body-mass-index, and amputation level.**
Conclusion: **Falls occurred regardless of clinical characteristics. Total BBS and select item scores were independent determinants of fall history. Unlike other balance-impaired populations, adults with leg amputation and better balance ability had greater odds of falling.**

Key words: amputation; lower limb; balance and falls; balance measurement; prosthesis.

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INTRODUCTION

Falls represent a significant public health risk with approximately 12 million people falling each year (1). With 2.6 million people needing medical attention each year, falls accounted for 20% of the $19 billion total cost of injuries in the United States (1). As the most common cause of injury in older adults (2), falls are particularly common in community-dwelling adults over 60 years old with the annual incidence of having any fall 19–60% per year, the rate of recurrent falls 5–36%, and the occurrence of injurious falls 12–32% (3).

People with leg amputations, the majority of whom are over 65 years (4), have a greater risk of falling than the general public: reported incidences within the community range from 52% (5) to 80% in a study of people over 65 (6). Since falling is such a common experience for people with amputations, it is unsurprising that nearly half of all people with leg amputations report a fear of falling (7). The risk and reality of falling may be affected by decreases in both subjective balance confidence and measurable balance ability.

Balance confidence is typically assessed with a self-report questionnaire such as the 16-item Activities-specific Balance Confidence (ABC) scale that subjectively quantifies patient confidence when performing mobility tasks (8). Community-dwelling individuals with leg amputations average 62.8% on the ABC (7), well below the 80% threshold suggested for healthy elderly functioning (8). Even lower scores have been reported after vascular amputations (9). For people with amputations, the ABC has been associated with functional mobility and social activity (7) as well as a fear of falling (10).

A person's balance confidence, or subjective perception of their ability to balance, is a different though related entity from their objectively measured balance ability; ABC and Berg Balance Scale (BBS) scores demonstrate only fair to strong correlations (11–12). The BBS has been widely accepted as an assessment of balance ability in community-dwelling elderly (13), people with neurologic disorders (14), and increasingly in people with leg amputations (15–17). A Rasch analysis has demonstrated that the BBS is a valid measure of balance ability in a heterogeneous sample of people with unilateral and bilateral leg amputations of mixed etiologies and levels who had a range of balance ability levels, including non-prosthesis and prosthesis users (16).

The BBS has been used to determine the risk of falling with good predictive validity in community-dwelling elderly (18) and people with stroke (19). Since both balance ability and confidence may be related to the occurrence of falls, combining both self-reported ABC and clinician-tested BBS may yield even more information. A retrospective study of elderly community-dwellers, for instance, identified fall history with 89% sensitivity and 96% specificity using a model that combined BBS and ABC scores with reaction time (12). The relationships among BBS, ABC, and falls have not been studied in the population of people with leg amputations.

This cross-sectional study examined the multivariate relationships among balance ability, balance confidence, prosthetic functional use, and other individual characteristics to determine which variables correctly classified people with leg amputations into different categories of fall history. The hypothesis was that performance-based assessment of balance ability measured with the BBS would be a significant independent variable in multivariate models classifying fall history.

METHODS

This study was conducted in accordance with the protocol approved by the Institutional Review Board of the participating university medical center.

Subjects

Subjects were recruited from local support groups and prosthetic clinics by flyer and word of mouth. Inclusion criteria included unilateral or bilateral lower extremity amputation of any level or etiology; whether a prosthesis was used or not. Exclusion criteria included other medical issues that could affect balance including uncontrolled cardiovascular disorders, neurological disorders such as stroke or vestibular dysfunction, blindness, or cognitive disability that prevented understanding of the study. Sample size was determined by consideration of the anticipated number of variables of clinical interest and the guideline that a minimum of 5 subjects per variable entered was sufficient to assure the results were stable and not due to chance (20). An intended sample size of 50 was thus deemed adequate for up to 10 entered variables.

Assessments

Houghton Scale of Prosthetic Functional Use. The Houghton is an ordinal scale with 4 questions quantifying prosthetic functional use including prosthetic use in different environments and the use of a wheelchair and assistive devices (21). The sum score ranges from 0 to 12 with greater scores indicating better function (22) without appreciable floor or ceiling effects (23). Houghton scores demonstrate excellent test–retest reliability (22–23) and moderate convergent validity with performance-based assessments such as the 2-Minute Walk Test (22–23) and self-reports of perceived functional ability such as the Prosthetic Evaluation Questionnaire (22). The Houghton scale has been shown to discriminate between groups (22) and be responsive to change upon discharge from prosthetic rehabilitation (23). Compared to the Prosthetic Evaluation Questionnaire, the Houghton scale has greater reliability and convergent validity with gait performance measures (22).

Activities-specific Balance Confidence Scale. The ABC scale was used to quantify each subject's self-reported balance confidence in performing 16 different activities with the average percent confidence reported; higher percent indicates greater confidence in one's balance (8). Tasks range from simply reaching out for a can at eye level to tasks known to be challenging for people with leg amputations like walking up and down a ramp or on icy sidewalks. The ABC score for self-assessed subjective balance confidence has been associated with prosthetic functional mobility (7), and falls in elderly adults (24) and stroke survivors (25). Reliability (9) and validity of the ABC have been established for people with leg amputations (22) and associations have been noted between ABC and BBS scores (17) and ABC and fall incidence (7).

Berg Balance Scale. The BBS is a performance-based assessment of balance ability (26). The 14 BBS tasks, scored from 0–4 with the total score reported, challenge static and dynamic balance (26), as described for use in people with leg amputations (16). The validity of the BBS as a clinical assessment of the unidimensional construct of balance ability has been established in heterogeneous clinical populations (14, 16) that include people with unilateral and bilateral leg amputations of vascular and non-vascular etiologies at the transfemoral and transtibial levels, whether using a prosthesis or not or demonstrating the highest or lowest balance ability (16). The BBS also has moderate concurrent validity with the ABC and 2-Minute-Walk-Test (17). Intra-rater reliability of the BBS in people with leg amputations has been excellent (17, 27) with inter-rater reliability also excellent among testers of varying levels of clinical experience for individuals with leg amputations of all balance abilities from the highest to the lowest strata (27).

Procedure

After giving informed consent, subjects participated in a single session during which subjects provided information through questionnaires. All subjects self-reported demographic, medical, and clinical information including: age, sex, race, weight, height, alcohol consumption (any or none), comorbidities, amputation etiology, level of amputation, prosthetic functional use (Houghton), balance confidence (ABC), and history of falls in the past 12 months. A fall was defined as any loss of balance event in which the person came to rest on the ground. Self-reported fall history was recorded in a manner consistent with past fall research as no fall, any fall (one or more), and recurrent falls (more than one) (3). Balance ability was clinically assessed by 11 trained clinicians that demonstrated excellent inter-rater reliability in determining BBS for people with lower limb loss (27). Testing was completed in a single bout of less than 15 min in a variety of spaces using consistent equipment.

Statistical analyses overview

Two multivariate logistic regression analyses were conducted to determine which variables best classified subjects using the different history of fall categories: 1) people who had any fall compared to people with no fall and 2) people who had recurrent falls compared to those who had not. For each category, the initial model before reduction included 10 variables: age, years since amputation, amputation etiology, level, unilateral or bilateral amputation status, body mass index (BMI), number of comorbidities, balance ability (BBS), balance confidence (ABC), and prosthetic functional use (Houghton). Variables with missing data for $\geq 10\%$ of subjects (28), such as alcohol consumption, were excluded. Also excluded were variables such as assistive device and wheelchair use that were included within the Houghton scale and could demonstrate collinearity (20, 28).

The initial models were subsequently reduced by deleting variables in a manual backward order common in the development of regression models (28–30). Variables with significance at $p < 0.10$ were preserved; variables with p-values between 0.10 and 0.15 were considered for inclusion to maintain the most authentic confounding variables, if deemed clinically important (28). Because smaller sample sizes can overestimate the strength of regression coefficients, a simple bootstrapping procedure was performed with 95% confidence interval and 1,000 samples per step (30). The bootstrapping procedure reduces the impact of distribution variability, which results in wider confidence intervals and a robust conservative estimate of model strength (28). Model significance level was set at $p < 0.05$ with percent correct classifications reported.

To determine whether individual balance ability tasks were significantly independent variables in models to classify subjects in the two fall categories, we modified an analytic method that replaced the total BBS scores with individual BBS task scores in a multivariate regression model (12). Using this method, one study found that the single item BBS 14 (Standing-on-one-leg) was predictive of falls in an elderly population (12). Individual BBS items were substituted for the total BBS score and logistic regression analysis was performed as before, after excluding balance tasks with insufficient score variability, such as unsupported sitting.

Cross tabulations for variables among the different fall history categories and balance ability strata (16) were analyzed to determine possible associations in the frequency data. Independent *t*-tests and ANOVA with Tukey *post-hoc* tests were used to analyze mean differences in continuous variables between individuals of different fall categories and among balance ability strata with significance level set at $p<0.05$. Correlations between continuous variables were determined by calculating Pearson coefficients.

RESULTS

Descriptive subject information

Sixty subjects were recruited for the study. Fifty-four completed all assessments and were therefore included in the study and data analysis. Six subjects did not complete the study: 5 never attended the assessment session and one had insufficient time available to complete the assessments. The 54 study subjects had a mean age of 56.8 years (standard deviation (SD) 10.9) ranging from 34 to 82 years and represented the multi-ethnic population of the community (Table I). Most had lost legs due to vascular etiologies, had unilateral amputations, and were able to use their prosthesis at the assessment session. Mean time since amputation was 5.9 years (SD 9.9) ranging from <1 to 47 years. Subjects were categorized by fall incidence within the past year and by balance ability strata (Table I). Of the 54 subjects, 53.7% had experienced any fall and 25.9% had recurrent falls. When categorized by balance ability strata (16), 31.5% scored in the lowest stratum (I), 27.8% in stratum II, and 16.7% and 24.1% in the two highest ability strata (III–IV), respectively.

Table I. *Subject demographic and clinical characteristics (*n = 54*)*

Subject descriptor	*n* (%)[a]
Gender	
Women	18 (33.3)
Men	36 (66.7)
Race	
White	16 (29.6)
Hispanic Non-White	19 (35.2)
African American	15 (27.8)
Asian American	1 (1.9)
Native American	1 (1.9)
Other	2 (3.7)
Etiology	
Peripheral vascular disease and diabetes	22 (40.7)
Peripheral vascular disease	18 (33.3)
Trauma	6 (11.1)
Other medical diagnoses	8 (14.8)
Amputation levels	
Unilateral	48 (88.9)
Transtibial	29
Transfemoral	18
Ankle disarticulation	1
Bilateral	6 (11.1)
Transtibial	3
Transtibial-transfemoral	2
Transfemoral	1
Prosthesis	
Users	46 (85.2)
Non-user	8 (14.8)
Fall categories	
Fallers	29 (53.7)
Single fallers	15
Recurrent fallers	14
Non-fallers	25 (46.3)
Injuries	
Injury requiring medical care	2 (3.7)
No injury	52 (96.3)
Balance ability strata: Berg Balance Scale (BBS) score range[16]	17 (31.5)
Stratum I (BBS 0–33)	15 (27.7)
Stratum II (BBS 34–49)	9 (16.7)
Stratum III (BBS 50–53)	13 (24.1)
Stratum IV (BBS 54–56)	

[a]Percentages do not always add up to 100 due to rounding.

Logistic regression analyses

Separate final models were obtained for two different fall history categories: any fall, and recurrent falls. After controlling for the initial 10 variables, the final regression models included 3 or fewer variables (Table II).

Any fall: The final model to differentiate between those who had any fall compared to no fall at all included 3 variables (BMI, BBS, and ABC). The model correctly classified 72.5% ($p=0.02$) of the 51 subjects (3 had missing BMI data). Only total BBS score was a significant independent variable within the model. Subjects with better balance ability had higher odds of falling, such that for each unit increase in BBS the subject had 5.0% greater odds of having had any fall. Though neither variable reached the significance level, people with higher balance confidence (ABC) had lower odds of falling and people with higher BMI had greater odds of falling; such that a single point increase in ABC translated to a 2.3% reduction in the odds of having any fall and a single unit BMI increase corresponded to 11.8% higher odds of falling. (See Table II)

When individual BBS items replaced the total BBS score, 72.5% of subjects were also correctly classified ($p=0.003$) as having any or no fall by the 3-variable model which included

Table II. *Predictive models for classifying people who had past falls*

	Odds ratio (95% CI)	SE	*p*
*Any fall (*n = 51*)*[a]			
Body mass index	1.118 (1.009–1.238)	0.092	0.065
Berg Balance Scale	1.050 (0.991–1.113)	0.026	0.013
Activities-specific Balance Confidence	0.977 (0.949–1.007)	0.017	0.105
*Recurrent falls (*n = 54*)*			
Berg Balance Scale	1.079 (1.011–1.151)	0.035	0.003
Amputation level	3.808 (0.957–15.146)	0.901	0.060

[a]BMI data missing in 3 subjects. CI: confidence interval.

Table III. *Predictive models including specific Berg Balance Scale (BBS) items for classifying people who had past falls*

	Odds ratio (95% CI)	SE	*p*
Any fall (n = 51)[a]			
BBS 10: Look behind over shoulder	2.980 (1.198–7.414)	2.836	0.007
BBS 11: Turning-360°	0.436 (0.192–0.991)	2.556	0.023
Body Mass Index	1.126 (1.016–1.247)	0.088	0.032
Recurrent falls (n = 54)			
BBS 10: Look behind over shoulder	32.613 (2.600–409.124)	19.708	0.005
BBS 11: Turning-360°	0.212 (0.073–0.613)	8.558	0.001
Amputation etiology	0.225 (0.038–1.333)	7.635	0.051

[a]BMI data missing in 3 subjects.
CI: confidence interval.

as significant independent variables: BMI, BBS 10 (Looking-behind-over-shoulder), and BBS 11 (Turning-360°) (Table III).

Recurrent falls: The final 2-variable model to differentiate between subjects who had experienced recurrent falls and those who had not (see Table II) included amputation level and total BBS score and classified 74.1% of the 54 subjects correctly ($p < 0.01$). Subjects with better balance ability were more likely to have recurrent falls such that for each unit increase in BBS the subject had 7.9% greater odds of having had recurrent falls. While people with transfemoral amputation levels were 3.8 times more likely to have recurrent falls, this did not reach significance ($p = 0.06$). When individual BBS items replaced the total BBS score, the resulting 3-variable model including BBS 10, BBS 11, and amputation etiology classified 81.5% of the cases correctly as having had recurrent falls or not ($p = 0.001$) (Table III). Subjects with better ability on BBS 10 had 32 times greater odds of having recurrent falls for each unit score increase.

Analyses of fall categories and balance strata

Comparing categorical and continuous variables within the two fall categories revealed few significant bivariate differences. There were no differences in amputation etiology and level; number of amputations (unilateral or bilateral); prosthesis, wheelchair, or walking device use for either people who reported any fall compared to no fall or people who reported recurrent falls compared to those that did not. People who reported any fall had significantly greater BMI (29.9 (SD 6.8)) compared to those who had no fall (25.2 (SD 5.9)). People who had recurrent falls had higher mean total BBS scores of 48.4 (SD 5.9) compared to those who had not (BBS 36.3 (SD 16.6)). There was no other significant difference in the continuous variables within the two fall categories.

Cross tabulations of categorical variables across balance ability strata (I–IV) suggested possible patterns among balance ability strata for recurrent falls, vascular etiology, bilateral amputation status, prosthesis, and wheelchair use. As shown in Table IV, none of the 17 subjects in the lowest balance ability stratum (I) had recurrent falls. Moreover, all subjects with bilateral amputations and all but one prosthesis non-user were in stratum I (Table IV); 86% of subjects with non-vascular etiologies were in the highest two balance strata (III–IV) whereas 75% of subjects with vascular etiology were in the lowest two strata. All wheelchair users were in the lowest two balance ability strata (Table IV). No non-prosthesis user or person with bilateral amputations experienced recurrent falls (Table V).

When comparing means across balance ability strata, there were significant differences in years since amputation,

Table IV. *Frequency distribution and differences for selected variables among subjects of different balance ability strata (16)*

Balance Ability Strata (BBS sum score range)	I (1–33)	II (34–49)	III (50–53)	IV (54–56)
Fall categories, *n*				
No fall	9	5	5	6
Any fall	8	10	4	7
Recurrent falls	0	7	3	4
Etiology, *n*				
Vascular	16	14	6	4
Non-vascular	1	1	3	9
Side, *n*				
Bilateral	6	0	0	0
Unilateral	11	15	9	13
Prosthesis, *n*				
Yes	10	14	9	13
No	7	1	0	0
Wheelchair use, *n*				
Yes	13	7	0	0
No	4	8	9	13
Years since amputation, *n*	3.9[a]	2.6[a]	3.1[a]	14.2[a]
Houghton scale score	1.9[b,c]	6.5[b,c]	9.9[b]	10[b]
Activities-specific Balance Confidence, %	42[b,c]	54[b,c]	89[b]	86[b]

[a]strata I–III significantly different than stratum IV ($p < 0.05$).
[b]strata I–II significantly different than strata III–IV ($p < 0.05$).
[c]stratum I significantly different than stratum II ($p < 0.05$).

Table V. *Differences for selected variables among subjects with different fall histories*

Fall history	No fall	Any fall or falls	Recurrent falls[a]
Etiology, *n*			
Vascular	18	22	8
Non-vascular	7	7	6
Side, *n*			
Bilateral	4	2	0
Unilateral	21	27	14
Prosthesis, *n*			
Yes	19	27	14
No	6	2	0
Wheelchair use, *n*			
Yes	8	12	4
No	17	17	10
Demographics, mean (SD)			
Age, years	57.7 (12.5)	56.0 (9.4)	54.1 (8.5)
Years since amputation	6.8 (10.3)	5.1 (9.6)	5.5 (12.4)
Houghton scale score	6.6 (4.8)	6.4 (4.0)	7.6 (3.1)
Activities-specific Balance Confidence, %	66.6 (30.5)	61.2 (26.7)	73.7 (19.5)

[a]Recurrent falls is a subset of the Any Falls category.
SD: standard deviation.

Houghton and ABC scores. Tukey *post-hoc* test indicated that subjects in the highest ability stratum (IV) had lost their limbs > 10 years earlier than those in all other balance ability strata. Subjects in the higher two strata had higher Houghton and ABC mean scores compared to subjects in the lower two strata (Table IV).

DISCUSSION

This study of community-dwelling people with leg amputations examined the relationship among balance ability (BBS), balance confidence (ABC), prosthetic functional use (Houghton), individual characteristics, and the history of falls. The study hypothesis that performance-based assessment of balance ability would be a significant independent variable in multivariate models classifying fall incidents was confirmed. Balance ability measured with the BBS was the only significant independent variable in the logistic regression models for both fall categories: any fall and recurrent falls. To our knowledge, this is the first study to combine physical balance ability and subjective self-reported balance confidence in multivariate analysis to analyze factors related to falls in a heterogeneous sample of people with leg amputations. Study results demonstrate that unlike other balance-impaired populations like the elderly or stroke survivors, people with leg amputations who have better balance have a higher incidence of falls. While the cross-sectional study design precluded causal inference and the small sample limited the scope of the conclusions without prospective validation, the study findings may be used to identify and educate people at risk for falls.

Multivariate analysis was critical to understand the complex population of people with leg amputation that includes young athletes after traumatic amputation and elderly adults battling vascular disease, but also high functioning older people with traumatic amputations from long ago and low functioning younger people with diabetes and recent vascular amputations. The study sample subject characteristics were similar to other samples reported in the literature with respect to sex and age (4, 7, 31), race (32), vascular amputation etiology (4, 32), amputation level (33), percent using prostheses (34), and incidence of past falls (7). Subjects in this study included people with both high and low levels of balance ability, balance confidence, and prosthetic functional use. In the past 12 months, 53.7% had fallen, similar to a larger sample of people with lower limb amputations that reported 52.4% incidence of falls (7). Potential links have been suggested in past research between falls and vascular amputation etiologies (35), unilateral amputations (36), amputation level (6, 37), age (6), and balance confidence (5). However, past studies have relied upon bivariate analysis (6, 36, 37) or employed multivariate analysis without accounting for objective physical performance (5, 35). This study included a performance-based measure of balance ability in combination with the other variables. When balance ability was included while controlling for age, BMI, number of medical co-morbidities, years since amputation, amputation etiology and level, number of limbs amputated, prosthetic functional use, and balance confidence, many variables were no longer significant. Performance ability was more important than a person's descriptive characteristics.

While balance ability, balance confidence, BMI, and amputation level were retained in the multivariate models to differentiate subjects based on fall history, only BBS was a significant independent variable in both models. Greater balance ability increased the odds of having any fall and recurrent falls, although the odds were not increased by more than 10% in either model (Table III). Two individual BBS tasks remained significantly independent variables in both models: BBS 10 (Looking-behind-over-shoulder) and BBS 11 (Turning-360º). In both models (see Table III), the odds ratios for BBS 10 and BBS 11 had consistently opposing directions, suggesting that greater ability on the average-difficulty BBS 10 task (16) made a fall more likely; while greater ability on the higher-difficult BBS 11 task (16, 39) made a fall less likely.

While the study results showed that falls occurred regardless of balance ability (Table IV), analysis of the balance ability strata revealed two distinct pictures:

1) For people with leg amputations, higher balance ability actually increased the odds of having experienced a fall. This finding stands in contrast to other balance-impaired populations such as elderly community dwellers (18) and stroke survivors (40) for whom lower balance ability has increased the odds of falling; but is congruent with a sample of people with leg amputations who scored 53.9 on the BBS but averaged over 5 falls in the past 12 months (37). Subjects with leg amputations in the highest balance ability stratum (IV) were more likely to have non-vascular amputations and had over 11 years more experience as an amputee than the others (Table IV). Subjects with BBS sum scores ≥ 50 (strata (III–IV) rated their confidence higher on the ABC by 32–46 points and reported higher prosthetic functional use on the Houghton scale by 4.6–8.0 points compared to subjects in the lower strata (I–II). Having recurrent falls was associated with better balance ability: subjects with the lowest ability did not have recurrent falls (Table IV). That subjects with better balance ability were also more likely to have falls parallels past research in people with leg amputations that found those with unilateral amputations were more likely to fall than those with bilateral amputations (36). Informal discussion with subjects in the support groups revealed that those with better balance did feel more confident to participate in activities that may pose greater fall risks such as walking outdoors, even if they had fallen before. Those with the poorest balance ability reported avoiding potential risk exposure by accessing their environment by wheelchair and participating in fewer activities.
2) Conversely, although roughly half the subjects in the lowest balance ability stratum fell once, none had recurrent falls. This was the case even though ability stratum I subjects were arguably more impaired: with more bilateral amputations, non-prosthesis users, and wheelchair users (see Table IV). In fact, no non-prosthesis user or person with bilateral amputations fell twice (Table V). Some subjects reported relatively

high balance confidence regardless of low clinically tested balance ability, a mismatch that can lead to unnecessary risk taking. The results suggested that subjects with low balance ability may have had insufficient confidence and inadequate functional ability to use their prosthesis in more challenging community-based activities, and thus limited or modified their activities to reduce their risk of recurrent falls.

The BBS provides valuable performance-based clinical information distinct from self-reported subjective perceptions of capability. As found in another study that examined balance ability and confidence in people with leg amputation (17), this study found that balance confidence was moderately correlated ($r=0.66$) but not equivalent with balance ability. While convenient for the clinician, self-reports may not tell the whole story. Combining BBS and ABC may help identify people at risk of falls more than a self-report or clinical test alone (12). As a potential screening tool, however, the BBS can be time-consuming for the busy clinician to set-up and complete due to subject performance variations. The results of this study suggest that a small subset of individual BBS tasks that can be conducted in a small examination room without specific equipment (looking-behind-over-shoulder and turning-360º) may help screen people with leg amputations to determine their risk of falling. Such a screening method could assist the clinician decide whether the patient would benefit from preventative education or additional care.

One limitations of this study's cross sectional design is that no causal inference is possible. Future prospective research is required to determine the accuracy of these multivariate models to predict fall events. More frequent data collection points could reduce the possibility of recall bias in remembering how long ago a fall occurred, and specific information about the circumstances surrounding each fall may provide meaningful qualitative understanding. The small sample size was certainly a limitation of this study. While the sample size was sufficient for statistical modeling, the small sample led to more stringent selection of variables entered into the multivariable regression analysis than would have been necessary with a larger sample. Another limitation related to sample size was the inclusion of mixed sub-groups of people with amputation including different etiologies, amputation levels, numbers of amputations, and different genders and age groups. Results from subgroup analyses must be interpreted with caution due to the small samples within different balance strata that leave multiple cells with fewer than 5 subjects. Future research could document and explore confounding by physical activity level, which was not included in the self-report questionnaire, nor were specific medical data such as visual acuity and medications. Finally, it is noted that subject data lacked screening for medications and analysis included only dichotomous fall classifications.

In conclusion, people with leg amputations were found to have experienced falls regardless of amputation etiology, levels, prosthetic functional use, balance confidence and balance ability. Unlike other balance-impaired populations such as elderly community-dwellers or stroke survivors, people with leg amputations who have better balance ability had greater odds of falling, while those with lower ability had fewer falls. Balance ability, whether assessed with the total BBS score or with a subset of the balance tasks, was the most important determinant in identifying people with a history of falls.

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