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Engineering improved balance confidence among older adults with complex health care needs: Learning from the Muscling Up Against Disability study

Abstract

Objective: To investigate the associations of balance confidence with physical and cognitive markers of wellbeing among older adults receiving government-funded aged care services, and whether progressive resistance plus balance training could positively influence change.

Design: Intervention study.

Setting: Community-based older-adult-specific exercise clinic.

Participants: Older adults (N=245) with complex care needs who were receiving government aged care support.

Intervention: 24 weeks of twice-weekly progressive resistance plus balance training carried out under the supervision of accredited exercise physiologists.

Main Outcome Measures: The primary measure was the Activity-specific Balance Confidence score. Secondary measures included the Short Physical Performance Battery, fall history, hierarchical timed balance tests, Geriatric Anxiety Index, Geriatric Depression Score, FRAIL scale and EuroQol 5D 3L.

Results: At baseline, higher physical performance (r = 0.54, p < .01) and quality of life (r = 0.52, p < .01) predicted better balance confidence. In contrast, at baseline, higher levels of frailty predicted worse balance confidence (r = -0.55, p < .01). Change in balance confidence following the exercise intervention was accompanied by improved physical performance (+12%) and decreased frailty (-11%). Baseline balance confidence was identified as the most consistent negative predictor of change scores across the intervention.

Conclusions: This study shows that reduced physical performance and quality of life, and increasing frailty, are predictive of poor balance confidence among older adults with aged care needs. However, when a targeted intervention of resistance and balance exercise is implemented, that reduces frailty and increases physical performance, balance confidence will also improve. Given the influence of balance confidence on a raft of wellbeing determinants, including the capacity for positive physical and cognitive change, this study offers important insight to those looking to reduce falls among older adults.

Key Words: aging; exercise, balance, balance confidence

List of abbreviations:

ABC	Activity-specific Balance Confidence
DNF	Did Not Finish
DNS	Did Not Start
EQ-5D-3L	EuroQoL 5D 3L
FIN	FINished
FRAIL	Fatigue, Resistance, Ambulation, Illness, weight Loss
GAI	Geriatric Anxiety Index
GDS	Geriatric Depression Score
PRBT	Progressive Resistance plus Balance Training
SPPB	Short Physical Performance Battery

Introduction

For older adults, falls are a significant and debilitating event, with such acknowledged consequences that many individuals fear falling more than becoming a victim of crime [1].

While a large, positive body of work has focused on falls prevention, fall rates have remained unchanged during the past decades, with an increasing percentage of the population falling with advancing age[2-4]. For older adults, falls are the primary cause of emergency service utilisation and admission to hospital, and have recently been acknowledged as the leading cause of avoidable death among people in residential aged care[5-7]. This represents significant personal and physical burden for the individual and has extensive financial implications for national health spending[5].

Given the significant implications of a fall, it is understandable that the ensuing consequences can erode an individual's confidence in their ability to maintain their balance and remain steady; erode their balance confidence[8, 9]. Declining balance confidence is, in itself, an acknowledged fall risk factor. Specifically, decreased balance confidence compromises general activity, promotes restriction of physical activity and activities of daily living[10]. This activity restriction drives physical and mental deconditioning and disability[11] and, unless addressed, can set in motion a downward spiral resulting in an increased likelihood of falling[12]. While the implications of physical decline on falls risk are well studied, work exploring the relationship between frailty, anxiety, depression, quality of life and balance confidence is inconclusive[13].

In contrast to the increasing fall risk associated with normal aging, exercise is known to have positive implications for balance confidence. While activities employing weight transfer and body weight exercises [14, 15] have received the greatest attention, our group has shown progressive resistance plus balance training (PRBT) to be a potential positive promoter of complete physical wellbeing for older adults including demonstrated falls reduction[16-18]. This aligns with current evidence reporting that when targeted balance exercise is combined with a minimum of 50 hours of resistance and weight bearing exercise, falls risk significantly declines[19]. The current study was undertaken as a secondary analysis of a larger trial designed with a primary focus on investigating the cost-benefit of PRBT among wait-list randomized, community-dwelling older adult with government supported aged care provision. Specifically, the aims of this study were to explore the associations between balance confidence and physical and mental wellbeing, and whether these markers could be positively influenced individually, or by association, by 24-weeks of PRBT participation. It was hypothesized that an association between reduced balance confidence and other markers of decline would be present, but that balance confidence would improve with increased physical health.

Methods

Study Design and Participants

A complete description of the protocols for the primary study can be found elsewhere[20]. Briefly, community-dwelling older Australians receiving government-funded in-home aged care services were recruited to participate in a PRBT intervention. Participants were recruited from the membership database of a large north-Brisbane community and senior citizens' center that offered, among a suite of other services, domestic assistance, personal care, day respite and transport for older adults with government supported aged care packages. A letter was sent to a random selection of the organization's membership who were receiving in-home aged care services.

From the membership mail out, 388 individuals returned an expression of interest in the study and 349 were found eligible by telephone interview. These individuals were forwarded a study pack containing the participant information sheet, the consent form, health history questionnaire and balance questionnaire; they were also scheduled to attend the exercise clinic for baseline assessment. Of these, 104 withdrew from the study prior to baseline assessment. The participant's doctor was forwarded a study brief, identifying the individual's intention to participate in the study and requesting they contact the research manager if they had any concerns. Baseline assessments were conducted in the same exercise clinic in which the training occurred. Following the baseline assessment, participants were randomized to exercise (EX) or wait-list control (CON) at a ratio of 1:2 using block randomization through a sealed envelope selection method. The project employed a modified stepped-wedge randomization to ensure all participants were given the opportunity to benefit from the exercise intervention. Ethics approval was obtained from the University of Queensland Human Research Ethics Committee (Approval number #2015000879) and the study registered with the Australian New Zealand Clinical Trials Registry (ACTRN12615001153505).

The eligibility criteria were: (a) over 65 years of age, (b) community-dwelling, (c) with an Australian government-funded aged care package, (d) mobile with or without an aid, (e) able to follow instructions and commit to the study period, and (f) with no recent history of resistance training. The exclusion criteria were (a) requiring more than one person to assist with transfers, standing and/or mobilizing, (b) medications and/or diseases with contraindications for exercise, (c) terminal illness or receiving palliative care, (d) an imminent move to residential care, (e) difficult behaviors and (f) inability to obtain a doctor's consent to participate.

Intervention

Participants undertook 24 weeks of twice-weekly PRBT under the supervision of accredited exercise physiologists experienced in exercise delivery to older adults with complex healthcare needs. Sessions included a light five-minute warm-up, 45 minutes of machine-based resistance training and targeted balance exercises, followed by a 5 minute cool down incorporating stretches. Resistance exercises were performed on air-pressure driven, computer-integrated machines proven effective for use among older adults (HUR Australia Pty Ltd, Birkdale, QLD, Australia), with balance exercises (static, dynamic and agility) incorporated, in addition to the pre-workout warm-up and a post-workout cool down[16, 19].

Resistance exercises were (1) chest press, (2) seated row, (3) leg press, (4) leg curl, (5) leg extension, (7) leg abduction, (8) leg adduction, and (9) abdominal crunch. Following a four-week conditioning phase[16] exercises were performed for 3 sets of 8–12 repetitions, with resistance set at a moderate to high intensity (up to approximately 75% of the estimated 1 repetition maximum). At baseline, participants' grip strength informed the starting resistance for each exercise, with those having below normal muscle strength (men < 30 kg and women < 20 kg) given a lower, more conservative resistance.

Balance exercises were (1) single leg stand - 2 sets aiming for 20 s on each leg, (2) tight rope walking - 2 sets of 10 steps forwards and 10 steps backwards, (3) box stepping - 5 times clockwise and 5 times anticlockwise and (4) calf raises—2 sets of 10. The same four-week conditioning phase was implemented with the balance exercises. Participants were encouraged to work towards completing the balance exercises without support where possible. PRBT has been employed safely and effectively in similar populations [16, 18]. All sessions were delivered in small groups (up to 10 participants), under the supervision of exercise physiologists who offered support and motivation. If participants experienced pain or discomfort when performing an exercise, the exercise in question was modified, and if this did not alleviate the issue, the exercise was removed from that participant's program.

Measures

Measures were collected prior to entering the PRBT phase and following the completion of this phase. All data were collected by accredited exercise physiologists, questionnaires were collected by interview and, in the same session, physical performance was measured. The exception was balance confidence, where the questionnaire was part of the mailed out initial project pack that also included the health history questionnaire and participant information sheet. To ensure consistency, the post-intervention balance confidence questionnaire was mailed to participants and returned by reply paid post.

The primary measure for this study was the Activity-specific Balance Confidence (ABC) questionnaire which was used to assess balance self-efficacy. Averaged scores for the 16 ABC questions range from 10 (not at all confident) to 100 (completely confident). The ABC is valid for predicting total falls risk and can distinguish between fallers and non-fallers[21, 22].

Secondary measures included:

- Fall history and a list of diagnosed morbidities and prescribed medications were gathered as part of the health history questionnaire. Sum total of morbidities and medications were used in analyses.

- Physical performance, measured using the Short Physical Performance Battery (SPPB)[23, 24]. The components of the SPPB are hierarchical tests of standing balance, a timed 4-metre walk and a timed 5-repeat chair stand test. Measures were collected as per the Guralnik et al [23] protocol, and can be analyzed as independent measures or as a summary score with a range between 0 (worst performance) and 12 (best performance). The SPPB is a known predictor for loss of mobility, hospitalization, institutionalization and mortality[23, 24].
- Balance; assessed as a component of the SPPB, this is a hierarchical timed test of balance in three stances – side-by-side, semi-tandem and tandem. Test scores range from 0 (unable to complete) to 30 (able to complete 10 seconds in each stance).
- Depression, measured by the Geriatric Depression Scale – Short Form (GDS)[25]. Participants are classified as without depression (normal (0–4)), or having mild depression (5–8), moderate depression (9–11) or severe depression (12–15) based on their summary score.
- Anxiety, measured by the Geriatric Anxiety Inventory (GAI)[26]. Participants scoring between 0 and 8 are reported as having an absence of clinical anxiety, where those with a score between 9 and 20 have suspected clinical anxiety.
- Frailty, measured by the FRAIL scale[27]. FRAIL scale scores range from 0 (absence of frailty) to 5 (severe frailty).
- Quality of life, was measured by the EuroQoL EQ-5D-3L. This valid and reliable measure of health related quality of life provides a single index value between 1.0 (perfect health) and 0.0 (death)[28].

Statistical analyses

One-way analysis of variance (ANOVA) was employed to detect differences between those who did not start (DNS), did not finish (DNF) and did finish (FIN) the exercise component and least significant difference (LSD) calculations were employed to explore loci of any differences. Paired *t*-tests were used to ascertain changes in outcome measures. A *p* value of less than .05 was considered statistically significant. Pearson product correlation was used to explore relationships between variables at baseline, with balance confidence set as the primary measure of interest and secondary variables included to determine association. An *r* value of .10, .30 and .50 was taken to represent small, medium and large correlation coefficients, respectively[29]. Data were analyzed using IBM SPSS Statistics Version 24 (IBM Corp., New York, USA).

Separate multivariate models predicting ABC scores at baseline and change in ABC scores across the intervention were constructed using LASSO (least absolute shrinkage and selection operator) penalty for model building. All baseline secondary measures identified above were included as predictors for ABC scores at baseline (see Figure 1). The same predictors in addition to ABC scores at baseline were included for the final model predicting change in ABC scores across the intervention (see Figure 2). Continuous regression inputs were scaled by dividing values by two standard deviations to facilitate comparisons with binary predictors and assist with model interpretation[30]. Optimal LASSO penalty was obtained via tenfold cross-validation. Models were generated using the glmnet package[31] in R with statistical properties of estimates based on 2500 bootstrap samples. Results presented include median, 2.5 and 97.5% quantiles for regression coefficients and the frequency that each variable was retained in the 2500 bootstrap samples (Figures 1-2).

Results

Two hundred and forty-five eligible participants completed the baseline assessment. The average age at baseline assessment was 78.7 ± 6.4 years and 78% of the participants were female. Twenty-eight participants (11%) had experienced at least one fall in the 6 weeks preceding entry to the study; two of these had had multiple falls.

Thirty participants failed to start the exercise program and 47 failed to finish, with no clear and observable missingness mechanism. Differences in baseline measures were detected between completion groups (DNS, DNF and FIN) (Table 1). Those who did finish had significantly better balance confidence and physical performance (SPPB) and were significantly less frail than those in the other two groups. Those who did not start had significantly lower balance scores than those in the other two groups. Pre- and post-intervention data for the study measures are presented in Table 2. At baseline, balance confidence had a small correlation with anxiety, a medium correlation with depression, and a large correlation with physical performance, frailty and quality of life (see Table 3). Other large correlation coefficients were observed between depression and anxiety; and between frailty and quality of life. Multivariate analyses of predictors was undertaken based on the fact that no single variable was an adequate predictor of balance confidence and there were no issues of multicollinearity.

Multivariate analyses of baseline predictors of balance confidence and change in balance confidence are displayed in Figure 1 and Figure 2, respectively. Important predictors positively associated with baseline balance confidence included physical performance

(SPPB) and quality of life scores with both variables selected for 100% of bootstrap samples. In contrast, frailty was identified as an important negative predictor of balance confidence with inclusion in 99% of bootstrap samples. Similar findings were obtained for change in balance confidence across the intervention with physical performance (94% of bootstrap samples) and frailty (96% of bootstrap samples) identified as important positive and negative predictors of change in ABC score, respectively. In addition, baseline ABC score (100% of bootstrap samples) exhibited a large regression coefficient and was identified as the most consistent negative predictor of change scores across the intervention.

Discussion

Declining balance confidence among older adults has implications for increasing sedentary behavior, disability and fall risk. The current study demonstrated that, among community-dwelling older adults with aged care needs, better balance confidence was strongly predicted by better physical performance, better perceptions of quality of life and less frailty. When these adults participated in targeted resistance plus balance training, improved balance confidence was accompanied by improvements in physical performance and reductions in frailty. Further, those with the lowest initial balance confidence obtained the largest improvements. A strong predictor of positive change in balance confidence was baseline physical performance. While a number of studies have looked at predictors of balance confidence in an older cohort, to our knowledge, this is the first study to construct a comprehensive prediction model of change as the product of an exercise intervention.

Participants in this study were older Australian adults receiving government-funded aged care services to aid them to remain in their own homes in the face of functional decline and decreased ability to carry out activities of daily living. Assumptions about participants' level of functional decline are supported by their SPPB scores. At baseline, as a group, participants had a mean SPPB score of 8.0, which is less than that suggested elsewhere for frailty (<9)[32] and mobility disability (<8.4)[33]. Furthermore, the cohort as a whole were found to be pre-frail using the subjective FRAIL scale[27]. Analysis of differences between completion groups showed that those in the DNS and DNF groups were frailer, had lower physical performance scores and lower balance confidence than those who completed the study. Nevertheless, even the FIN group had significantly lower baseline balance confidence than that of healthy community-dwelling older adults reported elsewhere ($t(334)=-5.86$, $p<0.0001$)[34].

Our study supports previous cross-sectional studies that report an association between balance confidence and physical performance[35-37]. It also supports studies reporting associations between self-reported anxiety, depression and health-related quality of life and balance confidence in older adults[34, 35]. Our study has taken a primary step toward improving balance confidence by embracing current evidence showing exercise as a feasible intervention[16]. Specifically, our intervention embraced recommendations that support the use of progressive resistance training in combination with targeted balance exercise, engaging participants for up to 50 hours, as the most effective modality in fall reduction best practice[38].

The present study compliments a body of work supporting the use of PRBT in older frail populations and supports this form of training as having more than just physical benefits. For participants in this study, physical gains were augmented by improved balance confidence and quality of life, and reduced anxiety and depression. Interestingly, results show that those with lower initial balance confidence experienced the greatest gains. This has important implications for older adults, where loss of balance confidence is a primary driver of reduced physical activity that spirals into social withdrawal and increasing fall risk.

Data show that fall rates have remained virtually unchanged among older populations for the past four decades [39, 40], and that falls have serious consequences for older people[5]. Studies such as the current one offer significant promise to older people, in particular those with already low balance confidence, frailty and complex aged care needs. Within the World Health Organisation International Classification of Functioning, Disability and Health (ICF) model[41, 42], balance confidence would be classified as a personal factor influencing, and influenced by, activity. Activity impacts upon health but it also impacts body function and structure. Introduction of a PRBT intervention into this model would change activity patterns with resultant changes in health, body function and structure and personal factors such as balance confidence. This assertion is well supported by the findings presented in this paper.

Some limitations need to be taken into account when interpreting the results of this study. The DNS and DNF groups participated in pre-intervention testing and contributed to baseline analyses. However, both groups failed to complete the intervention or participate in post-intervention testing and therefore were unable to contribute to the post exercise analysis. If the groups had participated in the exercise program this may have strengthened the reported outcomes given their low initial balance confidence. For those who did commence the exercise intervention the completion rate was 78% which compares favorably with other community-based exercise intervention studies[43-45] and approaches recommended retention rates of 80% for clinical trials[46]. To maintain consistency the second ABC questionnaire was posted to participants following the final exercise intervention intake wave. ABC data is missing for thirty-nine participants who did not return the second ABC questionnaire; evidence from return to sender mail indicated that several had passed away and others had moved out of the area. A final consideration is that the data are not compared to a control group. While among this cohort it would be assumed usual care controls would continue to decline, a comparative arm would enhance confidence in the accuracy of our outcomes.

This study shows that poor balance confidence, a factor closely associated with increased fall risk, is associated with low physical performance and increased frailty. However, employing a targeted intervention, designed and supervised by accredited exercise physiologists, these variables can be positively modified and balance confidence increased. Physical performance gains made through PRBT may contribute to improved balance confidence and in this study we noted that those with lower initial balance confidence realized greater improvements. Quality of life is also improved through PRBT engagement and this may also contribute to improved balance confidence. However, what our results for the DNS and DNF groups also show is that additional supports and scaffolding[47] are needed for older adults with poor balance and low balance confidence to assist them to initiate and maintain engagement in an exercise program. In summary, in an appropriate environment, with competent supervision and support, even pre-frail older people can use PRBT to improve their strength, balance, quality of life and their balance confidence.

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Table 1: One-way ANOVA between completion categories.

Measure	DNS		DNF		FIN		F	p value
	M	SD	M	SD	M	SD		
Morbidities	4.6	(3.4)	6.1*	(2.8)	4.8	(2.6)	4.3	.01
ABC	47.3	(25.8)	49.8	(27.1)	65.5**	(24.3)	10.7	.00
SPPB	6.2	(2.5)	7.0	(3.0)	8.6**	(2.5)	15.6	.00
Balance	22.7*	(5.6)	25.6	(5.7)	26.8	(5.1)	7.9	.00
FRAIL	2.1	(1.6)	2.4	(1.4)	1.5*	(1.4)	8.6	.00

Note. *p<.05 **p<.01

Table 2: Paired t-test results pre- and post-exercise intervention.

Measure	n	Pre-intervention		Post-intervention		t	p value	Change in variable
		M	SD	M	SD			
ABC	129	65.4	(24.0)	68.6	(23.1)	-2.2	.03	+5%
SPPB	168	8.6	(2.5)	9.7	(2.8)	-6.5	.00	+12%
Balance	168	26.8	(5.1)	28.1	(4.7)	-3.5	.00	+5%
GDS	166	3.0	(2.5)	2.4	(2.5)	3.9	.00	-21%
GAI	166	3.9	(4.6)	3.0	(4.4)	3.6	.00	-23%
FRAIL	166	1.5	(1.4)	1.3	(1.3)	1.5	.13	-11%
EQ-5D-3L	166	0.79	(0.14)	0.84	(0.15)	-3.8	.00	+5%

Table 3: Correlations among variables at baseline.

	ABC	SPPB	GDS	GAI	FRAIL	EQ-5D-3L
ABC		.54**	-.35**	-.25**	-.55**	.52**
SPPB			-.07	.02	-.45**	.33**
GDS				.51**	.23**	-.27**
GAI					.19*	.29**
FRAIL						-.56**

Note. *p < .05, **p < .01

Figure 1: LASSO regression coefficients predicting baseline balance confidence (ABC score).

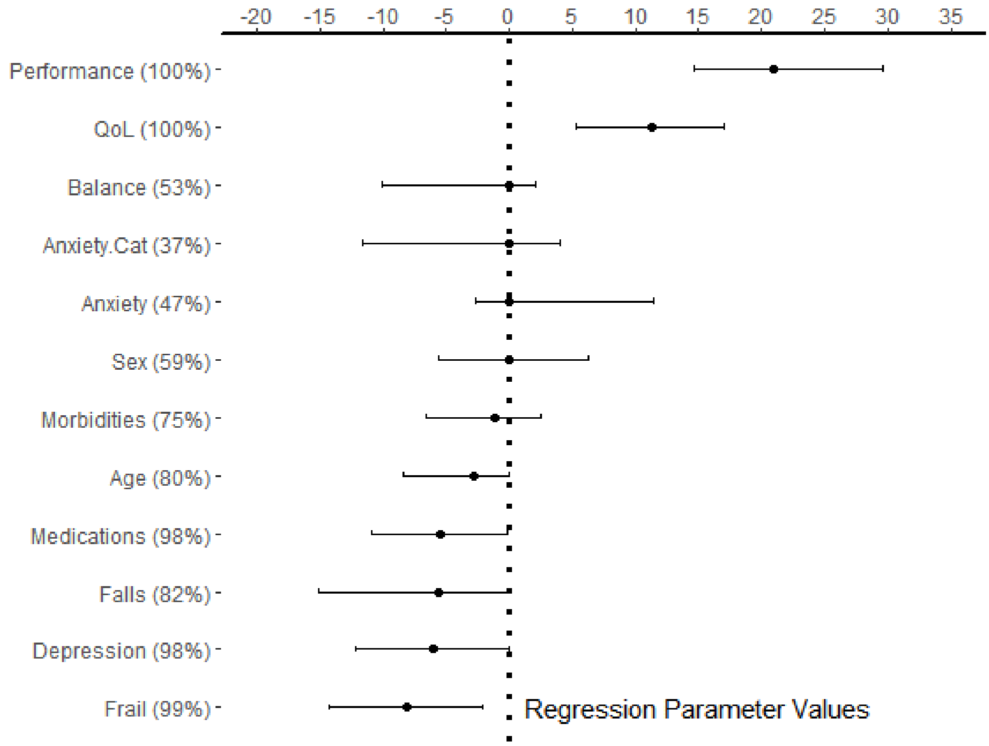

Figure 2: LASSO regression coefficients predicting pre-post intervention change in balance confidence (ABC score).