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Community-based group exercise improves balance and reduces falls in at-risk older people: a randomised controlled trial

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Abstract

Background: recent studies have found that moderate intensity exercise is an effective intervention strategy for preventing falls in older people. However, research is required to determine whether supervised group exercise programmes, conducted in community settings with at-risk older people referred by their health care practitioner are also effective in improving physical functioning and preventing falls in this group.

Objectives: to determine whether participation in a weekly group exercise programme with ancillary home exercises over one year improves balance, muscle strength, reaction time, physical functioning, health status and prevents falls in at-risk community-dwelling older people.

Methods: the sample comprised 163 people aged over 65 years identified as at risk of falling using a standardised assessment screen by their general practitioner or hospital-based physiotherapist, residing in South Western Sydney, Australia. Subjects were randomised into either an exercise intervention group or a control group. Physical performance and general health measures were assessed at baseline and repeated 6-months into the trial. Falls were measured over a 12-month follow-up period using monthly postal surveys.

Results: at baseline both groups were well matched in their physical performance, health and activity levels. The intervention subjects attended a median of 23 exercise classes over the year, and most undertook the home exercise sessions at least weekly. At retest, the exercise group performed significantly better than the controls in three of six balance measures; postural sway on the floor with eyes open and eyes closed and coordinated stability. The groups did not differ at retest in measures of strength, reaction time and walking speed or on Short-Form 36, Physical Activity Scale for the Elderly or fear of falling scales. Within the 12-month trial period, the rate of falls in the intervention group was 40% lower than that of the control group (IRR=0.60, 95% CI 0.36–0.99).

Conclusions: these findings indicate that participation in a weekly group exercise programme with ancillary home exercises can improve balance and reduce the rate of falling in at-risk community dwelling older people.

Keywords: *accidental falls, exercise, aged, balance, physical functioning, general practice*

Background

The role of exercise as a means of reducing falls has been the focus of considerable recent research. Interventions found to be effective include Tai Chi [1], supervised strength and endurance training [2], and home exercise prescribed by a physiotherapist [3, 4] or specially trained nurse [5]. Supervised general group exercise has also been found to be effective in moderating falls risk factors [6], and a recent study involving a factorial design found that those randomised to the exercise intervention suffered significantly fewer falls [7].

However, not all interventions have been successful [8, 9], and it has been suggested that the ineffectiveness of some trials may have resulted from recruitment of subjects at too low a risk of falling for the programmes implemented [5, 10, 11]. Indeed, the recent successful trials have targeted their interventions to those likely to benefit most, i.e. older people with strength and balance deficits [2], women aged 80 years and over [3, 4], and those aged 70 years and over with one or more falls risk factors [10].

From a public health perspective, it is also important to assess the effectiveness of interventions that are acceptable to older people, and sustainable in the long term [11]. Community-based group exercise programmes that are easily accessible, affordable and held at times and frequencies suitable for older people may meet these needs. However, there is inadequate evidence to date to determine whether group exercise targeted to at-risk older people is effective in preventing falls.

With the above issues in mind, we conducted a randomised controlled trial of supervised group exercise involving 163 older people identified as being at risk of falls by a standardised assessment screen administered by general practitioners (GPs) and hospital-based physiotherapists.

Objective

A randomised controlled trial was conducted to determine whether participation in a weekly supervised group exercise programme with ancillary home exercises over one year improves physical functioning, health status and prevents falls in at-risk community-dwelling older people.

Methods

Subjects and recruitment

The subjects were drawn from 601 people aged 65 years and older who attended one of 24 general practice clinics or two acute hospital physiotherapy departments in South Western Sydney, Australia. Subjects were considered eligible for the study if they had one or more physical performance impairments that have been found to be important risk factors for falls that could be addressed by exercise participation; lower limb weakness, poor balance and slow reaction time [12, 13]. Impaired performance was determined by the following screening assessments: an inability to stand from a 45 cm high chair in less than 2 seconds [14]; a need to step to maintain balance when performing a near-tandem balance test [15]; and an inability to catch a rod dropped from above the hand within 300 milliseconds [12].

Subjects were excluded if they had cognitive impairments, degenerative conditions such as Parkinson's disease or a medical condition involving the neuromuscular, skeletal or cardiovascular system that precluded taking part in an exercise program. Figure 1 shows the recruitment process. The subjects were randomised in matched blocks ($n=6$) after the baseline assessment using consecutively numbered opaque envelopes. The South Western Sydney Area Health Service Ethics Committee gave approval for this study, and informed consent was obtained from all subjects prior to their participation.

The exercise intervention

Subjects' randomised to the intervention arm attended a weekly structured exercise group run in a community setting. An accredited exercise instructor trained to provide the same programme led each class. Three instructors in total participated in the study. These classes ran for 1 hour, over four terms for 1 year (37 classes in all).

The class content was designed by a physiotherapist to specifically address physical falls risk factors. After 5–10 minutes warm up including stretching of the major lower limb muscle groups the participants performed exercises designed to improve balance, coordination, aerobic capacity and muscle strength. Functional exercises such as sit to stand practice, weight transference and reaching were an important part of the group exercise. Balance and co-ordination exercises included modified Tai Chi exercises, stepping practice, change of direction, dance steps and catching/throwing a ball. Strength work included using the participants' body weight (e.g. sit to stand, wall press-ups), and using resistance bands, for both the upper and lower limbs. Aerobic activity was addressed by fast walking practice including change of pace and direction. There was a 10-minute cool down where the participants performed gentle stretches, and then in a seated position practised relaxation and controlled breathing. All the exercises were performed to music chosen by the group. The complexity and speed of the exercise and the resistance of the bands were all steadily increased over the four terms. The number of exercise subjects in each group ranged from 6 to 18 (mean=9). A home exercise programme based on the class content was also given to the participants, with diaries to record participation.

The exercise groups also received information on practical strategies for avoiding falls; such as hand and foot placement if a loss of balance occurred. The control subjects were provided with the same written information about falls prevention, but no alternative 'non-exercise' activity.

Physical performance and general health outcome measures

Three assessors blind to treatment status administered the physical performance and general health measure assessments. The subjects were assessed at baseline, and 26 weeks into the trial at the physiotherapy departments at the Liverpool and Bankstown-Lidcombe Hospitals.

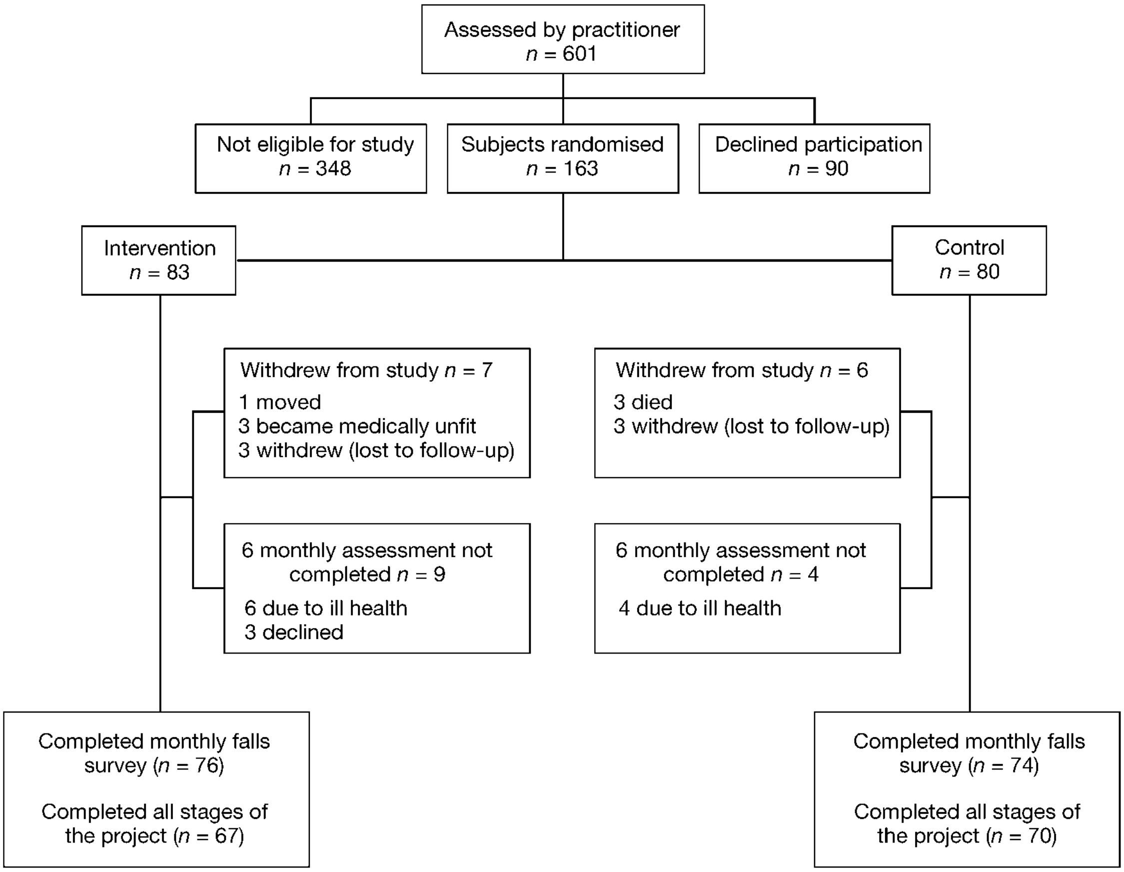

Figure 1. Study design – flow of participants through the study.

Physical performance measures

The physical performance measures were selected because they have been identified as important falls risk factors in previous studies [12, 13, 15–17], are important for performing daily tasks such as rising from a chair and walking [18–20] and because they are salient measures that may be influenced by exercise.

Knee extension strength was measured isometrically using a strap assembly incorporating a spring gauge with subjects seated and the angles of the hip and knee joints positioned at 90°. Ankle dorsiflexion strength was assessed isometrically using a pivoted platform attached to a spring gauge and the angle of the knee positioned at 110°. For both tests, three trials were performed and the greatest force was recorded.

Simple reaction time (SRT) was measured in milliseconds with subjects seated using a light as the stimulus and a foot-press as the response [6]. Subjects had 10 practice trials and 10 test trials, and the average of the 10 test trials was the test measure.

Sway was measured using a meter that measured displacement of the body at the level of the waist [6]. It consisted of a rod attached to the subject at waist level by a firm belt. The rod was 40 cm in length and extended behind the subject. A sheet of graph paper (with a millimetre square grid) was fastened to the top of an adjustable height table that was positioned behind the subject. The height of the table was adjusted so that the rod was horizontal and the tip of a pen (mounted vertically at the end of the rod) could record the movements of the subject on the paper. Testing was performed with subjects standing on the floor and a foam rubber mat (40×40×15 cm thick) with eyes open and eyes closed.

Leaning balance was measured using the coordinated stability test – a balance test that requires subjects to adjust their balance in a steady and coordinated manner when near the limits of their base of support [21]. Step-up ability was measured using the Berg alternate step-up test [20]. Sit-to-stand performance was assessed by asking subjects to rise from a 45 cm high chair five times as fast as possible with their arms folded [14, 18]. Walking speed in ms^{-1} was assessed over a 6-metre distance [20].

Test-retest reliability for all of these physical performance measures has been established in previous studies in similar groups [20–22].

General health status

Items from the Short-Form 36 Health Status Questionnaire (SF-36) were used to provide validated assessments of general health, physical function, vitality and mental health [23]. Activity levels were assessed using the Physical Activity Scale for the Elderly (PASE) [24]. The number of falls for each subject in the year before the commencement of the study were determined by self-report.

Falls surveillance

Falls were defined as 'events which lead to the conscious subject coming to rest inadvertently on the ground' [25]. Injurious falls were defined as falls that resulted in bruises, strains, cuts and abrasions, back pain and fractures. Falls frequency and severity were monitored for one year in both groups with postal surveys sent to the subjects at the end of each calendar month. If not returned within 2 weeks, further contact was made by telephone interview.

Statistical analysis

The data were analysed on an intention to treat basis, using SPSS v 9.01 [26] and STATA 7 statistical software [27]. Variables that were not normally distributed were transformed using natural logarithm (sway, walking velocity), square root (strength) or inverse functions (reaction time, sit-to-stand and Berg balance scores) before comparisons between the groups were made. Comparisons of group characteristics and baseline scores were undertaken using a Chi Square test for differences in proportions and Student's *t*-tests for differences in means. The continuous physical performance and scaled SF-36 scores at the 6-month retest were compared by forced entry multiple linear regression analysis, with baseline scores and experimental group included as independent variables in the models. This analysis procedure provides a more precise indication of the treatment effect than provided by group×time ANOVAs [27]. The Mann-Whitney *U* test was used to compare the number of errors by subjects on the coordinated stability test at baseline and 6 months. The physical performance measures were assessed at 6 months as it has been shown that this is a sufficient period to achieve the beneficial effects of an exercise program, with no or only minor improvements occurring after this period [6]. We compared the number of falls over the 12-month follow-up period in the two groups by calculating relative risks and incidence rate ratios using negative binomial regression models [5, 27].

Results

Baseline characteristics

Table 1 shows the demographic, health, activity and physical performance characteristics of the intervention and control groups at the beginning of the trial. The groups were similar in all measures with the exception of one sway measure (eyes open, foam) where the exercisers performed better than the controls.

Exercise adherence

Of the 37 exercise classes offered, the median number attended by the exercise group subjects was 23 – range 0–36. Twenty-eight subjects (33.7%) attended 30 or more classes. Ninety-one percent of the subjects who were still attending exercise classes at the end of the trial were performing the home exercise program at least once a week, with 13% performing the exercises daily.

Physical functioning, health status and activity outcome measures

Table 2 shows the baseline and 6-month retest scores for the physical functioning, health status and activity measures for the intervention and control groups. The exercise group performed significantly better than the controls in three of the six balance measures; postural sway on the floor with eyes open and eyes closed and coordinated stability. The groups did not differ on the strength, reaction time and walking speed tests or the fear of falling, SF-36 or PASE measures.

Falls

Falling rates and the number and proportion of intervention and control subjects who reported falls and falls injuries within the 12-month trial period are shown in Table 3. The falling rate in the intervention group was significantly (40%) lower than that of the control group. This was also reflected in a significantly lower proportion of subjects in the intervention group reporting two or more falls. There were also 34% fewer injurious falls reported in the intervention group compared with the control group and lower proportions of exercise subjects who reported at least one or two or more injurious falls. However, these levels did not reach statistical significance. Adherence to the exercise programme, measured by the number of classes attended by intervention subjects (categorised in quartiles) was not related to the reduction in falls in this study population ($-\chi^2=1.50$, df=3, $P=0.68$).

Discussion

The study findings indicate that participation in a weekly group exercise programme with ancillary home exercises reduces the rate of falling in at-risk community dwelling older people. Although of only relatively low intensity, two factors in the study design may have contributed to its success in this regard. Firstly, the subjects had reduced physical functioning as identified with validated assessments of strength, balance and reaction time. Thus the programme was targeted to a group that was at increased risk, and in consequence likely to benefit most from the

Table 1. Demographic, health, and physical performance characteristics of intervention and control groups at baseline

	Intervention $n=83$	Control $n=80$
Female (%)	58 (69.9%)	51 (63.8%)
Mean age (SD)	74.4 (4.9)	75.4 (6.0)
Live alone (%)	25 (30.1%)	19 (23.8%)
English main language (%)	75 (90.4%)	71 (88.8%)
Medications (%)		
Four or more	46 (55.4%)	33 (41.3%)
Central nervous system drugs	18 (21.7%)	13 (16.3%)
Antihypertensive drugs	43 (51.8%)	38 (47.5%)
Medical history (%)		
Stroke	8 (9.6%)	8 (10.0%)
High blood pressure	48 (57.8%)	41 (51.3%)
Osteoporosis	20 (24.1%)	12 (15.0%)
Hip fracture	2 (2.4%)	2 (2.5%)
Falls		
Fell in last year	36 (43.4%)	33 (41.3%)
Afraid of falling (%)	14 (16.9%)	9 (11.3%)
SF-36 scores – mean (SD)		
General health	59.7 (20.7)	65.2 (21.3)
Physical functioning	63.6 (23.2)	69.8 (20.1)
Vitality	58.0 (20.5)	58.1 (23.0)
Mental health	75.5 (17.5)	78.0 (17.1)
Physical Activity Scale – mean (SD)	157.9 (46.3)	154.9 (47.2)
Balance		
Perceive balance is steady	21 (25.3%)	21 (26.3%)
Alternate step-up test – mean secs (SD)	12.2 (4.7)	12.4 (4.2)
Sway on floor, eyes open – mean mm (SD)	63.3 (41.1)	62.7 (40.1)
Sway on floor, eyes closed – mean mm (SD)	97.6 (56.5)	103.8 (72.5)
Sway on foam, eyes open – mean mm (SD)	189.2 (91.7)*	244.5 (135.0)
Sway on foam, eyes closed – mean mm (SD)	401.1 (163.4)	417.0 (164.1)
Coordinated stability score – median errors (IQR)	5 (11.5)	7 (11)
Strength		
Sit to stand time – mean secs (SD)	14.8 (5.2)	15.1 (4.3)
Knee – mean kg force (SD)	24.6 (10.3)	25.1 (11.1)
Ankle – mean kg force (SD)	8.3 (4.0)	8.5 (4.0)
Reaction time – mean ms (SD)	364 (78)	380 (78)
Walking speed over 6m – mean s (SD)	6.4 (2.0)	6.3 (2.4)

*$P=0.01$.

intervention. Secondly, the programme placed considerable emphasis on balance exercises. As with the successful interventions conducted by Campbell *et al.* [3–5], the programme was devised by a physiotherapist to specifically address training in functional activities of daily living requiring good balance, such as weight transfers, reaching and rising from a chair. However, unlike the Campbell *et al.* study, this programme was conducted as a group activity and led by experienced exercise instructors. The current findings therefore indicate that targeted exercise programmes can also be successfully carried out in a community setting and adds further weight to the conclusions of the meta-analysis of the FICSIT trials which found that exercise interventions that contain a balance component are the most effective programmes for preventing falls in older people [8].

In addition to the reduced falling rate in the exercise subjects, there was also a trend indicating fewer injurious falls in the intervention group. Parallel decreases between all falls and injurious falls have also been observed in other studies [3–5], and it appears that the lack of a significant association in this trial was due to the relatively small sample size with consequent low statistical power for this outcome measure.

The overall reduction in falls of 40% compares favorably with the FICSIT interventions that contained a balance training component [8] and multifaceted falls prevention interventions [10]. However, multifaceted studies have a limitation in that it is not possible to determine the independent effects of component parts of their intervention packages [9, 28]. This study is therefore helpful, in that it provides information on the effectiveness of a single low-cost and replicable intervention in an at-risk population.

In terms of mediating factors, the intervention subjects showed significant improvements in three balance tests at the 6-month retest. The improved performance in the coordinated stability test may indicate greater

Table 2. Outcome variables at baseline and 6 months retest

	Baseline		Retest	
	Intervention (n=67)	Control (n=70)	Intervention (n=67)	Control (n=70)
Afraid of falling (%)[a]	11 (16.4%)	9 (12.9%)	5 (7.5%)	6 (8.6%)
SF-36 scores – mean (SD)[b]				
General health	60.3 (20.3)	65.5 (21.4)	62.1 (20.1)	65.7 (21.6)
Physical functioning	64.6 (22.5)	70.6 (20.0)	70.6 (20.7)	70.9 (21.1)
Vitality	59.0 (19.1)	57.7 (22.6)	63.5 (20.4)	62.9 (24.0)
Mental health	74.5 (18.5)	78.0 (17.6)	76.8 (16.5)	80.4 (19.5)
Physical Activity Scale – mean (SD)[b]	163.5 (44.7)	154.4 (46.1)	158.2 (37.7)	152.8 (40.3)
Sit to stand time – mean s (SD)[b]	14.9 (5.2)	15.2 (4.5)	13.3 (4.8)	14.3 (5.8)
Strength – mean kg force (SD)[b]				
Knee	24.9 (10.0)	25.0 (11.3)	27.3 (9.7)	27.1 (11.2)
Ankle	8.6 (3.8)	8.4 (4.2)	9.0 (3.9)	8.6 (3.9)
Alternate step-up test – mean s (SD)[b]	12.0 (4.7)	12.5 (4.3)	11.1 (4.2)	13.1 (6.6)
Sway – mean mm (SD)[b]				
Floor, eyes open	65.9 (43.7)	62.6 (41.7)	62.4 (34.1)*	77.2 (41.7)
Floor, eyes closed	96.1 (56.9)	105.7 (76.0)	85.4 (51.2)*	117.2 (67.2)
Foam, eyes open	198.7 (95.0)	248.6 (137.8)	181.1 (77.3)	225.5 (112.0)
Foam, eyes closed	401.9 (156.2)	421.4 (158.4)	340.4 (134.2)	390.8 (160.8)
Coordinated stability score – median errors (IQR)[c]	5 (11)	8 (11)	3 (12)*	8 (7)
Reaction time – mean ms (SD)[b]	359 (76)	382 (82)	363 (82)	366 (68)
Walking speed in ms^{-1} over 6 m – mean s (SD)[b]	6.3 (1.9)	6.2 (2.2)	6.1 (1.8)	6.1 (2.3)

*$P<0.01$.

[a]Follow-up values compared by multiple logistic regression with adjustment for baseline score.

[b]Follow-up values compared by multiple linear regression with adjustment for baseline score.

[c]Follow-up values compared using the Mann–Whitney U test.

Note: High scores on the sit-to-stand time, alternate step, sway, coordinated stability, reaction time, and walking speed tests, and low scores in the SF-36 scale, PASE scale and strength tests indicate impaired performance.

Table 3. Falls in the 12 month trial period

	Intervention (n=76)	Control (n=74)	Risk (95% CI)
Falls			
Rate	0.605	0.946	0.60[a] (0.36–0.99)
One or more	27 (35.5%)	37 (50.0%)	0.71[b] (0.49–1.04)
Two or more	8 (10.8%)	18 (24.3%)	0.44[b] (0.21–0.96)
Falls injuries			
Rate	0.395	0.541	0.66[a] (0.38–1.15)
One or more	22 (28.9%)	28 (37.8%)	0.77[b] (0.48–1.21)
Two or more	6 (7.9)	10 (13.5)	0.58[b] (0.22–1.52)

[a]Incident rate ratios calculated for comparing the rate of falls and injurious falls between the groups.

[b]Relative risks calculated for comparing the number of intervention and control subjects who suffered falls and falls injuries.

functional balance control as this test assesses subject's ability to adjust their balance in a steady and controlled manner when near the limits of their base of support [21].

The programme was not effective, however, in improving strength, increasing activity levels outside the classes or improving health status as measured by five SF-36 scales. In a previous study that used a similar exercise intervention, Lord *et al.* [6, 29] found improvements in strength, reaction time and walking speed in addition to improvements in balance. The lack of improvement in these areas in this study is likely to be due to the change in emphasis to balance-related exercises in the current program, and a less frequent programme.

This study involved health practitioners in the process of participant assessment and recruitment. The support of GPs, in particular, is likely to have assisted participation as it has been reported that older patients seek advice and support about physical activity from their physicians [30], and are more likely to participate in regular physical activity if they receive such advice [31]. As more than 90% of older people visit their GP each year [32], GPs are in an ideal position to both identify older people at risk of falls and support exercise participation where appropriate. The simple assessment tool used in this study may assist in identifying older people likely to benefit from an exercise intervention of this nature.

The programme was implemented using existing services and facilities in the community, so is likely to be sustainable and transferable to other settings. The level of satisfaction with the programme was high in that 63 of the 83 subjects randomised to the intervention (76%) continued participating in the exercise classes after the trial was completed. Thus it presents a programme that meets many of the five criteria of the RE-AIM model [11] of effective health promotion interventions, particularly efficacy, adoption, implementation and maintenance.

It is acknowledged that the study has certain limitations. Firstly, it is possible that factors other than the exercises may have played a role in the lower falling rate observed in the intervention group. The control group did not take part in an equivalent non-exercise activity, so there is the potential that the educational component of the programme may have contributed to behavioural changes and subsequent lower rate of falls reported in the exercise group [2]. Secondly, due to the relatively low intensity of the programme, it may have been instructive to have also measured the physical performance and health related measures at 12 as well as at 6 months to determine whether benefits were accrued over this longer period. Finally, the inclusion of a cost benefit analysis would have been beneficial, but such an analysis was beyond the resources of the study.

In conclusion, the findings indicate that participation in a weekly group exercise program with ancillary home exercises improves balance and reduces the rate of falling in at-risk community dwelling older people. As the programme used existing community services and facilities it is likely to provide a model for an effective and sustainable public health intervention.

Key points

- GPs and physiotherapists can be engaged in identifying older people at-risk of falling in the course of their usual care and referring them to exercise interventions.
- Participation in a weekly group exercise programme with ancillary home exercises can improve balance and reduce the rate of falling in at-risk community dwelling older people.
- The programme was implemented using existing services and facilities in the community, so is likely to be sustainable and transferable to other settings.

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