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Relationships between fear of falling, balance confidence, and control of balance, gait, and reactive stepping in individuals with sub-acute stroke

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ABSTRACT

Fear of falling is common in individuals with stroke; however, the associations between fear of falling, balance confidence, and the control of balance and gait are not well understood for this population. This study aimed to determine whether, at the time of admission to in-patient rehabilitation, specific features of balance and gait differed between individuals with stroke who did and did not report fear of falling, and whether these features were related to balance confidence. Individuals with stroke entering in-patient rehabilitation were asked if they were afraid of falling, and completed the Activities-Specific Balance Confidence Scale. Participants performed quiet standing, gait, and reactive stepping tasks, and specific measures were extracted for each (quiet standing: centre of pressure amplitude, between-limb synchronization, and Romberg quotients; gait: walking velocity, double support time, and variability measures; reactive stepping: number of steps, frequency of grasp reactions, and frequency of assists). No significant differences were identified between individuals with and without fear of falling. Balance confidence was negatively related to centre of pressure amplitude, double support time, and step time variability, and positively related to walking velocity. Low balance confidence was related to poor quiet standing balance control and cautious behavior when walking in individuals with sub-acute stroke. While the causal relationship between balance confidence and the control of balance and gait is unclear from the current work, these findings suggest there may be a role for interventions to increase balance confidence among individuals with stroke, in order to improve functional mobility.

1. Introduction

Fall risk for individuals with stroke is over twice that of healthy older adults [1]. Falling is a common medical complication post-stroke [2,3], with an especially high risk of occurrence during hospital stay [4] and after discharge home from in-patient rehabilitation [5]. Falls often contribute to fear of falling (FOF); alternatively, or FOF can develop in absence of a fall [6]. FOF is prevalent post-stroke, with up to 88% of individuals with stroke who experience a fall developing FOF [7]. Resulting activity avoidance may lead to restricted mobility and deconditioning, contributing to reduced functional capabilities, loss of functional independence, and further increases in fall risk and FOF [8–10]. FOF [11] and balance confidence [12] are both associated with falls in individuals with stroke, suggesting that these factors are influential in fall occurrence post-stroke.

FOF has been shown to influence balance and gait control in older adults. Compared to older adults with no FOF, those with FOF demonstrate greater centre of pressure (COP) amplitude during eyes-closed quiet standing [13]. Gait in older adults with FOF is characterized by decreased velocity and step length, and increased step width, double support time, and spatio-temporal variability [14–19]. Similarly, quiet standing and walking measures have been linked to balance confidence in older adults [16,20]. Rosen et al. [21] identified significant, positive correlations between falls self-efficacy and clinical measures of balance and gait capability in individuals with stroke. However, no previous study has examined relationships between balance and gait features, FOF, and balance confidence in individuals with stroke.

A better understanding of the relationships between FOF, balance confidence, and features of balance and gait may provide insight into the mechanism(s) by which FOF and balance

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confidence relate to fall risk in individuals with stroke, and inform rehabilitation strategies to minimize these changes and their impact on fall risk. This study determined whether features of quiet standing balance, gait, and reactive stepping (a) differed between individuals with stroke with and without FOF, and (b) were related to balance confidence. It was hypothesized that, compared to individuals without FOF, those with FOF would exhibit: increased COP amplitude and greater reliance on vision (quiet standing); reduced velocity, increased double support time, and increased variability (gait); and increased frequency of failed responses (reactive stepping). Furthermore, balance confidence was expected to be negatively related to these measures, with the exception of walking velocity (positive relationship).

2. Methods

2.1. Participants

Data from individuals with stroke who underwent in-patient stroke rehabilitation at a rehabilitation hospital between October 2009 and September 2012 were analyzed retrospectively. To be included in the analysis, participants must have undergone a clinical assessment with a physiotherapist (part of routine care) at admission to in-patient rehabilitation, and answered a self-report FOF question. They must have completed at least one of: quiet standing, self-paced walking across a pressure-sensitive mat without a walking aid, or lean-and-release reactive stepping (assessment details below). These criteria were met by 208 of 512 individuals (41%). All procedures were approved by the institution's Research Ethics Board with a waiver of patient consent approved for the purpose of the review.

2.2. Assessments

2.2.1. Demographic information

Sex, age, date of stroke, lesion location, side of the body affected, and National Institutes of Health Stroke Scale (NIHSS) [22] score were extracted from participants' hospital charts (Table 1).

Table 1
Demographic and stroke-related characteristics of the study participants. Continuous variables are presented as mean (SD), while nominal variables are presented as *N* (% of group). Variables for which data were missing for some participants are specified.

Characteristic	Fear group ($N = 84$)	No fear group ($N = 124$)	*p*-value
Sex (number)			
Men	32 (38.1%)	81 (65.3%)	<0.001
Women	52 (61.9%)	43 (34.7%)	
Age (years)	68.6 (11.6)	65.3 (13.6)	0.065
NIHSS score*	3.3 (2.7)	3.3 (2.5)	0.98
Time since stroke (days)	18.5 (19.7)	16.8 (15.9)	0.50
Affected side of the body (number)			
Right	42 (50.0%)	66 (53.2%)	0.29
Left	34 (40.5%)	49 (39.5%)	
Both	8 (9.5%)	6 (4.8%)	
No paresis	0 (0.0%)	3 (2.4%)	
Fall history (number)			
Fallers	46 (54.8%)	53 (42.7%)	0.089
Non-fallers	38 (45.2%)	71 (57.3%)	
% Body weight supported by release cable**	8.26 (2.39)	9.36 (3.19)	0.074

* Data only available for 142 participants (Fear group: $N = 62$; No Fear group: $N = 80$).
** Data only available for 115 participants (Fear group: $N = 34$; No Fear group: $N = 81$).

Participants were also categorized as 'fallers' (having fallen prior to or during their stroke, or in acute care) or 'non-fallers'.

2.2.2. Fear of falling and balance confidence

While related, FOF and balance confidence are distinct constructs [23], with FOF defined as persisting concern regarding falling [24], and balance confidence defined as an individual's confidence in their ability to maintain their balance and remain steady [25]. As such, the outcome measures were analyzed with respect to both FOF and balance confidence [26].

FOF was determined by asking participants 'Are you afraid of falling?'. Responses were classified as 'yes' (Fear; $N = 84$) or 'no' (No Fear; $N = 124$). This single-item question has been utilized to categorize participants into dichotomous groups [6,13,15,19], and demonstrates good test–retest reliability ($\kappa = 0.66$) [27]. Balance confidence was assessed using the Activities-Specific Balance Confidence (ABC) Scale [25], which quantifies individuals' confidence in performing 16 everyday tasks from 0 to 100% with higher scores representing greater confidence. The ABC Scale has good internal consistency (Cronbach's $\alpha = 0.94$) and test–retest reliability in individuals with chronic stroke (intra-class correlation coefficient = 0.85 [28]). The ABC Scale was conducted for participants who were independently ambulatory at the time of initial assessment and had the cognitive-communicative ability to respond to the questionnaire ($N = 134$).

2.2.3. Quiet standing

Participants performed one 30 s trial of eyes-open ($N = 195$) and eyes-closed ($N = 194$) quiet standing, with one foot on each of two force plates positioned side-by-side and the feet in a standardized position [29]. Force data were sampled at 256 Hz and low-pass filtered with a dual-pass, fourth-order Butterworth filter (cutoff frequency: 10 Hz) [30]. The total and individual-limb antero-posterior (AP) and medio-lateral (ML) COP signals were calculated. COP amplitude was quantified by the root mean square (RMS) of the total AP and ML COP. Romberg quotients were calculated for AP and ML COP as the eyes-closed value divided by the eyes-open value, to assess the contribution of visual information to postural control [31]. The individual-limb AP COP time series' were cross-correlated to quantify between-limb synchronization (coefficient at zero lag, ρ_0) [32]. Only AP synchronization was calculated as individual-limb AP COP is more important than individual-limb ML COP for overall balance control [33].

2.2.4. Gait

Walking measures were obtained using a 4.6 m long pressure mat (Gaitrite, CIR Systems, Clifton, NJ). Participants ($N = 141$) completed 3–5 passes across the mat at their usual pace such that at least 18 footfalls were recorded. Outcome measures included mean walking velocity and double support time (expressed as percentage of the gait cycle), as well as variability of step length, step width, and step time (average of the standard deviations for the left and right legs) [34].

2.2.5. Reactive stepping

Reactive stepping capacity was assessed for 115 participants using a lean-and-release system [34]. A safety harness attached to an overhead track was worn to prevent a fall to the floor if the participant was unable to recover balance, and a physiotherapist provided assistance if required. A cable connected a harness around the trunk to a support beam behind the participant. Participants stood with the feet in a standardized position [29] and leaned forward until the cable supported 5–10% of body weight. The cable was released at an unpredictable time, causing the participant to fall forward. The perturbation magnitude was such