Economic evaluation of a community based exercise programme to prevent falls

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Abstract

***Objective*—To assess the incremental costs and cost effectiveness of implementing a home based muscle strengthening and balance retraining programme that reduced falls and injuries in older women.**

***Design*—An economic evaluation carried out within a randomised controlled trial with two years of follow up. Participants were individually prescribed an exercise programme (exercise group, n=116) or received usual care and social visits (control group, n=117).**

***Setting*—17 general practices in Dunedin, New Zealand.**

***Participants*—Women aged 80 years and older living in the community and invited by their general practitioner to take part.**

***Main outcome measures*—Number of falls and injuries related to falls, costs of implementing the intervention, healthcare service costs resulting from falls and total healthcare service costs during the trial. Cost effectiveness was measured as the incremental cost of implementing the exercise programme per fall event prevented.**

***Main results*—27% of total hospital costs during the trial were related to falls. However, there were no significant differences in health service costs between the two groups. Implementing the exercise programme for one and two years respectively cost $314 and $265 (1995 New Zealand dollars) per fall prevented, and $457 and $426 per fall resulting in a moderate or serious injury prevented.**

***Conclusions*—The costs resulting from falls make up a substantial proportion of the hospital costs for older people. Despite a reduction in falls as a result of this home exercise programme there was no significant reduction in healthcare costs. However, the results reported will provide information on the cost effectiveness of the programme for those making decisions on falls prevention strategies.**

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Every 100 women aged 80 years and older living in the community will sustain 100 falls in any one year.[1] Falls have serious consequences for older people and adversely affect health, function and independence. Falls result in injuries,[2] psychological distress,[3] increased healthcare use[4] and admission to an institution.[5] The economic costs of falls include medical, rehabilitation, and hospital costs and the costs of morbidity and mortality.[6] Costs borne by society as the result of fall injuries are substantial and will increase because of aging of the population.[6–8]

Prevention programmes that included strength or balance training, or both, have been shown to reduce falls.[9–13] Intensive falls prevention programmes are costly to develop, implement and evaluate, but the benefits of interventions may include fewer injuries[13], fewer hospitalisations[14 15] and savings on healthcare costs.[12]

We designed a programme of muscle strengthening and balance retraining exercises as a community health measure to prevent falls. The exercise programme was effective in reducing falls and moderate injuries for up to two years in a sample of women aged 80 years and older.[13 16] In this study we report the results of a cost effectiveness analysis carried out within the same randomised controlled trial.

Methods

STUDY FRAMEWORK

We designed the trial to test the effectiveness and cost effectiveness of the exercise programme in reducing falls and injuries in a group of women aged 80 years and older living in the community. Study numbers were based on the expectation of a 20% reduction in the proportion of women who fell during one year of follow up and allowed for a significance level of 0.05, a power of 0.80, and a drop out rate of 20%. The Southern Regional Health Authority Ethics Committee (Otago) gave ethical approval for the study. Recruitment took place over a six month period in 1995. Women aged 80 years and older from 17 general practices were invited by their general practitioner to take part and were excluded if they were unable to walk around their own residence, were receiving physiotherapy, or were not able to understand the study requirements. Otherwise there were no restrictions on entry to the programme. After one year falls and “moderate” injuries resulting from falls were significantly reduced in the group randomised to receive the exercise programme (n=116) compared with control group participants (n=117).[13]

Participants remaining in the study at the end of the first year were invited to continue in the study for a further year and 71% (152 of 213) agreed. The effectiveness in reducing falls and injuries continued for a second year.[16]

The exercise programme intervention was a set of muscle strengthening and balance retraining exercises and suggestions for a walking plan, individually prescribed by the research physiotherapist during four visits to the person's own home.[13] The exercises took about 30 minutes to complete; participants were expected to exercise three times a week and encouraged to walk for up to 30 minutes on three alternate days.[17] The women randomised to the control group received usual care and an equivalent number of social visits at home and telephone calls by the research nurse.

A cost effectiveness analysis was incorporated in the study design using the control group as the comparator. Costs were assessed from the societal perspective and monetary values were reported in 1995 New Zealand dollars exclusive of government goods and services tax. Cost effectiveness was measured as the cost of implementing the programme, minus any savings in healthcare use, per fall event prevented during one and two years of the trial. One way sensitivity analyses were performed.

HEALTH OUTCOME MEASURES

Falls, falls resulting in injuries

Falls were defined as "unintentionally coming to rest on the ground, floor, or other lower level".[18] Falls were monitored using return addressed, postage paid, tear off monthly postcard calendars to record falls daily. If the card was not returned, research staff telephoned the person. Combining postcards and follow up contact has been found to be the best method for reporting falls.[19] The date and circumstances of any fall and a record of any injuries were recorded by completing a fall event form by telephone. Falls were classified as resulting in "serious" injury if the fall resulted in a fracture, admission to hospital or stitches were required, "moderate" injury if bruising, sprains, cuts, abrasions or reduction in physical function for at least three days resulted, or if the participant sought medical help, and "no" injury. Monitoring stopped only if the person died, or withdrew from the study.

Health status

The Short Form 36 questionnaire (SF-36) was used to estimate components of self perceived health status at entry to the study and after one year.[20]

COST MEASURES

Costs of the exercise programme

The costs of the exercise programme that were the focus of this evaluation were the costs of implementing the programme in the person's home. Although there were costs associated with developing the programme, these costs would not be incurred when replicating the programme. Similarly, we did not include the research costs for evaluating the programme.

The resources used for implementing the programme included those for recruiting participants, the time and transport for the physiotherapist who delivered the programme, programme materials (instruction booklets, ankle cuff weights used during leg strengthening exercises to improve muscle strength), and overhead costs. These resources were provided in addition to existing healthcare services and no services were replaced. The costs of these items were obtained from study records using actual costs when available. We valued the shared institutional costs for programme implementation in the same way as the overhead costs for the hospital services (see below).

Healthcare service costs

We estimated the hospital and other healthcare service costs incurred by participants as a result of a fall, and their total healthcare costs during the time each person was in the study. Healthcare costs for the control group and the exercise group participants were compared to determine whether there had been healthcare cost savings attributable to the exercise programme.

For each fall event we recorded healthcare service use as a result of the fall reported by the participant. Hospital service use by participants during the trial was identified from Dunedin Hospital financial records and the self reported information was used for the healthcare services from other providers.

We used fall related and total actual costs incurred by Dunedin Hospital, the only public hospital (a tertiary teaching hospital) and provider of emergency services, outpatient clinics, and home health services in the area. For each participant these were the hospital inpatient costs, the accident and emergency department costs, outpatient clinic costs, and costs of home care services provided during the time each participant was in the study. Hospital overhead costs (cleaning, heating, lighting, telephone, laundry, food, administration, orderlies, computing, and depreciation on equipment) were incorporated in each cost item. These had been calculated using the accounting convention of the hospital as 35% of observed resource use. Inpatient cost records included the date of admission and discharge and this enabled us to calculate hospital inpatient days.

Cost items were identified as being associated with a fall during the study by investigators blinded to group allocation. We matched the date of the cost record with the date of a study fall event record. In addition, hospital inpatient cost items coded as an accidental fall (International Classification of Diseases, Ninth Revision, Clinical Modification, codes E880 to E888) were investigated to ensure we had not missed any events that met our definition of a fall and resulted in costs. Most outpatient cost records were dated monthly. In these cases a cost was defined as being related to a study fall event if the cost was recorded in the month of the fall or the month after the fall. Cost records were included only if the department and product description indicated that the item was likely to have been used as a result of a fall.

The hospital cost records detailed when a person who had been admitted to hospital as a result of a fall had been discharged to a private nursing home. An estimate of the cost of the resulting nursing home care was taken as the average cost per day to the funder for "high care".[21] To be consistent with our valuation of the hospital costs resulting from falls, the length of care was estimated as the number of

Table 1 Incidence of fall events and follow up times in control and exercise group participants

	Year 1		Year 2	
	Control group (n=117)	Exercise group (n=116)	Control group (n=81)	Exercise group (n=71)
Number of falls	152	88*	68	50†
Falls per 100 person years	134.0	80.9	94.2	85.7
Number of injurious falls	77	33‡	21	14§
Serious	13	12	4	5
Moderate	64	21	17	9
Injurious falls per 100 person years	67.9	30.3	29.1	24.0
Number of falls for which medical care sought	29	27	14	7
Follow up time (person years)	113.44	108.80	72.19	58.33

*Relative hazard for exercise group compared with control group 0.68 (95% confidence intervals 0.52 to 0.90).[13] †Relative hazard over two years 0.69 (95% confidence intervals 0.49 to 0.97).[16] ‡Relative hazard 0.61 (95% confidence intervals 0.39 to 0.97).[13] §Relative hazard over two years 0.63 (95% confidence intervals 0.41 to 0.95).[16]

days from the hospital discharge date to the end of the month after the fall.

For the services not provided by the local hospital an estimate of their actual cost was made. An estimate of the cost for a general practitioner consultation, a medical specialist consultation and visit to a dentist was taken from healthcare data items used in the calculation of the Consumers Price Index, supplied to us by Statistics New Zealand. We also recorded the out of pocket expenses reported by participants.

Cost effectiveness measures
Cost effectiveness was measured as the ratio:

$$\frac{\Delta C}{\Delta E} \quad (1)$$

where ΔC (incremental cost in 1995 New Zealand dollars) is the change in resource use resulting from the exercise programme. The incremental cost of implementing the exercise programme was taken as the total cost of implementing the exercise programme, and not as the cost difference between implementing the exercise and the control group intervention. When the exercise programme is implemented in the future, social visits would not be offered as an alternative. We planned to include estimates for healthcare services in ΔC if these costs or the number receiving hospital care were significantly different between the control and exercise groups. We used this approach because, in this trial where study numbers were based on falls and not on costs, the monetary values of the healthcare costs have no relevance unless they can be shown to be higher or lower as a consequence of the intervention. We measured ΔE (incremental effectiveness) as the difference between the number of falls, and the number of falls resulting in a moderate or serious injury in the control and exercise groups. The actual number of fall events was used and also a standardised measure, fall events per 100 person years. This measure takes into account the variable follow up times for participants in the trial.

Sensitivity analysis
One way sensitivity analyses were carried out by using a range of estimates of the main cost items for implementing the exercise programme to investigate robustness of the cost effectiveness ratios.

The 125th centile of the total implementation costs, the total, and the 75th centile of the total were used when calculating the cost effectiveness ratios to account for the possibility of different cost conditions when replicating the programme in different settings. Four times the distance the exercise instructor travelled was used to give an indication of programme delivery costs in a more widely dispersed community. Double the recruiting costs were used because we felt recruiting may take longer in a different setting. We designed the ankle cuff weights and they were manufactured cheaply in a non-commercial environment. Also, we are now recommending heavier weights per person in our current trials. Therefore the implementation costs were calculated using four times the actual cost of the weights. We used 85% of salaries as an alternative method to using 35% of total costs for valuing overhead costs for programme implementation. This method of valuing overheads is the policy of our university for research project budgets. Given that it is the marginal cost of the programme that is relevant in economic evaluation, we also considered the scenario of no extra overhead costs as it is possible no additional, shared institutional costs would be incurred as a result of running the programme.

Time horizon
Assuming that participants keep exercising, the benefits of the exercise programme will extend past the time each person participated in the study, but the extent of this benefit and longer term compliance rates are uncertain. Given these uncertainties we calculated cost effectiveness ratios for the trial duration only.

STATISTICAL ANALYSIS
All data were analysed on an intention to treat basis using SPSS 6.1.1. There were no deviations from random allocation. Sample size calculations, method of random allocation and assessment blinding, reasons for non-participation, baseline characteristics of participants in the two groups, comparison of those remaining in the study for a second year with those who did not and the flow of participants through the study have been reported previously.[13 16] Differences in the proportion of participants receiving healthcare services in the control group compared with the exercise group were tested using the Fisher's exact or χ^2 test. Student's *t* test was used to compare healthcare service costs, number of hospital days and changes in SF-36 component scores between the two groups. Healthcare costs and hospital days were first converted to their natural logarithm value in order to transform the data from a skewed to a normal distribution.

Results

The mean (SD) age of the women was 84.1 (3.3) years, and ages ranged from 80 to 97 years. Participants took an average (SD) of 3.3 (2.5) prescription medications, 179 (77%)

Table 2 Incremental costs of implementing the exercise programme

Cost item	*Resource use*	*Unit cost ($)*	*Total cost ($)*
Year 1 (n=116)			
Recruiting costs	(Details available from authors)		1 895
Prescribing the programme:			
Exercise instructor time	4 hours/person	16.61/hour	7 707
Exercise instructor transport	2980 km	0.56/km	1 669
Materials for the programme:			
Ankle cuff weights	180 weights	9.85/weight	1 773
Instruction booklet	116 folders, paper	3.71/booklet	430
Participant follow up costs:			
Exercise instructor time	10 min telephoning 4 times/person	16.61/hour	1 285
General practitioner time	Total 1 hour	146.36/hour	146
			14 905
Overhead costs	University of Otago services	35% of total costs	5 217
Total exercise programme implementation costs for year 1			20 122
Year 2 (n=71)			
Exercise instructor time	10 min telephoning two monthly/person	16.61/hour	1 179
Overhead costs	University of Otago services	35% of total costs	413
Total exercise programme implementation costs for year 2			1 592
			$
Average cost per person year 1			173
Average cost per person year 2			22

Average exchange rate in 1995 New Zealand $1.00 = UK £0.42, USA $0.66.

lived alone, 102 (44%) reported a fall in the previous year, and 19 (8%) had a previous hip fracture. The characteristics of the women in the exercise and control groups were well balanced at entry to the trial.

HEALTH OUTCOMES

The number of falls and the number of falls resulting in moderate and serious injuries during the two years of the study are shown in table 1.

The mean change in the SF-36 physical functioning score from baseline to one year was the only SF-36 component score that differed significantly for the two groups. The exercise group participants reported improved physical functioning at one year compared with the control group (mean (SD) score change 4.7 (16.4) and −1.3 (13.6) respectively; difference 6.0; 95% confidence intervals 1.9 to 10.1).

COST OF IMPLEMENTING THE EXERCISE PROGRAMME

The costs for implementing the exercise programme are shown in table 2. The exercise programme cost $173 per person to deliver in year 1 and a further $22 each for the 71 exercise group participants who were in the study for the second year.

HEALTHCARE USE AND COSTS

Healthcare services were used after 22% (77 of 358) falls in the two years of the study (table 1). Of the total hospital inpatient costs for all study participants during the time they were in the study, 27% ($119 528 of $437 188) were costs resulting from falls (table 3).

In this study 90% of the estimated healthcare costs resulting from falls were hospital inpatient and associated health service costs. A further 4% were for those services used as a result of serious injuries and not provided by the local hospital. Estimated costs for injuries we classified as moderate made up the remaining 6% of total healthcare costs resulting from falls.

A further $8198 and $1287 were incurred as a result of a fall in years 1 and 2 respectively for general practitioner visits, dental consultations, private nursing home stays and out of pocket expenses.

Table 3 Hospital costs and inpatient days for participants during the study

	Resulting from falls		*Total*	
	Year 1 (n=233)	*Year 2 (n=152)*	*Year 1 (n=233)*	*Year 2 (n=152)*
Hospital admissions:				
Number (%)	17 (7)	4 (3)	62 (27)	37 (24)
Total cost ($)	97828	21700	286211	150977
Mean (SD) cost per person admitted ($)	5755 (4445)	5425 (4361)	4616 (5330)	4080 (3609)
Median cost ($)	4633	4476	2772	2509
Mean (SD) cost per person ($)	420 (1901)	143 (1066)	1228 (3413)	993 (2488)
Total hospital days	310	50	764	320
Mean (SD) days per person admitted	18.2 (14.4)	12.5 (10.8)	12.3 (14.9)	8.6 (11.0)
Median days	15	9.5	7.5	4
Mean (SD) days per person	1.3 (6.1)	0.3 (2.5)	3.3 (9.4)	2.1 (6.5)
Emergency, outpatient and community services:				
Number (%)	36 (15)	10 (7)	184 (79)	113 (74)
Total cost ($)	14375	4481	113868	81724
Mean (SD) cost per person receiving care ($)	399 (291)	448 (275)	619 (740)	723 (1164)
Median cost ($)	376	337	335	360
Mean (SD) cost per person ($)	62 (184)	29 (130)	489 (704)	538 (1051)

Average exchange rate in 1995 New Zealand $1.00 = UK £0.42, USA $0.66.

Table 4 Cost effectiveness ratios and sensitivity analyses: cost of implementing the exercise programme per fall event prevented in exercise group compared with control group participants

Cost scenario	*After one year ($)*	*After two years ($)*
Cost per fall prevented:		
Total cost of exercise programme	314	265
125th centile total cost of exercise programme	393	331
75th centile total cost of exercise programme	236	199
× 4 travel distance	420	347
× 4 cost ankle cuff weights	427	352
× 2 recruitment costs	354	296
Overhead costs calculated as 85% salaries	395	335
No extra overhead costs incurred	233	196
Adjusted cost per fall prevented*:		
Total cost of exercise programme	379	353
125th centile total cost of exercise programme	474	441
75th centile total cost of exercise programme	284	264
× 4 travel distance	506	462
× 4 cost ankle cuff weights	514	469
× 2 recruitment costs	427	394
Overhead costs calculated as 85% salaries	476	446
No extra overhead costs incurred	281	261
Cost per injurious fall prevented:		
Total cost of exercise programme	457	426
125th centile total cost of exercise programme	572	532
75th centile total cost of exercise programme	343	319
× 4 travel distance	611	558
× 4 cost ankle cuff weights	621	567
× 2 recruitment costs	515	476
Overhead costs calculated as 85% salaries	574	538
No extra overhead costs incurred	339	315
Adjusted cost per injurious fall prevented*:		
Total cost of exercise programme	535	509
125th centile total cost of exercise programme	669	636
75th centile total cost of exercise programme	401	381
× 4 travel distance	715	667
× 4 cost ankle cuff weights	726	677
× 2 recruitment costs	603	568
Overhead costs calculated as 85% salaries	672	643
No extra overhead costs incurred	396	377

Average exchange rate in 1995 New Zealand $1.00 = UK £0.42, USA $0.66. *Calculated using fall events per 100 person years to adjust for the variable follow up times for women in the study.

There were no differences in year 1 between the control and exercise groups in the proportions of participants admitted to hospital as a result of a fall (10 (9%) and 7 (6%) respectively, p=0.616) or receiving outpatient care as a result of a fall (21 (18%) and 15 (13%) respectively, p=0.365). We therefore compared these costs and number of hospital days for the two groups by Student's *t* test using the natural logarithm value. These tests showed that there were no differences between the control and exercise groups for the inpatient costs (mean (SD) cost per person admitted $4621 (3582) and $7374 (5314) respectively, p=0.483), the number of hospital days, or the combined emergency, outpatient clinic, and community services costs in year 1 (mean (SD) cost per person receiving care $414 (318) and $378 (258) respectively, p=0.303), or for outpatient costs in year 2 (mean (SD) cost per person receiving care $451 (207) and $441 (461) respectively, p=0.866). Numbers receiving inpatient care in year 2 were too small to test for significance.

We found no differences in the proportions of participants in the two groups either admitted to hospital for all causes, or receiving outpatient care during the trial, and no differences between the hospital total costs for inpatient or outpatient care, or total number of hospital days.

COST EFFECTIVENESS MEASURES

Cost effectiveness ratios and the sensitivity analyses are shown in table 4. The incremental cost per fall prevented was $314 in year 1, and $265 after two years, and $457 per fall resulting in a moderate or serious injury prevented in year 1 and $426 after two years.

Cost effectiveness ratios were lower after two years than after one year and appeared robust to changes in the cost scenarios.

KEY POINTS

- Falls are the most common cause of injuries in older people.
- The healthcare costs from falls make up a substantial proportion (27%) of the total hospital costs in this group.
- There are few successful falls prevention programmes and even fewer suitable for use as a community health initiative.
- This home based, individually prescribed exercise programme is effective in preventing falls in elderly women living in the community.
- This is a low cost public health programme suitable for widespread implementation.

Discussion

The home based, individually tailored exercise programme resulted in wide ranging benefits for participants receiving the programme. We have reported previously significantly lowered falls risk, lowered risk of moderate injuries, improvements in strength and balance measures, maintenance of physical activity levels and maintenance of falls self efficacy scores as a result of the exercise programme.[13 16] Participants in the study also reported a clinically significant improvement in a quality of life measurement—their self assessed physical functioning. Other health benefits of physical activity have been reported.[22]

Despite the reduction in falls and the fact that falls accounted for just under one third of total hospital costs, there was no significant reduction in healthcare use as a result of the exercise programme. There are a number of explanations for this finding. Firstly, while the exercise programme is demonstrably effective, the falls that were prevented in this study were those resulting in moderate injury. Secondly, study sample size calculations were based on effectiveness and not on cost measures. The distribution of healthcare costs, particularly inpatient costs (at 90%, the dominant healthcare cost of falls), was highly skewed. This means that the cost effectiveness of the programme will vary considerably with small numbers of costly events such as hip fractures.

This falls prevention programme was not shown to save money but the results reported will provide information for those making decisions on falls prevention strategies. We consider cost effectiveness, measured as the incremental cost of implementing the programme per number of fall events prevented, is a useful measure for comparison of programme efficiency with other falls prevention interventions. However, there is little information available at present to enable comparisons with other falls prevention programmes.

We found only two reports of detailed economic evaluations incorporated within a randomised controlled trial.[23 24] Rizzo *et al* reported on the cost effectiveness of a home based, targeted, multifactorial prevention programme that included an exercise component.[23] Intervention group participants received up to 22 home visits by a nurse practitioner or physical therapist. The mean cost per intervention participant was $905 (1993 US dollars; range $588 to $1346). This cost included the cost of developing the programme, and the cost of implementing the programme for one year. Our exercise programme was more cost effective when implementation costs only are considered. Comparing similar results from the two studies, the multifactorial intervention cost $1658 (1993 US dollars; 1995 New Zealand $3675 approximately) to implement per fall prevented and our programme $314 (1995 New Zealand dollars) per fall prevented in year 1. Estimated total healthcare costs (multifactorial intervention, hospital, emergency department, outpatient, home care and nursing home facility costs) gave a mean value $2000 lower and a median value $1000 higher for the intervention than the control group. The authors reported cost effectiveness ratios calculated using mean total healthcare costs (<$0 per fall and per fall resulting in medical care prevented) and using median values ($2150 per fall prevented). However, the difference in total healthcare costs between the groups was not tested statistically.

Salkeld *et al* reported a cost effectiveness analysis of a home assessment and modification programme that successfully reduced falls by 36% in a subgroup of participants in the trial—those with one or more falls in the previous year.[24] Comparison with the control group showed that intervention group participants used, on average, an extra $1805 (1997 Australian dollars) in healthcare resources, but median costs were not significantly different between the two groups. The average cost per fall prevented was $4986 for all participants and $3980 for those who fell in the previous year. The cost effectiveness ratios incorporated all healthcare resource use during the trial.

Whether or not to include total healthcare costs in the cost effectiveness ratios remains a point of contention. In this study the healthcare costs were highly skewed, the sample size was based on falls and not on costs, and there was no difference in these costs between the two groups. Therefore we felt it was not valid to incorporate them in the cost effectiveness ratios.

Other interventions that have proved successful in reducing falls have been two centre based programmes of balance, muscle strengthening and/or endurance exercises[11 12]; gradual withdrawal of psychotropic medication[25]; and a medical assessment with referral if needed, and a home assessment by an occupational therapist, after a visit to an accident and emergency department as the result of a fall.[15] It has not been possible to isolate the successful components of the multifactorial programmes.

Some randomised controlled trials have shown reduced hospital admissions, shorter hospital stays, or fewer participants with health service costs over $5000 (1993 US dollars) as a result of a community falls prevention programme.[12 14 15] Benefits may result from early identification of health problems, referrals made sooner or physically fitter people spending a shorter time in hospital.

There are a number of factors in this study that affect the generalisability of the results. A research team in a university setting was able to devote uninterrupted time to developing, implementing and evaluating the intervention. The exercise programme was implemented by a dedicated, motivated research physiotherapist. When other health professionals act as exercise instructors they will need training and close supervision, which will entail further costs. The age and level of frailty of those who participate and the setting may affect both the costs and effectiveness of the programme.

An important finding of the study was that a substantial proportion (27%) of total hospital inpatient costs for the women during the trial were made up by costs resulting from falls. This indicates the very real potential for cost savings by preventing falls and injuries in this age group. Although it did not result in net savings, our exercise programme was not expensive to implement and resulted in extensive benefits for participants. We recommend that those developing community health programmes for older people consider incorporating an exercise programme designed specifically to reduce falls.

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