Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 1: Randomised controlled trial

M Clare Robertson, Nancy Devlin, Melinda M Gardner, A John Campbell

Abstract

Objectives To assess the effectiveness of a trained district nurse individually prescribing a home based exercise programme to reduce falls and injuries in elderly people and to estimate the cost effectiveness of the programme.
Design Randomised controlled trial with one year's follow up.
Setting Community health service at a New Zealand hospital.
Participants 240 women and men aged 75 years and older.
Intervention 121 participants received the exercise programme (exercise group) and 119 received usual care (control group); 90% (211 of 233) completed the trial.
Main outcome measures Number of falls, number of injuries resulting from falls, costs of implementing the programme, and hospital costs as a result of falls.
Results Falls were reduced by 46% (incidence rate ratio 0.54, 95% confidence interval 0.32 to 0.90). Five hospital admissions were due to injuries caused by falls in the control group and none in the exercise group. The programme cost $NZ1803 (£523) (at 1998 prices) per fall prevented for delivering the programme and $NZ155 per fall prevented when hospital costs averted were considered.
Conclusion A home exercise programme, previously shown to be successful when delivered by a physiotherapist, was also effective in reducing falls when delivered by a trained nurse from within a home health service. Serious injuries and hospital admissions due to falls were also reduced. The programme was cost effective in participants aged 80 years and older compared with younger participants.

Introduction

The frequency, serious consequences, and healthcare costs of falls in elderly people are well documented.[1–5] Randomised controlled trials of single and multiple interventions have shown that falls can be reduced.[6] The effectiveness of these programmes and their costs in usual healthcare settings have not been reported. Our research group developed a home based programme of strength and balance retraining, which was effective in reducing falls and falls resulting in moderate injuries when delivered by a research physiotherapist to a group of women aged 80 years and older living in the community.[7 8]

We have now tested in two healthcare settings the effectiveness and efficiency of the programme when delivered by health professionals previously untrained in prescribing exercise. This first paper reports on the effectiveness and cost effectiveness of the exercise programme in both men and women aged 75 years and older when delivered from an established home health service by a trained district nurse.

Participants and methods

Participant recruitment

We identified potential participants aged 75 years and older from computerised registers at 17 general practices (30 doctors) in the West Auckland area, New Zealand. These patients received a letter from their doctor inviting them to take part in the study. The criteria for exclusion were inability to walk around own residence, receiving physiotherapy at the time of recruitment, or not able to understand the requirements of the trial. Recruiting took place over a six month period in 1998.

The sample size calculation was based on an expected reduction from 0.50 to 0.30 of the proportion of elderly people who fell once or more in a 12 month period, and 20% allowance for dropouts. Our study was approved by the ethics committee of the Health Funding Authority Northern Division.

After written informed consent was obtained and baseline assessments (personal characteristics, health, and function) completed at home by an independent assessor, we randomised 240 participants: 121 to the exercise programme (exercise group) and 119 to usual care (control group).

Intervention

The implementation of the exercise programme was run from a home health service based in a geriatric assessment and rehabilitation hospital. The nurse, who attended a one week training course, delivered the exercise programme in conjunction with her work as a district nurse. The intervention consisted of a set of muscle strengthening and balance retraining exercises

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that progressed in difficulty, and a walking plan.[7] The programme was individually prescribed during five home visits by the instructor at weeks 1, 2, 4, and 8, with a booster visit after six months. The number of repetitions of the exercise and the number of ankle cuff weights (1, 2, and 3 kg; range 0 to 6 kg) used for muscle strengthening were increased at each visit as appropriate. Participants were expected to exercise at least three times a week (about 30 minutes per session) and to walk at least twice a week for a year. Compliance was monitored with postcard calendars similar to those used to monitor falls. For the months when no home visit was scheduled the nurse telephoned participants to maintain motivation and discuss any problems.

Measurement of falls and injuries and health status

Falls were defined as "unintentionally coming to rest on the ground, floor, or other lower level."[9] Falls were monitored for one year in both groups by asking participants to return preaddressed and prepaid postcard calendars for each month. The independent assessor telephoned participants to record the circumstances of the falls and any injuries or resource use as a result of the falls. She remained blind to group allocation.

Fall events were classified as resulting in "serious" injury if the fall resulted in a fracture, admissions to hospital with an injury, 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. The circumstances of "serious" injuries were confirmed from hospital and general practice records. The SF-12 questionnaire was used to estimate self perceived health status at entry to the trial.[10]

Methods used in economic evaluation

We used cost effectiveness analysis to enable comparisons of programme efficiency with other interventions for preventing falls. We considered costs from the societal perspective because of the broad nature of the problems caused by falls, and we reported them in New Zealand dollars according to 1998 prices, exclusive of government goods and services tax. The control group was used as the comparator for the analysis. We measured cost effectiveness as the incremental cost of introducing the programme per fall event prevented during the trial.

The concept of opportunity costs was kept in mind so that all relevant costs—that is, those resources that could have been employed elsewhere—could be included. We performed one way sensitivity analyses.

Costs of the exercise programme

We focused on the costs of implementing the exercise programme. Although there were costs associated with developing the programme, these costs were incurred before the trial and were not incremental to this programme.

Costs for implementing the programme were obtained from trial records and the financial records of the hospital and research group, using actual costs when available. We estimated overhead costs as 21.9% of observed resource use because this was the sector average reported for all hospital and health services in New Zealand for operating costs and overhead expenses in 1998-9.[11]

Resource use and healthcare costs resulting from falls

In a previous trial of the exercise programme we found that 90% of the estimated healthcare costs resulting from falls were for hospital inpatient and associated health service costs.[12] A further 4% were for those services used as a result of serious injuries and were 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.

Therefore to estimate the costs resulting from fall injuries in this trial we restricted measurement to actual costs incurred by the hospitals admitting participants as a result of a fall. For more detail see www.bmj.com.

Calculation of cost effectiveness ratios

We measured cost effectiveness as the ratio ΔC: ΔE, where ΔC (incremental cost) was the change in resource use resulting from the exercise programme.[13]

We measured ΔE (incremental effect) as the difference between the number of falls and the number of falls resulting in moderate or serious injury in the two groups. We calculated cost effectiveness ratios for the duration of the trial only.

Sensitivity analysis

We carried out one way sensitivity analyses by calculating cost effectiveness ratios. We did this with a range of estimates of cost items for implementing the exercise programme to investigate robustness of the ratios to different delivery scenarios.

Statistical analysis

We analysed data on an intention to treat basis. No deviations occurred from random allocation. The mean (SD) time between baseline assessment and the first home visit was 11.5 (6.1) days.

We compared the numbers of falls in the two groups using negative binomial regression models.[14]

Table 1 Characteristics of participants at entry to trial. Values are numbers (percentages) unless stated otherwise

Characteristic	Control group (n=119)	Exercise group (n=121)
Mean (SD) age (years)	81.1 (4.5)	80.8 (3.8)
Aged ⩾80 years	66 (55)	60 (50)
Men	39 (33)	39 (32)
Living arrangements:		
Two or more participants in one home	31 (26)	26 (21)
Living alone	60 (50)	66 (55)
Living in nursing home	—	1 (1)
Fallen in previous year	45 (38)	44 (36)
Medical conditions:		
Parkinson's disease	2 (2)	2 (2)
Stroke	21 (18)	13 (11)
Hip fracture	2 (2)	5 (4)
Knee or hip pain, or both	35 (29)	41 (34)
Mean (SD) scores on SF-12*:		
Physical component	39.1 (11.7)	40.1 (10.9)
Mental component	54.5 (7.9)	54.9 (8.2)
Mean (SD) No of current prescribed drugs	3.1 (2.4)	2.9 (2.3)
Taking psychotropic drugs	25 (21)	21 (17)
Home assistance:		
Cleaning	33 (28)	32 (26)
Showering	4 (3)	—
Meals on wheels	14 (12)	19 (16)

*Score ranges 0–100, lower scores indicate poorer health.

We used Student's *t* test to compare means and Fisher's exact test or c^2 test to compare proportions between groups.

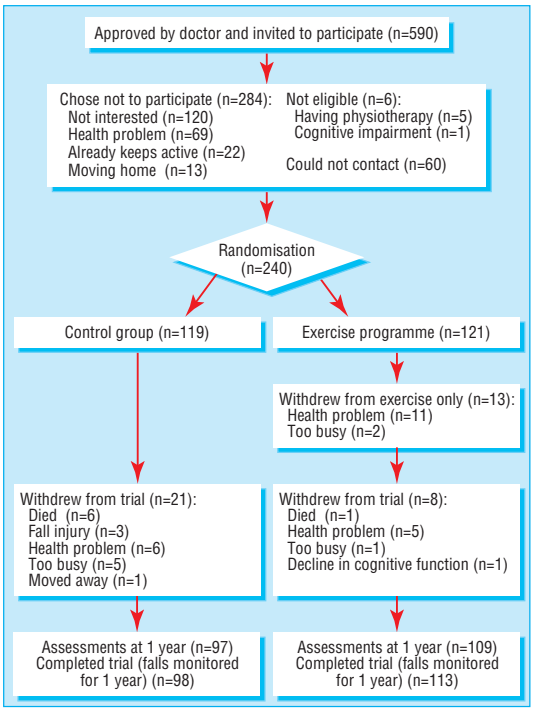
Results

Trial participants and follow up

Table 1 shows the characteristics of participants at entry to the trial.

The figure shows the flow of participants through the trial. More participants from the exercise group than the control group completed the trial (113 *v* 98, difference 11%, 95% confidence interval 3% to 19%). Those who died or withdrew were more likely to have had a fall in the year before the trial and took more drugs at entry to the trial (mean (SD) number 4.3 (2.4) *v* 2.8 (2.3), P = 0.002).

Overall, 43% (49 of 113) of participants who completed the trial carried out their prescribed exercise programme three or more times a week, 72% (n = 81) carried it out at least twice a week, and 71% (n = 80) walked at least twice a week during the year's follow up.



Flow of participants through trial

Falls and fall related injuries

Table 2 shows the actual and standardised numbers of falls and the numbers of falls resulting in injuries during the trial. We found a 46% reduction in the number of falls during the trial for the exercise group compared with the control group (incidence rate ratio 0.54, 95% confidence interval 0.32 to 0.90). The number of falls was reduced in those aged 80 years and older (81 *v* 43 falls for control and exercise groups, respectively; P = 0.007), and there was no difference in participants aged 75 to 79 years. One participant did fall while exercising according to instructions.

Fewer participants in the exercise than control group had a serious injury resulting from a fall during the trial (2 *v* 9, relative risk 4.6, 95% confidence interval 1.0 to 20.7). Nine falls resulted in fractures (five required hospital admission) and three in lacerations requiring sutures. The same numbers of moderate injuries occurred in the two groups.

Table 2 Incidence of fall events and follow up times

	Control group (n=119)	Exercise group (n=121)
No of falls	109	80*
Falls per 100 person years	100.6	68.5
No of injurious falls:	49	42
Serious	9	2†
Moderate	40	40
Injurious falls per 100 person years	45.2	36.0
No (%) of falls for which medical care sought	26 (24)	18 (23)
Mean (SD) follow up time (months)	10.9 (2.7)	11.6 (1.9)‡
Total follow up time (person years)	108.33	116.79

*Incidence rate ratio 0.54 (95% confidence interval 0.32 to 0.90), P=0.019.
†Fisher's exact test, P=0.033.
‡Student's *t* test, P=0.028.

Economic evaluation

The programme cost $NZ52 229 ($NZ432 per person) to deliver to the 121 participants for one year.

Overall, 44 of 189 (23%) falls resulted in the use of healthcare services (table 2). The five people admitted to hospital were all from the control group and were aged over 80 years. The actual cost of these admissions and therefore the hospital cost averted by the exercise programme was $NZ47 818.

Cost effectiveness measures

The incremental cost per fall prevented was $NZ1803. Estimates for the cost per fall with an injury prevented ranged from $NZ5603 to $NZ9437 for the different cost scenarios. When we included cost savings from hospital admissions in the calculation of cost effectiveness ratios, the estimates of the ratios were considerably lower (some indicated cost savings) than for those calculated using the exercise programme costs alone (see www.bmj.com).

The exercise programme was considerably more cost effective for those aged 80 years and older than for the total sample. Estimates for cost effectiveness ratios for implementing the exercise programme in this age group were $NZ682 per fall prevented and $NZ1852 per injurious fall prevented. When hospital costs averted and costs for implementation were both used in the calculations of the cost effectiveness ratios, the net cost of the programme for those aged 80 years and older resulted in cost savings of $NZ576 per fall event prevented and $NZ1563 per injurious fall event prevented.

Discussion

An individually tailored exercise programme delivered at home can prevent falls. Subgroup analysis showed that the programme was effective in those aged 80 years and older but not in those aged 75 to 79 years. Although our trial was not designed to test this, the finding is consistent with our previous finding that falls were not reduced by the exercise programme in a sample of women and men aged 65 years and older who were taking psychotropic drugs.[15] The programme may be more effective in frailer, elderly people than

younger, fitter people because the exercises increase strength and balance above the critical threshold necessary for stability.

As with all age groups only a proportion will be prepared to join an exercise programme, but as shown by the characteristics at trial entry, the participants represented a general population of this age group. Follow up was good, although more people withdrew from the control than exercise group. This may have biased the results against effectiveness because those who withdrew were at a higher risk of falling.

The exercise group had the same number of moderate injuries but fewer serious injuries as a result of a fall than the control group. Injuries resulting in hospital admissions are costly, and reducing injuries such as fractures and lacerations in our trial resulted in cost savings.

Comparison with other interventions for preventing falls

Effectiveness

Implementing this single intervention proved as or more effective in reducing falls than other successful community based programmes reported in the literature.[16–19] Withdrawing psychotropic drugs reduced the risk of falls by 66%, but there were difficulties in recruiting participants to the trial and a high dropout rate.[15] Other community based interventions have not proved successful in reducing falls.[20–23]

Economic efficiency

Little information is available at present for comparing the efficiency of the exercise programme with other interventions aimed at preventing falls. We found only two publications reporting the cost effectiveness of implementing an intervention for preventing falls in the community.[24 25] The exercise programme in our trial was more cost effective than a home based, targeted, multifactorial intervention (total intervention implementation costs per fall prevented $US2668 (at 1993 prices; around $NZ6141) versus $NZ1803, although this figure did include "developmental" costs for the programme).[24] A home assessment and modification programme, successful in reducing falls in those with a history of a fall in the previous year, cost an average of $A4986 (according to 1997 prices; $NZ1.00=$A0.89 in 1997) per fall prevented. This cost effectiveness ratio incorporated all healthcare resource use during the trial.[25]

Some other studies have shown reduced healthcare use or cost savings occurred as a result of a programme to prevent falls.[17 26] Benefits may result from early identification of health problems, earlier referrals, or physically fitter people spending a shorter time in hospital.

Conclusions

In our previous trials, the exercise programme was delivered by a physiotherapist.[7 15] We conclude that a trained district nurse is also an appropriate person to implement the programme. Implementation of the programme worked well when run from an established home health service and required the minimum of input from other staff. We recommend that nurses are trained and supervised by a suitably qualified physiotherapist. Although supervision in the same centre would be less time consuming and less costly, long distance supervision combining site visits and telephone contact worked well. This trial studied one trained nurse in one health service delivering a home based exercise programme. Our second pragmatic trial studies practice nurses trained to deliver the programme from general practices.[27]

What is already known on this topic

Falls are the costliest type of injury among elderly people, and the healthcare costs increase with frequency of falls and severity of injuries

An exercise programme delivered by a physiotherapist was successful in reducing falls and moderate injuries in elderly people

What this study adds

An exercise programme to prevent falls in elderly people worked well when delivered by a district nurse from a home health service in the suburbs of a large city

Researchers, public health administrators, and health practitioners can work together to benefit elderly people in the community

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Contributors: All authors contributed to the study or protocol design, or both, interpreted the data, and wrote the paper. AJC directed the project. MCR managed the project and the data gathering, analysed and interpreted the data, and wrote the paper. MMG trained and supervised the exercise instructor. ND and Dr Paul Scuffham advised on the economic evaluation. AJC and MCR will act as guarantors for the paper.

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Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 2: Controlled trial in multiple centres

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Abstract

Objectives To assess the effectiveness of trained nurses based in general practices individually prescribing a home exercise programme to reduce falls and injuries in elderly people and to estimate the cost effectiveness of the programme.
Design Controlled trial with one year's follow up.
Setting 32 general practices in seven southern New Zealand centres.
Participants 450 women and men aged 80 years and older.
Intervention 330 participants received the exercise programme (exercise centres) and 120 received usual care (control centres); 87% (371 of 426) completed the trial.
Main outcome measures Number of falls, number of injuries resulting from falls, costs of implementing the programme, and hospital costs as a result of falls.
Results Falls were reduced by 30% in the exercise centres (incidence rate ratio 0.70, 95% confidence interval 0.59 to 0.84). The programme was equally effective in men and women. The programme cost $NZ418 (£121) (at 1998 prices) per person to deliver for one year or $NZ1519 (£441) per fall prevented. Fewer participants had falls resulting in injuries, but there was no difference in the number who had serious injuries and no difference in hospital costs resulting from falls in exercise centres compared with control centres.
Conclusions An individually tailored exercise programme, delivered by trained nurses from within general practices, was effective in reducing falls in three different centres. This strategy should be combined with other successful interventions to form part of home programmes to prevent falls in elderly people.

Introduction

Three questions need to be addressed in the development and evaluation of a public health intervention: "can it work?", "does it work in practice?", and "is it worth it?"[1]

In this paper we report the results from the second of two pragmatic trials designed to test the effectiveness and efficiency of a home exercise programme to prevent falls in elderly people. In this trial the programme was delivered from general practices by trained practice nurses to men and women aged 80 years and older. We initiated the trial as a health promotion exercise to evaluate the processes involved and to determine whether the exercise programme would be as effective in reducing falls in routine clinical practice in the wider community as it had been for women in an initial trial in a research setting.[2 3]

Participants and methods

Participant recruitment

We identified potential participants aged 80 years and older from computerised registers at 32 general practices (56 doctors) in seven southern New Zealand centres. These patients received a letter from their doctor inviting them to take part in the study. The criteria for exclusion were inability to walk around own residence, receiving physiotherapy at the time of recruitment, or not able to understand the require-

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