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Additional standing balance circuit classes during inpatient rehabilitation improved balance outcomes: an assessor-blinded randomised controlled trial

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Abstract

Objective: to evaluate the impact on balance (postural control) of six 1-h circuit classes that targeted balance in addition to usual therapy for rehabilitation inpatients.
Design: a randomised controlled trial with 2-week and 3-month follow-up.
Participants: one hundred and sixty-two general rehabilitation inpatients, Bankstown-Lidcombe Hospital, Australia.
Intervention: intervention group participants received six 1-h circuit classes over a 2-week period in addition to usual therapy. Control group participants received usual therapy.
Results: standing balance performance (primary outcome) was better in the intervention group than in the control group at 2 weeks (between-group difference after adjusting for baseline values 3.3 s; 95% confidence interval (CI) 0.84 to 5.7, $P = 0.009$), but the between-group difference was not statistically significant at 3 months (3.4 s; 95% CI −0.56 to 7.38, $P = 0.092$). Intervention group outcomes were significantly better than the control groups for mobility performance (Short Physical Performance Battery) at 2 weeks (1.19, 95% CI 0.52 to 1.87, $P < 0.01$) and 3 months (1.00, 95% CI 0.00 to 2.00, $P < 0.049$) and self-reported functioning (AM-PAC) at 2 weeks (5.39, 95% CI 1.20 to 9.57, $P = 0.012$). The intervention group had a 4.1-day shorter rehabilitation unit stay (95% CI −8.3 to 0.16, $P = 0.059$) and a lower risk of readmission in the 3 months after randomisation (incidence rate ratio 0.70, 95% CI 0.42 to 1.18, $P = 0.184$), but these differences were not statistically significant.
Conclusion: two weeks of standing balance circuit classes in addition to usual therapy improved balance in general rehabilitation inpatients at 2 weeks.

Keywords: *balance, physiotherapy, circuit classes, rehabilitation, inpatients, older people*

Introduction

Postural control, or balance, is defined as the ability to maintain the projection of the body's centre of mass within manageable limits of the base of support [1]. Balance plays an essential role in tasks such as moving from sitting to standing, standing, walking, performing many activities of daily living [2], maintaining independence [3], as well as reacting to external disturbances. The maintenance of balance involves compensatory and anticipatory postural movements. Balance can decline with older age and pathology [4] but can be improved with training and practice [5].

Systematic reviews have found that targeted exercise interventions can improve balance [6] and decrease falls [7] in older people. In particular, programmes involving balance and coordination exercises are effective in improving balance [6], and exercise programmes that included challenging balance activities (exercising without using the hands for support and narrowing the base of support) were associated with a greater fall prevention effect than other programmes [7]. This positive response to balance training is consistent with a 'task-specific' approach to exercise prescription, i.e. greater improvements are seen when exercises are most similar

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to the task for which improvement is sought [2]. A 12-week circuit class that incorporated functional balance exercises was effective in improving balance in frail older people [8], but a 12-week program is not feasible within most inpatient rehabilitation units due to decreasing lengths of stay [9].

Therefore, this study was designed to determine whether 2 weeks of standing balance circuit classes, in addition to usual therapy, lead to greater improvements in balance among rehabilitation inpatients than usual therapy alone.

Methods

Design

A single centre, randomised controlled trial with concealed allocation, assessor blinding and intention to treat analysis with 2-week and 3-month follow up was conducted. Figure 1 gives an overview of the study design.

Participants

All people admitted to the adult general rehabilitation ward at Bankstown-Lidcombe Hospital (a public hospital located in metropolitan Sydney) were screened for study eligibility. The unit accepts adults of all ages, but the majority of patients admitted are over 65 years of age. People were eligible if they were admitted to the ward for rehabilitation; able to stand for 30 s without physical assistance or the help of an assistive device; had no contraindications to exercise, such as uncontrolled hypertension or unstable cardiac disease; able to fully weight bear as ordered by a medical officer; and suitable for a group exercise class with minimal supervision as determined by the treating physiotherapist. People with a known infection that would pose a significant risk to others in a group setting were excluded. For those patients with a Mini Mental State Examination (MMSE) [10] score of 17 or less and those whom treating staff considered to have a cognitive impairment limiting their ability to give informed consent, consent was sought from a 'person responsible'. Written informed consent was obtained directly from all other participants.

Intervention

In addition to usual therapy, the intervention group received six 1-h standing balance circuit classes over a 2-week period. Following the 2-week period, intervention group participants were invited to continue with the classes until discharged from hospital. The class comprised seven exercise stations. Each station involved a specific balance exercise performed in standing. The classes were supervised by two physiotherapy staff (including an experienced, trained Physiotherapy Assistant). Up to eight participants were allowed per class, and participants spent 6 min at each station and completed six of the seven stations during each session. All stations were designed to challenge postural control while standing and stepping using the exercise principles shown to be associated with a greater reduction in falls in the review by Sherrington *et al.* [7]. This challenge was achieved by performing exercises in standing without the use of hands for support, by narrowing the base of support and encouraging a high number of repetitions. As participants' balance skills improved, they were progressed to more challenging balance exercises by the treating physiotherapist. The number of exercise repetitions completed at each station was counted by participants and recorded as is usual practice at this setting [11]. Details of the exercises and progression are described in the trial protocol paper [12].

All participants received usual therapy, assessment and treatment by the multidisciplinary ward team. Supplementary data, Appendix S1 available in *Age and Ageing* online for more details of usual therapy.

Outcome measures

Primary outcome

The primary outcome measures were balance at 2 weeks and at 3 months after randomisation. Balance was assessed using a composite balance measure comprising five balance tests: feet apart, feet together, semi-tandem (heel of one foot beside the big toe of the alternate foot), tandem and single leg stance. Each test was performed without aid or upper limb support and timed up to a maximum of 10 s (i.e. total range = 0–50 s) with stand-by assistance provided by the assessor. The time each position was able to be maintained was summed to give a total for which the maximal score was 50 s. Participants needed to complete 10 s on each position before progressing to the next position. This test was based on the balance item from the Short Physical Performance Battery [13] and has been found to predict falls in inpatient rehabilitation [14].

Secondary outcomes

Secondary outcomes included mobility, self-reported physical functioning, fall incidence, hospital readmissions and rehabilitation inpatient length of stay. Details on the assessment of secondary outcomes are shown in Supplementary data, Appendix S2 available in *Age and Ageing* online.

Sample size

The sample size (81 per group) was chosen to detect a between-group difference of 3 s (estimated to be 15% of discharge values [15]) for the primary outcome measure (assuming a standard deviation of 9, power = 80%, $P = 0.05$, correlation between baseline and follow-up measures 0.65 and 15% drop out rate). We considered an effect of this size to be clinically worthwhile.

Statistical methods

Data were analysed using Stata version 13 (StataCorp LP, College Station, TX, USA) on an intention-to-treat basis.

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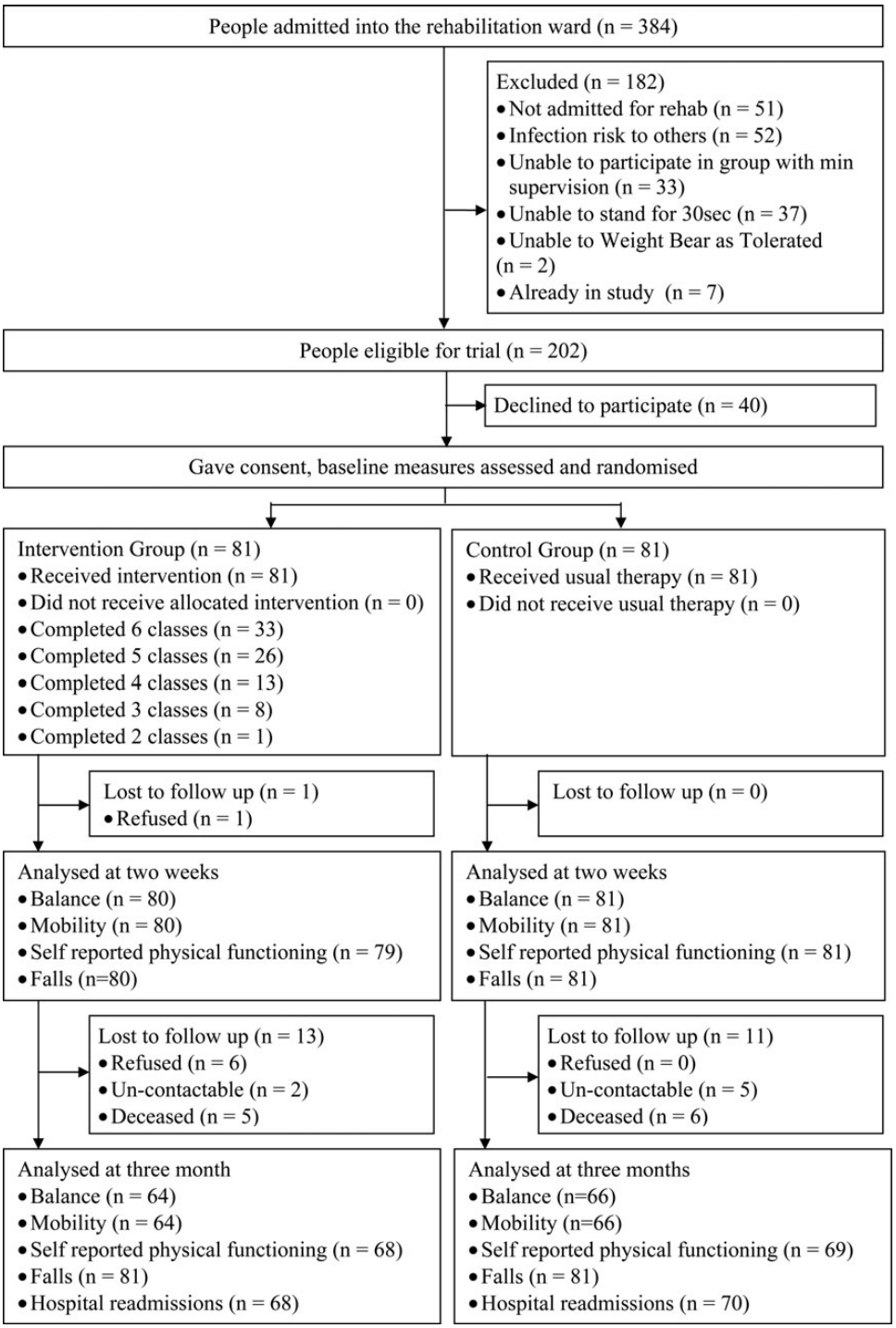

Figure 1. Recruitment and flow of participants through the trial.

All outcomes were initially assessed for normal distribution. Significance was set at $P < 0.05$. For the primary outcomes, between-group differences adjusted for baseline were assessed using linear regression models. This approach was also used for SPPB and AM-PAC. The number of falls and hospital readmissions per person was analysed using negative binomial regression to estimate the differences in rates between the two groups with length of follow-up included as an exposure term in the falls models. Length of stay was compared between groups using zero-truncated negative binomial regression [16].

Randomisation and blinding

A concealed allocation procedure (numbered, sealed opaque envelopes) was used in this study. The allocation schedule was computer generated using randomly ordered blocks of four and six. Participants were randomly assigned to intervention or

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usual-care control groups after consent, and baseline measurements were undertaken. Randomisation schedule and envelopes were prepared and held by a staff member not involved in study recruitment or intervention. Participants and therapists were made aware of group allocation once the envelopes had been opened. Outcome assessors were blinded to allocation.

Results

Participant flow and recruitment

Between May 2011 and June 2012, 384 people were admitted to the general rehabilitation ward at Bankstown-Lidcombe hospital. During this period, 202 people were eligible to participate in the study and 162 consented. The flow of participants through the trial is presented in Figure 1. At 2 weeks, one participant was lost to follow-up. At 3 months, 24 participants were lost to follow-up (13 intervention and 11 control). The mean age of participants was 82 (range: 48–99, SD 7.6). Table 1 and Supplementary data, Appendix S3 available in *Age and Ageing* online show participant characteristics at baseline.

Compliance with trial method

Fifty-nine of 81 (73%) participants in the intervention group completed either five or six 1-h standing balance circuit classes in the 2-week intervention period. Participants attended 92% of classes conducted during their inpatient stays. The average number of classes attended during the 2-week period was 5. Reasons for missed classes are presented in Supplementary data, Appendix S4 available in *Age and Ageing* online. There were no adverse events (e.g. falls) within the classes.

The average number of total repetitions of balance exercises performed by a participant during the standing balance circuit classes was 2,156 (median 2,140, range: 433–4,318). The average number of repetitions performed per class was 427 per person (median 412, range: 149–748).

Primary outcomes

Standing balance performance was better in the intervention group than in the control group at 2 weeks (between-group difference after adjusting for baseline values 3.26 s; 95% confidence interval (CI) 0.84 to 5.70, $P = 0.009$). At 3 months, the extent of the between-group difference was maintained, but it was no longer statistically significant (3.40 s; 95% CI −0.56 to 7.38, $P = 0.092$). Table 2 and Supplementary data, Appendix S5 available in *Age and Ageing* online show the full results.

Secondary outcomes

Short Physical Performance Battery results at 2 weeks were significantly better in the intervention group than in the control group (between-group difference after adjusting for baseline values 1.19, 95% CI 0.52 to 1.87, $P = 0.001$) and at 3 months (1.00, 95% CI 0.00 to 2.00, $P = 0.049$). A change of this size has been suggested to represent a substantial change [17]. The intervention group scored higher than the control group in all three domains of the Short Physical Performance Battery at both 2 weeks and 3 months. The intervention group also performed significantly better on the AM-PAC at 2 weeks (5.39, 95% CI 1.20 to 9.57; $P = 0.012$) but not at 3 months (2.32, 95% CI −3.38 to 8.01, $P = 0.423$) after randomisation.

Table 1. Baseline characteristics of participants by group

Demographics	Intervention ($n = 81$)	Control ($n = 81$)
Age (years), mean (SD)	82.6 (7.3)	81.4 (7.8)
Gender, *n* female (%)	51 (62)	53 (65)
MMSE (score/30), mean (SD)	24.7 (3.1)	25.3 (3.2)

Overall, there was a non-significant increase in falls in the intervention group at 3 months (incidence rate ratio (IRR) 1.13, 95% CI 0.65 to 1.96, $P = 0.662$). At 3 months, there were a total of 60 falls in the intervention group and 54 falls in the control group. More falls in the intervention group occurred after hospital discharge. Between randomisation and 2 weeks, there were a total of 7 falls within the intervention group and 11 falls in the control group (IRR 0.64, 95% CI 0.21 to 1.99, $P = 0.446$). There were a similar number of injuries from falls between the two groups. Supplementary data, Appendix S6 available in *Age and Ageing* online show summary of fall injuries.

The intervention group showed a strong trend towards a shorter length of stay (−4.1 days, 95% CI −8.3 to 0.16, $P = 0.059$). The average length of stay for participants in the intervention group was 22.7 days (standard deviation (SD) 11.8) and for participants in the control group was 26.8 days (SD 21.4).

At 3 months, there were a total of 30 hospital readmissions in the intervention group and 44 in the control group. At 3 months, the risk of readmission was 29% lower in the intervention group compared with the control group (IRR 0.71, 95% CI 0.42 to 1.18, $P = 0.184$), but this did not reach statistical significance. A fall was the primary cause of admission in 8 of the readmissions in the intervention group and 14 of the readmissions in the control group.

Discussion

This randomised controlled trial found that 2 weeks of additional balance exercises delivered as a circuit class in addition to usual therapy resulted in greater improvements in balance at 2 weeks within a general rehabilitation inpatient population. Between-group differences at 3 months did not reach statistical significance ($P = 0.09$). Secondary outcome analysis found that this intervention improved mobility performance at 2 weeks and 3 months and self-reported function at 2 weeks. There was also a trend towards a shorter length of stay. The clinical significance of the between-group difference seen in the primary outcome measure has yet to be formally

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Table 2. Mean (SD) before and after experimental and control interventions and between-group differences (95% confidence interval) at follow-up adjusting for between-group differences for primary and secondary outcomes

	Baseline		2 weeks		3 months		Between-group difference (95% CI) P	
	Intervention ($n = 81$)	Control ($n = 81$)	Intervention ($n = 80$)	Control ($n = 81$)	Intervention ($n = 68$)	Control ($n = 70$)	2 weeks adjusted for baseline	3 months adjusted for baseline
Balance time (s)[a]	24.18 (8.0)	24.22 (8.2)	34.25 (8.1)	30.98 (9.0)	32.12 (11.5)	28.77 (13.1)	3.27 (0.84 to 5.70) $P = 0.009$	3.41 (−0.56 to 7.38) $P = 0.092$
Short Physical Performance Battery Score[a]	3.05 (1.7)	2.95 (1.7)	5.55 (2.38)	4.30 (2.2)	5.86 (3.0)	4.94 (3.1)	1.19 (0.52 to 1.87) $P = 0.01$	1.00 (0.00 to 2.00) $P = 0.049$
AM-PAC—total score[b,c,d]	–	–	105.78 (12.87)	100.39 (13.92)	104.51 (16.75)	102.20 (16.97)	5.39 (1.20 to 9.57) $P = 0.012$	2.32 (−3.38 to 8.01) $P = 0.423$
AM-PAC—mobility score[b,c,d]	–	–	55.04 (12.87)	52.35 (6.53)	53.95 (9.30)	52.52 (9.03)	2.68 (0.66 to 4.71) $P = 0.01$	1.43 (−1.67 to 4.53) $P = 0.362$
AM-PAC—activity score[b,c,d]	–	–	50.74 (8.57)	48.04 (8.94)	50.56 (8.69)	49.68 (9.89)	2.70 (−0.03 to 5.44) $P = 0.053$	0.88 (−2.26 to 4.03) $P = 0.579$
Falls	2.91[e] (4.9)	3.00[e] (3.9)	7[f]	11[f]	60[f]	54[f]	IRR = 0.64 (0.21 to 1.99) $P = 0.446$	1.13 (0.65 to 1.96) $P = 0.662$

IRR, incidence rate ratio from negative binomial regression.
[a] $n = 64$ for intervention group at 3 months, $n = 66$ for control group at 3 months.
[b] Higher scores represent higher function.
[c] $n = 79$ for intervention group at 2 weeks.
[d] $n = 69$ for control group at 3 months.
[e] Total numbers of falls in 12 months prior to admission to study.
[f] Total numbers of falls since randomisation, $n = 81$ for both intervention and control groups.

investigated, but, on the basis of clinical experience, the authors suggest that a difference of this magnitude is likely to be important. The between-group difference in the Short Physical Performance Battery score is of the size that has previously been suggested to be important [17].

The strengths of this study include the use of blinded outcome assessors and very high follow-up rate (99%) at 2 weeks. The results are highly applicable to routine care as the intervention was delivered without additional staff resources to participants with a range of differing diagnoses and levels of physical functioning, including some participants who were initially unable to walk. The classes were run safely with a ratio of up to eight participants to two therapy staff. Participants were able to safely perform a high dosage of challenging tasks aimed at improving balance in the hour allocated for the class. The acceptability of the intervention program to participants is indicated by the high attendance rates (92%) as well as the large number of repetitions of exercise performed in the classes (median 2,140 repetitions over the 2-week period).

Limitations of this study include an inability to ensure that usual therapy was standardised between the two groups, the number of participants who were lost to follow-up at 3 months and the potential for inaccuracy in measuring falls post discharge. Though usual therapy was not standardised, the authors are confident that it was similar between the two groups. Usual therapy in the physiotherapy gymnasium is provided in both a supervised and semi-supervised environment with the emphasis on a high dose of practice. Eleven of the 32 people who did not complete the primary outcome at 3 months had died. As with all self-report measures, there is the chance of variability in reliability of data collection. In particular for this older population, the fall data collected after hospital discharge are limited by the accuracy of self-report. Where possible however, to maximise the accuracy of this outcome, the blinded assessor verified data including checking of falls data with hospital medical records [18] and used proxy respondents for participants who were suspected or confirmed to have cognitive deficits.

The trial was powered to detect a difference in the primary outcome measure and was not powered to detect a difference in falls, readmission rate or rehabilitation length of stay. The primary outcome was a composite standing balance measure that focussed on decreasing base of support, rather than a more ‘dynamic’ balance test involving reaching, stepping or walking. This was because more difficult balance tests may have shown a floor effect and change may have been more difficult to detect. Optimal outcome measure selection for studies of people with poor balance warrants further investigation.

This study confirms the benefit of circuit classes for improving balance and mobility in aged care rehabilitation settings. Both the present study and the study by Gine-Garriga *et al.* [8] found that functional balance exercises delivered in a circuit class are effective in improving balance. Importantly, this study showed an improvement in balance over a 2-week

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intervention period in contrast to 12 weeks in the study by Gine-Garriga *et al.* [8]. Sherrington *et al.* [19] found 5 weeks of two sessions per week of circuit style group exercises resulted in improved mobility and balance in an outpatient setting compared with a waiting list control. No previous study was found that has examined the efficacy of specific balance training on balance for aged rehabilitation inpatients. The results of this trial also indicate that high-dose balance-challenging exercise programs can be safely delivered in a group setting to older rehabilitation patients with multiple co-morbidities.

Overall, the addition of the standing balance circuit classes did not appear to prevent falls after discharge. Positively, Hill *et al.* [20] have shown that a patient-focussed education intervention can result in improved fall prevention behaviour in the month after hospital discharge. It is possible that this standing balance circuit class combined with an education program may be more effective in decreasing falls post discharge from hospital. Furthermore, ongoing group-based circuit exercise, including progressing of the exercises to focus on postural control during walking, may have greater benefits for falls after hospital discharge. Despite this, the decrease in falls over the 2-week period seen in this study is encouraging and requires reproduction in different hospital settings.

Conclusion

Two weeks of 1 h daily standing balance circuit classes, in addition to usual therapy, improved balance in older general rehabilitation inpatients. Encouraging findings on the maintenance of this benefit and on secondary outcomes, including strong trends towards decreased length of stay, suggest that this intervention warrants further investigation.

Key points

- Exercise programs that include balance and coordination exercises are effective for improving balance.
- Two weeks of additional balance exercises delivered within a group environment in addition to usual therapy within a general rehabilitation inpatient setting resulted in greater improvements in balance at 2 weeks.
- A high-intensity challenging balance exercise program can be provided safely in a group environment to older rehabilitation inpatient with high numbers of co-morbidities.

Conflicts of interest

None declared.

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Ethics approval

The South Western Sydney Local Health District Human Research Ethics Committee (HREC) approved this study. All participants gave written informed consent before data collection began.

Trial registration

Australian New Zealand Clinical Trials Registry ACTRN 12611000412932.

Authors' contributions

The standing balance circuit classes were designed by D.T. All authors played a role in the planning and design of the study. D.T. and C.S. were responsible for analysis of data. All authors played a role in writing the manuscript. All authors read and approved the final manuscript.

Supplementary data

Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

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