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ORIGINAL RESEARCH

Engineering Improved Balance Confidence in Older Adults With Complex Health Care Needs: Learning From the Muscling Up Against Disability Study

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Abstract

Objective: To investigate the associations of balance confidence with physical and cognitive markers of well-being in 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-funded aged care support.

Interventions: Twenty-four 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 Scale. Secondary measures included the Short Physical Performance Battery; fall history gathered as part of the health history questionnaire; hierarchical timed balance tests; Geriatric Anxiety Index; Geriatric Depression Scale; Fatigue, Resistance, Ambulation, Illness, Loss of Weight scale; and EuroQoL-5 dimension 3 level.

Results: At baseline, better physical performance ($r = .54$; $P < .01$) and quality of life ($r = .52$; $P < .01$) predicted better balance confidence. In contrast, at baseline, higher levels of frailty predicted worse balance confidence ($r = -.55$; $P < .01$). Change in balance confidence after the exercise intervention was accompanied by improved physical performance (+12%) and reduced 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 increased frailty are predictive of worse balance confidence in older adults with aged care needs. However, when a targeted intervention of resistance and balance exercise is implemented that reduces frailty and improves physical performance, balance confidence will also improve. Given the influence of balance confidence on a raft of well-being determinants, including the capacity for positive physical and cognitive change, this study offers important insight to those looking to reduce falls in older adults.

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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] Although a large positive body of work[2-4] has focused on fall prevention, fall rates

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have remained unchanged during the past decades, with an increasing percentage of the population falling with advancing age. For older adults, falls are the primary cause of emergency service utilization and admission to hospital and have recently been acknowledged as the leading cause of avoidable death in 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 and erode their balance confidence.[8,9] Declining balance confidence is in itself an acknowledged fall risk factor. Specifically, decreased balance confidence compromises general activity and 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] Although the implications of physical decline on fall risk are well studied, work[13] exploring the relation between frailty, anxiety, depression, quality of life, and balance confidence is inconclusive.

In contrast to the increasing fall risk associated with normal aging, exercise is known to have positive implications for balance confidence. Although activities using 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 well-being for older adults including demonstrated fall reduction.[16-18] This aligns with present evidence reporting that when targeted balance exercise is combined with a minimum of 50 hours of resistance and weight-bearing exercise, fall risk significantly declines.[19] The present study was undertaken as a secondary analysis of a larger trial designed with a primary focus on investigating the cost-benefit of PRBT in wait-list randomized, community-dwelling older adults with government-supported aged care provision. Specifically, the aim of this study was to explore the associations between balance confidence and physical and mental well-being 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 members 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 the baseline assessment. Of these, 104 withdrew from the study before the 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. After the baseline assessment, participants were randomized to exercise or wait-list control in a ratio of 1:2 using block randomization by means of a sealed envelope selection method. The project used 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 Gatekeepers approval through the St Vincent's Health Australia Human Research Ethic Committee (approval reference HREC 15/21). The study is registered with the Australian New Zealand Clinical Trials Registry (Clinical Trial Registration No.: ACTRN12615001153505).

Eligibility criteria were as follows: (1) >65 years of age; (2) community dwellers; (3) with an Australian government−funded aged care package; (4) mobile with or without an aid; (5) able to follow instructions and commit to the study period; and (6) with no recent history of resistance training. Exclusion criteria were as follows: (1) requiring >1 person to assist with transfers, standing, and/or mobilizing; (2) medications and/or diseases with contraindications for exercise; (3) terminal illness or receiving palliative care; (4) an imminent move to residential care; (5) difficult behaviors; and (6) 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 health care needs. Sessions included a light 5-minute warm-up, 45 minutes of machine-based resistance training and targeted balance exercises, followed by a 5-minute cooldown incorporating stretches. Resistance exercises were performed on air pressure−driven, computer-integrated machines[a] proven effective for use in older adults, with balance exercises (static, dynamic, agility) incorporated in addition to the pre-workout warm-up and a post-workout cooldown.[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. After a 4-week conditioning phase,[16] exercises were performed for 3 sets of 8 to 12 repetitions,

List of abbreviations:

ABC	Activity-specific Balance Confidence Scale
DNF	did not finish
DNS	did not start
FIN	finished
FRAIL	Fatigue, Resistance, Ambulation, Illness, Loss of Weight
PRBT	progressive resistance plus balance training
SPPB	Short Physical Performance Battery

with resistance set at a moderate to high intensity (up to ~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, <30kg; women, <20kg) given a lower, more conservative resistance.

Balance exercises were (1) single leg stand—2 sets aiming for 20 seconds on each leg; (2) tight rope walking—2 sets of 10 steps forward and 10 steps backward; (3) box stepping—5 times clockwise and 5 times anticlockwise; and (4) calf raises—2 sets of 10. The same 4-week conditioning phase was implemented with balance exercises. Participants were encouraged to work toward completing balance exercises without support where possible. PRBT has been used 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 before entering the PRBT phase and after 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 postintervention 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 fall risk and can distinguish between fallers and nonfallers.[21,22]

Secondary measures included the following:

1. Fall history and a list of diagnosed morbidities and prescribed medications were gathered as part of the health history questionnaire. Sum totals of morbidities and medications were used in analyses.
2. Physical performance was measured using the Short Physical Performance Battery (SPPB).[23,24] The components of the SPPB are hierarchical tests of standing balance, a timed 4-m walk test, and a timed 5-repeat chair stand test. Measures were collected as per the protocol of Guralnik et al[23] 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 of loss of mobility, hospitalization, institutionalization, and mortality.[23,24]
3. Balance was assessed as a component of the SPPB, which is a hierarchical timed test of balance in 3 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).
4. Depression was measured by the Geriatric Depression Scale. [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) on the basis of their summary score.
5. Anxiety was measured by the Geriatric Anxiety Index.[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.
6. Frailty was measured by the Fatigue, Resistance, Ambulation, Illness, Loss of Weight (FRAIL) scale.[27] FRAIL scale scores range from 0 (absence of frailty) to 5 (severe frailty).
7. Quality of life was measured by the EuroQoL-5 dimension 3 level. 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 was used to detect differences between those who did not start (DNS), did not finish (DNF), and finished (FIN) the exercise component, and least significant difference calculations were used to determine the loci of any differences observed. Paired *t* tests were used to ascertain changes in outcome measures. A *P* value of <.05 was considered statistically significant. A Pearson product correlation was used to explore relations 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 low, medium, and high correlation coefficients, respectively.[29] Data were analyzed using SPSS version 24.[b]

Separate multivariate models predicting ABC scores at baseline and change in ABC scores across the intervention were constructed using the least absolute shrinkage and selection operator penalty for model building. All baseline secondary measures identified above were included as predictors of ABC scores at baseline (fig 1). The same predictors in addition to ABC scores at baseline were included in the final model predicting change in ABC scores across the intervention (fig 2). Continuous regression inputs were scaled by dividing values by 2SDs to facilitate comparisons with binary predictors and assist with model interpretation.[30] The optimal least absolute shrinkage and selection operator penalty was obtained via 10-fold cross-validation. Models were generated using the glmnet package[31,c] in R, with statistical properties of estimates based on 2500 bootstrap samples. The results presented include median, 2.5% and 97.5% quantiles for regression coefficients, and the frequency that each variable was retained in 2500 bootstrap samples (see figs 1 and 2).

Results

Two hundred forty-five eligible participants completed the baseline assessment. The mean age at the baseline assessment was 78.7±6.4 years, and 79% (n=194) of the participants were female. Twenty-eight participants (11%) had experienced at least 1 fall in the 6 weeks before entry to the study; 2 of these (0.8%) 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, FIN) (table 1). Those who did finish had significantly better balance confidence and physical performance (SPPB) and were significantly less frail than were those in the other 2 groups. Those who did not start had

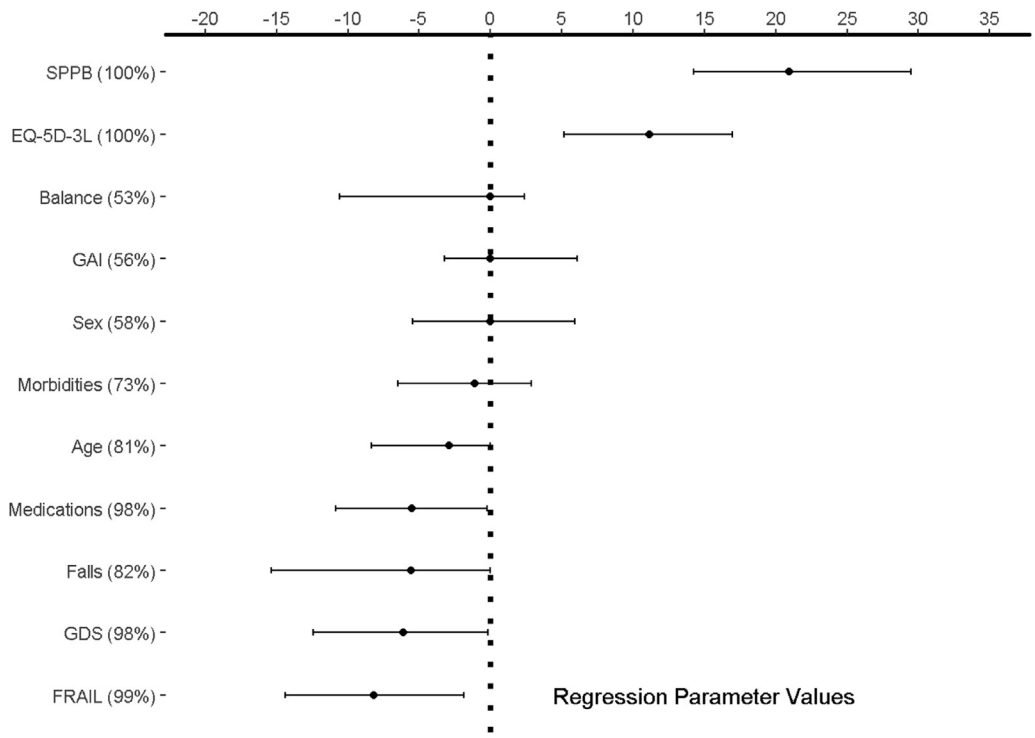

Fig 1 LASSO regression coefficients predicting baseline balance confidence (ABC score [n = 245]). NOTE. Results presented as median, 2.5% and 97.5% quantiles for regression coefficients, and the frequency that each variable was retained in 2500 bootstrap samples. Abbreviation: LASSO, least absolute shrinkage and selection operator.

significantly lower balance scores than did those in the other 2 groups. Pre- and postintervention data for the study measures are presented in table 2. At baseline, balance confidence had a low correlation with anxiety, a medium correlation with depression, and a high correlation with physical performance, frailty, and quality of life (table 3). Other high correlation coefficients were

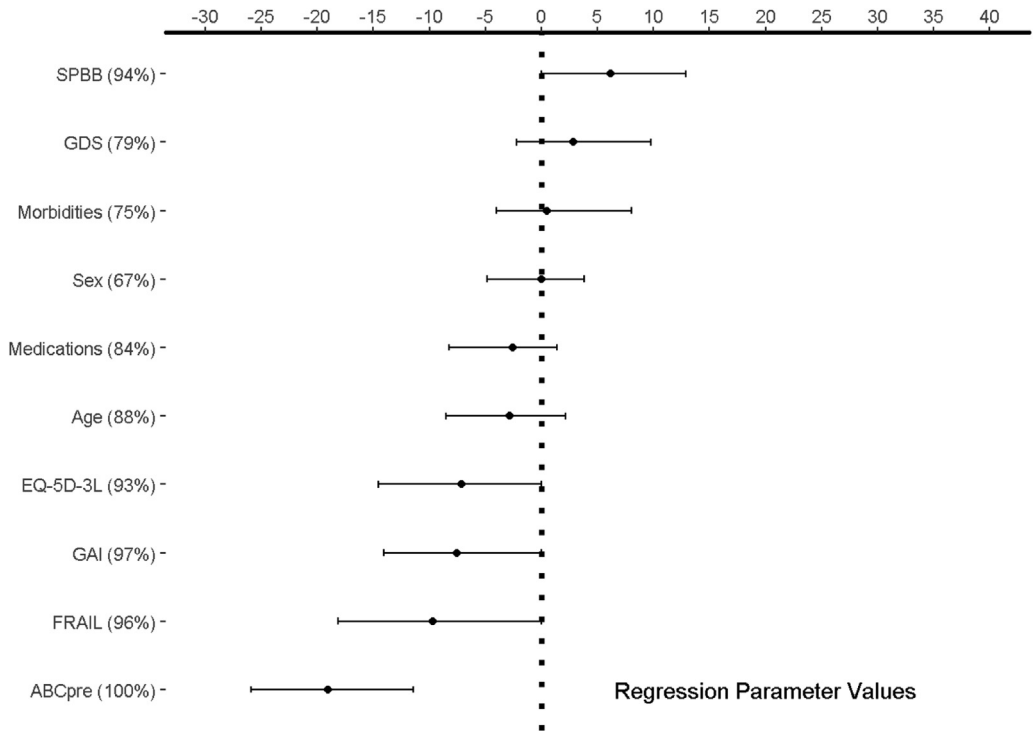

Fig 2 LASSO regression coefficients predicting pre- and postintervention change in balance confidence (ABC score [n = 168]). NOTE. Results presented as median, 2.5% and 97.5% quantiles for regression coefficients, and the frequency that each variable was retained in 2500 bootstrap samples. Abbreviation: LASSO, least absolute shrinkage and selection operator.

Table 1 Baseline variables and 1-way ANOVA results comparing completion categories

Characteristic	Cohort (N=245)	DNS (n=30)	DNF (n=47)	FIN (n=168)	ANOVA Results F	ANOVA Results P	LSD Results
Age (y)	78.7±6.4	80.4±7.1	79.0±6.5	78.3±6.3	1.4	.25	NT
No. of medications	5.2±3.2	5.0±3.8	5.7±3.4	5.1±3.1	0.6	.54	NT
No. of morbidities	5.0±2.8	4.6±3.4	6.1±2.8	4.8±2.6	4.3	.01	DNF > DNS,* FIN**
ABC score	60.7±26.0	47.3±25.8	49.8±27.1	65.5±24.3	10.7	.00	FIN > DNS,** DNF**
SPPB score	8.0±2.8	6.2±2.5	7.0±3.0	8.6±2.5	15.6	.00	FIN > DNS,* FIN**
Balance (s)	26.0±5.4	22.7±5.6	25.6±5.7	26.8±5.1	7.9	.00	DNS < DNF,* FIN**
GDS	3.1±2.4	2.9±2.1	3.5±2.5	3.0±2.5	1.0	.39	NT
GAI	4.0±4.7	3.6±4.2	4.6±5.0	3.9±4.6	0.5	.60	NT
FRAIL	1.8±1.4	2.1±1.6	2.4±1.4	1.5±1.4	8.6	.00	FIN < DNS,** DNF**
EQ-5D-3L	0.78±0.15	0.75±0.14	0.74±0.18	0.79±0.14	2.4	.10	NT

NOTE. Values are mean ± SD or as otherwise indicated. Results from LSD calculations: *P<.05; **P<.01.
Abbreviations: ANOVA, analysis of variance; EQ-5D-3L, EuroQoL-5 dimension 3 level; GAI, Geriatric Anxiety Index; LSD, least significant difference; NT, not tested.

observed between depression and anxiety and between frailty and quality of life. Multivariate analyses of predictors were performed because no single variable was an adequate predictor of balance confidence and there were no issues of multicollinearity.

The results of 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 scores, respectively. In addition, the baseline ABC score (100% of bootstrap samples) exhibited a high regression coefficient and was identified as the most consistent negative predictor of change scores across the intervention.

Discussion

Declining balance confidence in older adults has implications for increasing sedentary behavior, disability, and fall risk. The present study demonstrated that in 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 reduced 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. Furthermore, those with the lowest initial balance confidence obtained the greatest improvements. A strong predictor of positive change in balance confidence was baseline physical performance. Although 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 prefrail using the subjective FRAIL scale.[27] An analysis of differences between completion groups showed that those in the DNS and DNF groups were frailer, had lower physical performance scores, and had lower balance confidence than did those who completed the study. Nevertheless, even the FIN group had significantly lower baseline balance confidence than did community-dwelling older adults reported elsewhere ($t_{334}=-5.86$; P<.0001).[34]

Table 2 Per-protocol analysis data with pre- and postexercise intervention measures

Measure	n	Preintervention	Postintervention	t	P	Change in Variable (%)
ABC score	129	65.4±24.0	68.6±23.1	−2.2	.03	5
SPPB score	168	8.6±2.5	9.7±2.8	−6.5	.00	12
Balance (s)	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

NOTE. Values are mean ± SD or as otherwise indicated.
Abbreviations: EQ-5D-3L, EuroQoL-5 dimension 3 level; GAI, Geriatric Anxiety Index.

Table 3 Baseline correlations for the entire cohort

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

NOTE. *$P<.05$; **$P<.01$.
Abbreviations: EQ-5D-3L, EuroQoL-5 dimension 3 level; GAI, Geriatric Anxiety Index.

Our study supports previous cross-sectional studies[35-37] that report an association between balance confidence and physical performance. It also supports studies[34,35] reporting associations between self-reported anxiety, depression, and health-related quality of life, and balance confidence in older adults. Our study has taken a primary step toward improving balance confidence by embracing present 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 best practice for fall reduction.[38]

The present study compliments a body of work supporting the use of PRBT in frail older 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, the 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 in older populations for the past 4 decades[39,40] and that falls have serious consequences for older people.[5] Studies such as the present 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 Organization International Classification of Functioning, Disability and Health model,[41,42] balance confidence would be classified as a personal factor influencing, and influenced by, activity. Activity affects health, but it also affects 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 article.

Study limitations

Some limitations need to be taken into account when interpreting the results of this study. The DNS and DNF groups participated in preintervention testing and contributed to baseline analyses. However, both groups failed to complete the intervention or participate in postintervention testing and therefore were unable to contribute to the postexercise 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 mailed to participants after the final exercise intervention intake wave. ABC data are missing for 39 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 with those of a control group. Although in this cohort it would be assumed that usual care controls would continue to decline, a comparative arm would enhance confidence in the accuracy of our outcomes.

Conclusions

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, using a targeted intervention, designed and supervised by accredited exercise physiologists, these variables can be positively modified and balance confidence increased. Improvements in physical performance 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 prefrail older people can use PRBT to improve their strength, balance, quality of life, and balance confidence.

Suppliers

a. Computer-integrated machines; HUR Australia Pty Ltd.
b. SPSS version 24; IBM Corp.
c. glmnet package; Friedman, T. Hastie, and R. Tibshirani.

Keywords

Aging; Exercise; Rehabilitation

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