A prospective study examining balance confidence among individuals with lower limb amputation

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A prospective study examining balance confidence among individuals with lower limb amputation

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Abstract

Purpose: In this study we assessed whether balance confidence scores changed over a 2-year follow up period, and identified predictors of balance confidence and predictors of change in balance confidence among lower limb amputees.

Method: A prospective follow-up survey of 245 community living adults with unilateral below and above knee lower limb amputation who used their prosthetic limb daily was conducted. Balance confidence, assessed using the 16-item Activity-specific Balance Confidence (ABC) Scale, socio-demographic, health and amputation related variables were collected at baseline and 2 years later.

Results: ABC scores were similar at baseline (mean = 67.6; SD = 25.7) and follow up (mean = 68.0; SD = 25.8). Lower balance confidence scores at follow up were predicted by older age, being female, use of a mobility device, poor perceived health, increased symptoms of depression, having to concentrate while walking, and fear of falling (all p < 0.05). Predictors of change in balance confidence included gender and perceived health (all p < 0.05).

Conclusion: Balance confidence appears to be a persistent problem in the amputee population. Health professionals are encouraged to consider balance confidence as a potentially important variable that may influence function in this clinically unique group of individuals. The identified predictor variables may be useful to clinicians in targeting individuals who require attention to improve balance confidence.

Introduction

Belief does not guarantee success, however, it can contribute to performance. Bandura suggested that self-efficacy or confidence is a better predictor of engagement in activity than skill or ability. This suggests that successful rehabilitation of an acute or chronic impairment extends beyond the acquisition of endurance, strength, range of motion, or learning about a new strategy.

A major frustration experienced by therapists who work with individuals who are learning to use a prosthetic leg after amputation is that many patients do not achieve their potential. Failure to achieve occurs despite the technological advances in the fabrication of ultra light, durable and microchip ‘smart’ prosthetic limbs designed to improve the efficiency and quality of gait. Given the cost, estimated to be $56K US2 from time of amputation to one-year post rehabilitation, careful consideration must be given not only in determining the most appropriate candidates for prosthetic rehabilitation but also in deciding who may require additional intervention to facilitate success. Taking into consideration that there are 40–50 000 major lower limb amputations (at the ankle or higher) in the US3 and 2200–2500 in Canada4 who go on to receive prosthetic rehabilitation each year, the economic cost can be considerable.

A number of studies have attempted to identify indicators of successful prosthetic outcome in the lower limb amputation population. Most of the indicators studied to date have focused on obvious factors such as age, co-morbidity, cause and level of amputation. A common observation made at our outpatient clinic was that many patients appeared to be afraid of losing their balance. Reduced balance confidence when performing activities is a modifiable factor that can and should be addressed by rehabilitation professionals.5
A reduction in balance confidence among individuals with a lower limb amputation seems logical given the gait related impairments, such as an altered gait pattern associated with the use of prostheses, the loss of sensory feedback (proprioception), and altered postural sway. Moreover, because most incident cases are most often older adults with multiple comorbidities, the loss of a lower limb adds an additional challenge beyond other demands. It should not be surprising then, that 52% of a sample of people with unilateral above (AK) and below knee (BK) amputations reported that they experienced at least one fall in a year. This exceeds the annual incidence rate of falls (30%) among community living elderly. Falls are associated with functional disability and are indicative of declines in independence, decreased mobility and self-imposed restrictions in activity. Aside from the potential for physical injury associated with falling psychological sequelae can be expected.

The prevalence of reduced balance confidence among people with lower-limb amputations appears to be very high. In fact, 65% of a sample of individuals with lower limb amputation reported having balance confidence levels considered low enough that they would benefit from intervention. One potential outcome of diminished confidence is activity restriction and in fact up to 76% of those individuals with lower limb amputation reported that they avoided many activities as a result of loss of confidence. Ultimately self-imposed restriction can lead to deterioration in balance, muscle endurance, strength, flexibility and coordination and therefore, a debilitating cycle, including further reduction in balance confidence, may exist.

Research to date has provided cross-sectional evidence of the level of confidence among lower limb amputees. The present study builds on this early work by presenting the results of a 2-year follow up study. The specific study objectives were to: (1) determine if balance confidence scores change significantly over a two year period of time in a cohort of persons with lower limb amputation; (2) determine the longitudinal predictors of balance confidence; and (3) examine predictors of change in balance confidence between baseline and follow up.

Method

DESIGN

The design used was a prospective correlational study using a postal survey to collect data at two time points 2 years apart.

SAMPLE

The sample consisted of community living individuals who had a unilateral lower limb amputation, either below (BK) or above knee (AK). Individuals with a Symes amputation (n = 15) were included in the BK group, while those with a through knee amputation (n = 11) were classified as AK amputees. To ensure that subjects had the opportunity to become accustomed to using their prosthesis, only those who had been ambulating using their prosthesis for a minimum of 6 months prior to the first wave of data collection and were wearing their prosthesis on a daily basis were included. Individuals who had a bilateral amputation were excluded from the sample.

A convenience sample consisting of all subjects who responded to our first survey was recruited. These individuals were originally drawn from a University associated regional amputee clinic located in South Western Ontario. This clinic provides follow up visits at 3, 6 and 12 months the first year post discharge from prosthetic rehabilitation and a minimum of once a year after that. The sampling frame potentially consisted of every patient seen at the clinic, which serves the South Western Ontario Region in Canada.

PROCEDURE

Demographic and amputation specific variables were collected from the subject’s chart and linked with survey data. Chart review variables included, sex, age, amputation date, level (AK or BK), and cause (vascular disease or traumatic). The remainder of the variables were collected using a mailed survey that was designed and implemented using techniques recommended by Dillman. All survey questions were taken from published studies. Baseline data were collected between September and December of 1997 and follow up data were collected between January and March of 2000. The study was approved by the University of Western Ontario Human Ethics Board.

MEASURES

Socio-demographic factors

Age, sex, marital status, social support, education level employment and income status were collected. Marital status included individuals who were living common law. Employment status included those respondents who were working full or part time at the time of the survey. Social Support was measured using a six-item version of the Interpersonal Support Evaluation List
The ISEL taps four dimensions of support including tangible, belonging, self-esteem, and appraisal. Scores from the 4-point likert scale are summed with higher scores indicating greater source of support.

Amputation related factors

The time since amputation in years was determined based on the most recent major surgery indicated in the chart. For those cases where a revision of a previous amputation was performed (e.g., from BK to AK), the date of the revision was considered the amputation date. Amputation cause was determined from patient notes in the chart. Mobility device use was assessed using a checklist of the assistive devices, such as, canes, crutches, walker or wheelchair, the individual most commonly used. The ability to walk automatically which asks if a subject is required to concentrate on each step or not, was taken from the Prosthetic Profile of the Amputee.19

Health related factors

A profile of physical health was measured using a variety of variables. Perceived health status was assessed by having respondents rate their health on a five point likert scale ranging from ‘poor’ to ‘excellent’ health. A count of comorbidity was derived using a list of 19 common health ailments. Respondents were asked to indicate whether they had been told by a doctor that they had such disorders as heart disease, diabetes or stroke. Information on medication use was collected by asking respondents to indicate if they were taking prescribed medications for any of the comorbidity conditions they had. Joint pain was determined by asking if pain was experienced in their joints such as their wrists or hips. Fall history and injury over the past 12 months was determined by asking if the respondent had fallen, and if so had they seriously injured themselves after the fall. Disability status was established by identifying limitations related to 11 activities of daily living recorded using the Postal Barthel Index.20 Two prosthetically oriented items regarding independence with donning and doffing the prosthesis were added to the Barthel Index. Problems with the non-amputated leg were operationalized using a list of items about sensation, ulcers, pain and swelling in the non-amputated limb.19

The level of depressive symptomatology was measured using the Centre for Epidemiologic Studies Depression (CESD) scale.21 Responses on four-point likert scales are summed across 20 items yielding an index ranging from 0 to 60 with higher scores indicating a greater level of distress. Items tapping adaptation to amputation and adaptation to the prosthesis were taken from the Prosthetic Profile of Amputees.19 A five point likert scale anchored at each end by ‘not at all adapted’ to ‘completely adapted’ is used to indicate the degree of adaptation. For the purposes of the study responses were collapsed into a binary score representing adapted or not adapted. Finally, fear of falling, a related but conceptually unique variable, was assessed with a global question that asked subjects to indicate (yes or no) whether they had a fear of falling.

Balance confidence

The 16 item Activities-specific Balance Confidence (ABC) Scale22 was used to determine balance confidence. Individuals were asked to rate their level of confidence on a scale between 0 (no confidence) and 100% (total confidence) when performing a variety of specific activities, such as climbing stairs, reaching above the head, and walking on different surfaces. A total score is derived by summing the items and dividing by 16 with higher scores representing more confidence with balance. The ABC has been found to be reliable and support for validity has been reported for a number of populations including individuals with lower extremity amputation.23

Data analysis

Statistical analyses for the study included the calculation of percentages for descriptive purposes of all variables, the use of Pearson’s Product Moment Correlation Coefficient to assess the relationship and the paired t-test to determine the difference between the ABC scores at baseline and follow up. Multiple variable linear regression was used to examine which of the independent variables measured at baseline predicted ABC scores at follow up and change in ABC score between baseline and follow up. We included baseline ABC scores in the later model to control dependence in the change score regression. The forward elimination regression procedure was used to assess multivariable relationships. Highly skewed continuous variables (years since amputation, comorbidity, number of medications and problems with the good leg) were dichotomized to comply with the normalcy assumption necessary for parametric statistics. The perceived health variable was also dichotomized into ‘good’ or ‘better’ versus ‘fair’ to ‘poor’ categories to simplify analyses.
Fear of falling, measured at baseline, was introduced into both regression equations after regressing the dependent variables on all of the other predictors to determine if any additional variance in the balance confidence variable was explained by this variable. Balance confidence scores recorded at baseline were included in the regression equation assessing which variables predicted change in balance confidence in order to control for dependence between the independent and dependent variables. The conventional standard of \( p < 0.05 \) was used to determine statistical significance. All analyses were conducted using SPSS for Windows version 11.5.

**Results**

A total of 365 surveys were mailed to responders of the first survey from whom we received 245 valid responses. Non-responders consisted of individuals who: died \( (n = 32) \); were not using their prosthesis on a daily basis \( (n = 6) \); sent the questionnaire back uncompleted \( (n = 8) \); received an amputation to their other leg \( (n = 9) \); changed address but not provided notice to the clinic \( (n = 25) \). The reasons for the non-response for the 40 other subjects are not known. Our response rate was 80% after eliminating individuals who did not fit our inclusion criteria.

The primarily male (74%) sample had a mean age of 60.5 years \( (SD = 15.3) \). The mean time since amputation was 17.2 years \( (SD = 15.6) \) with the majority having a below knee amputation (68%) for reasons related to traumatic etiology (56%). While 45% of the sample had a grade 12 or higher education, 31% had at least some high school. Sixty-three percent of the sample was married while only 30% were working.

Descriptively the mean ABC summary scores representing balance confidence score were 67.6 \( (SD = 25.7) \) at baseline and 68.0 \( (SD = 25.8) \) at follow up. Scores ranged from 5–100% with approximately 60% of sample scoring less than 80 (table 1).

### Table 1

<table>
<thead>
<tr>
<th>Proportion Scoring</th>
<th>Mean</th>
<th>SD</th>
<th>( \geq 80 )</th>
<th>( 51–79 )</th>
<th>&lt; 51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline ABC</td>
<td>67.6</td>
<td>25.7</td>
<td>39.2</td>
<td>35.9</td>
<td>24.9</td>
</tr>
<tr>
<td>Follow Up ABC</td>
<td>68.0</td>
<td>25.8</td>
<td>42.0</td>
<td>32.7</td>
<td>25.3</td>
</tr>
</tbody>
</table>

### Table 2

Regression of balance confidence at follow up

<table>
<thead>
<tr>
<th>Factor</th>
<th>( \beta )</th>
<th>( b )</th>
<th>SE</th>
<th>p value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility Device Use</td>
<td>-0.300</td>
<td>-16.18</td>
<td>2.804</td>
<td>0.000</td>
<td>-21.704, -10.655</td>
</tr>
<tr>
<td>Automatic Walking</td>
<td>-0.180</td>
<td>-10.06</td>
<td>2.57</td>
<td>0.016</td>
<td>-14.975, -5.103</td>
</tr>
<tr>
<td>Age</td>
<td>-0.199</td>
<td>-0.317</td>
<td>0.083</td>
<td>0.000</td>
<td>-0.500, -0.173</td>
</tr>
<tr>
<td>Depressive Symptoms</td>
<td>-0.145</td>
<td>-0.515</td>
<td>0.172</td>
<td>0.003</td>
<td>-0.855, -0.176</td>
</tr>
<tr>
<td>Gender</td>
<td>0.148</td>
<td>8.22</td>
<td>2.73</td>
<td>0.002</td>
<td>3.327, 14.117</td>
</tr>
<tr>
<td>Perceived Health</td>
<td>0.120</td>
<td>7.28</td>
<td>2.94</td>
<td>0.013</td>
<td>1.480, 13.087</td>
</tr>
<tr>
<td>Fear of Falling</td>
<td>-0.192</td>
<td>-9.905</td>
<td>2.52</td>
<td>0.000</td>
<td>-14.881, -4.492</td>
</tr>
</tbody>
</table>

\( \beta = \) standardized regression coefficient; \( b = \) unstandardized regression coefficient; SE = Standard Error, CI = Confidence Interval.

**DIFFERENCE BETWEEN BASELINE AND FOLLOW UP BALANCE CONFIDENCE SCORES**

The difference between the ABC summary scores at baseline and follow up was not statistically significant \( t (244) = -0.418, \ p = 0.68, \ CI = -2.65, 1.73 \) although some individuals had considerable change in their scores. Overall the distribution of the residuals of the difference between baseline and follow up was normal, however 17 individuals were more than 2 SD away from zero suggesting individual variation in the scores. An approximately equal number of these individuals reported a better \( (n = 7) \) versus a worse \( (n = 10) \) score.

The most variation was observed in items E (reaching up high while standing on toes) and F (standing on a chair to reach) of the ABC. Finally, a positive linear correlation \( (r = 0.77) \) with 59% of the variation in follow up ABC score accounted by the baseline score.

**PREDICTING BALANCE CONFIDENCE**

Table 2 summarizes the results of regressing balance confidence on the baseline predictor variables. A total of seven predictors were included in the parsimonious model which accounted for 53% \( (R^2 = 0.523) \) of the variance in balance confidence. In brief, being younger, male, having good perceived health, being able to ambulate without thinking (automatic walking) and without the use of a mobility device and having fewer symptoms of depression were all independently related to having higher balance confidence. Fear of falling also provided a significant contribution to predicting balance confidence.
a significant contribution to the final model after all the other variables were permitted to enter. The strongest predictors, as indicated by the larger standardized coefficients, was mobility device use, followed by age, and fear of falling.

**PREDICTING CHANGE IN BALANCE CONFIDENCE**

Change in balance confidence between baseline and follow up was predicted by one variable after controlling for baseline ABC score (table 3). Specifically, over the time of the study we saw an improvement in scores among women. A second variable, perceived health, was included in the table because it was on very close to being significant ($p = 0.05$). In general, people reporting better health had a positive change in balance confidence. These variables explained 15% of the variance.

**Discussion**

The results of this longitudinal study confirm the findings of our earlier cross-sectional research which indicate that individuals with a lower limb amputation have a reduced level of balance confidence. The mean level of balance confidence at baseline and follow up was remarkably similar and did not vary statistically over the 2-year study period suggesting the level of balance confidence was stable in this population. The variation in the 17 respondents who had scores of greater than two standard deviations different between the two time periods may be attributable to regression towards the mean or individual change over time. Given the high test retest reliability of the tool (ICC = 0.91) and the natural tendency towards decline in physical ability associated with aging we are inclined to believe the latter explanation. In fact, we were somewhat surprised not to have observed a greater degree of decline in scores. The loss of a sizeable portion of the sample between time points may provide at least a partial explanation.

The mean ABC score was well below the cut point (ABC score < 80) that Myers and colleagues suggest is indicative of need for intervention. In fact a full 25% of our sample reported confidence scores of less than 50, which has been equated to a low level of physical functioning among older adults. The importance of a low level of balance confidence has been shown to be associated with a decrease in perceived prosthetic capability (what people can do), prosthetic performance (what people do) and social importance. However, to date, these associations have only been assessed cross-sectionally and no prospective evidence of a cause and effect relationship exists therefore further research investigating such relationships is necessary.

The longitudinal regression model predicting balance confidence in this study was very similar to the findings of our previous cross-sectional study. Primary differences were the absence of ADL status and amputation cause in the results of the present study. We anticipated that having a vascular amputation would be strongly related to lower balance confidence scores at follow up because individuals who have an amputation for these reasons tend to be older, have a greater number of comorbidities and generally take more medications. Further, studies have suggested that individuals who have had vascular related amputations tend to have greater difficulty with balance performance and postural sway. Amputation cause, however, was not a strong covariate in the present study and it seems that the other variables, such as age and mobility device use, that were included in the final regression model simply accounted for any variance attributable to amputation cause.

Interestingly, in the present longitudinal study we accounted for 13% less variation in balance confidence than was explained in the original cross-sectional study. The reason for this finding is not clear to us especially since so many of the predictor variables were similar in both studies and there was minimal group difference in baseline and follow up balance confidence scores.

In the original study we included amputation level in the model. Doing so in the present study provided little additional explanatory power and it was not statistically significant and therefore it was eliminated from the parsimonious model presented in table 2. Discovering that the level of amputation was not important puzzles us. Clinically it seems logical that individuals with an AK amputation who have lost both their ankle and knee

### Table 3: Regression of change in balance confidence

<table>
<thead>
<tr>
<th>Factor</th>
<th>$\beta$</th>
<th>SE</th>
<th>p value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC (Baseline)</td>
<td>-0.483</td>
<td>0.331</td>
<td>0.000</td>
<td>0.228, 0.434</td>
</tr>
<tr>
<td>Sex</td>
<td>0.146</td>
<td>0.331</td>
<td>0.023</td>
<td>0.747, 9.772</td>
</tr>
<tr>
<td>Perceived Health</td>
<td>0.128</td>
<td>2.401</td>
<td>0.050</td>
<td>-0.024, 9.437</td>
</tr>
</tbody>
</table>

$\beta$ = standardized regression coefficient; $b$ = unstandardized regression coefficient; SE = Standard Error, CI = Confidence Interval.
joints may experience a reduced sense of confidence in their balance. It seems likely that after considering mobility device use and automatic walking (concentrating on stepping while walking) amputation level simply had no remaining explanatory power.

Finally, fear of falling explained an additional 3% of the variance in balance confidence after controlling for all of the other variables considered in this study. This was not totally unexpected given the similarity between these two constructs. In fact, measures of balance confidence such as the ABC were created to provide a more refined measurement of fear of falling principally by increasing the responsiveness of the data captured and reducing the stigma that may be perceived when one admits a fear of something. Keeping this in mind, the presence of fear of falling, and its strong association with balance confidence suggests that simply asking whether an individual has a fear of falling would provide a clinician with one quick indicator of whether a patient was experiencing reduced balance confidence or not.

The regression models derived in this study provide us with clinically useful information. The predictors identified suggest those variables that should be considered to red flag or identify those individuals who are more likely to have either high or low levels and therefore require additional treatment. As an example individuals who are older, have greater symptoms of depression and/or use a mobility device are more likely to have reduced balance confidence. Further, we now know that men and individuals who report a poor level of perceived health are more likely to experience a change towards lower balance confidence scores over time if treatment is not provided to address the issue.

Balance confidence is an important health problem that is beginning to receive attention from health professionals and researchers because the associated reduction in function is potentially preventable or modifiable. Preliminary work has begun to suggest the effectiveness of a wide variety of interventions ranging from education, activity and gait training to address reduced levels of balance confidence among other populations. Development of intervention programmes and research assessing the efficacy and effectiveness of these interventions among individuals with lower limb amputation is essential for ensuring complete rehabilitation for individuals who use prosthetic limbs.

In this study we provided prospective evidence that supports our cross-sectional findings. Further, the design permits us to more confidently suggest that the identified independent variables predict balance confidence. Extending the study over a longer period of time and/or capturing data at more frequent intervals would have given us an even more robust design and a stronger assessment of longitudinal change. Doing so would provide a more detailed examination of the variation in confidence if it does exist. While we encourage others to replicate this work using such an approach using a different sample of amputees and perhaps a cohort of individuals without a lower limb amputation for comparison, we believe the 2-year period captured in the present study, supported by a relatively good response rate (quite good given the relative short life span of most vascular amputees) provides us with credible longitudinal data. Instead, we encourage study of the longitudinal relationship between balance confidence and social activity and other indicators of quality of life.

Conclusion

This study provides strong evidence to support the hypothesis that individuals with a unilateral lower limb amputation have an impaired level of balance confidence, which seems to be persistent over time. Further, the models presented here suggest individuals who should be targeted for treatment. Clinicians and researchers alike are encouraged to take up the next challenge of addressing this problem. That is determining if there are specific interventions that assist in improving the balance confidence among this special population and determining whether these interventions do in fact have a favourable influence on the quality of the life of individuals living with a lower limb amputation.

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Predicting balance confidence


