NoFalls

A program of fall reduction exercises for older people

by Susan Vincent

B.App.Sci (Physio) Grad.Dip.Ex.Rehab

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Disclaimer This manual is intended for use by trained exercise professionals (physiotherapists and registered fitness leaders) when conducting the NoFalls Exercise Program. Other exercise and activity workers leading the classes should work under the supervision of a trained leader. Exercise class leaders should consider their insurance needs and make appropriate arrangements.
The exercises themselves are not intended for general distribution without instruction by a trained exercise leader.
To gain the full fall reducing effect, as identified in the published research, the exercises should be delivered as a complete 15 week program, complemented with daily home exercises.

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Finally I thank Ann McCallum and my mother Althea Dunn for their patience during pictorial modelling sessions.

Note on the author

Susan Vincent graduated with as a Master of Applied Science in Physiotherapy from Lincoln Institute, Melbourne, Australia, in 1977. Working in England during the early 1980s, she then continued to develop her career in rehabilitation on returning to Australia. Establishing a neurological physiotherapy practice in 1987, Susan went on to complete a graduate diploma in Exercise for Rehabilitation at Footscray Institute of Technology. A background in neurology and community-based health lead her to implement a pilot balance project in the early 1990s under the auspices of the Whitehorse Division of General Practice, an intervention which culminated in her involvement in the City of Whitehorse NoFalls Program. Susan continues clinical practice as co-principal of the Neurological Rehabilitation Group in Melbourne.

Contents

Introduction

The NoFalls exercise program was designed as one of the interventions in a larger trial run by the Monash University Accident Research Centre and the City of Whitehorse, in the local government area of Whitehorse, in Melbourne, Australia.

Over 1100 people, 70 years and older, were randomly allocated to an exercise, vision assessment or home hazard reduction intervention group, or to a combination of these. Day et al[1] showed that these exercises significantly reduced the number of falls experienced in this population. The effect was greater when the exercises were combined with either or both of the other interventions.

We have produced this manual, in response to significant interest in the exercise program, to facilitate its implementation by appropriately trained exercise leaders.

The manual provides a successful exercise program to promote safety for older adults, by reducing the risk of falls. It assumes a basic level of training in exercise leadership, such as physiotherapists and registered fitness leaders. Note that the fall reducing effect of this program may be diminished unless delivered in its entirety.

- The exercises are designed for a 15 week group program.
- Exercises are clearly explained and illustrated.
- Details of precautions, modifications and progressions are given where necessary.
- Clear details of when to introduce different exercises are
- provided, with a chart giving the duration of exercises within each session.
- The manual self-supports, so can stand during exercise sessions for ready reference.
- Suggestions for a home exercise program are given.
- Pages can be photocopied for use by participants in home exercise programs.

About Balance

Balance can be summed up as the ability to maintain a chosen posture against the effect of gravity. Conversely, it can be viewed as the avoidance of falling. It is a finely tuned interplay of the sensory, processing and motor systems that gives us the freedom to experience a myriad of movements and postures, from sitting at a computer to safely stepping off a kerb to cross the street.

In fact it is only when balance becomes more difficult that we begin to recognise just how essential it is. An adequately functioning balance system is so important to most of our other abilities, that our bodies have developed highly adaptive balance mechanisms and numerous safety systems. These compensate for wear, tear and failure automatically, and we often ignore early signs of balance deterioration.

Information about movement and the environment is supplied to the central nervous system by vision, proprioception and labyrinthine discharges. The successful response to a balance challenge can be observed as one of three postural control strategies: ankle strategy, hip strategy, or stepping strategy (Herdman[2]). Understanding more about these responses assists in understanding balance and the content of this manual.

Ankle strategy employs primarily motion around the ankle joints when balance is challenged. It is currently thought to be most useful when shearing forces between the foot and ground need to be reduced (e.g. walking on a slippery surface).

Hip strategy is characterised by quick flexion and extension forces generated by the muscles around the hip, in an effort to maintain a person's centre of gravity above the base of support. This strategy seems to be better preserved than ankle strategy into older age (Herdman[2]).

Stepping strategy is the action of one or more steps as a response to displacement of a person's centre of gravity outside the base of support. This response is optimal only when balance recovery is no longer possible, but can be seen happening early if a person has lost ability to use the other two strategies (hip and ankle).

Stepping, ankle and hip strategies are not mutually exclusive – when balance is challenged any one, or two or three, may occur. Balance can also be thought of as one of two types: static or dynamic.

Static balance is considered to be the maintenance of body mass above a base of support which is not moving. Dynamic balance occurs when the balance is maintained above a base of support that shifts. Single leg stance is an example of static balance, while walking demonstrates dynamic balance. Usually, stepping strategy is more readily utilised in dynamic balance, while ankle and hip strategy are evident in successful static balance challenges.

Exercise Selection

Studies show that balance can be improved through challenging the balance systems and practising balance strategies, and by improving strength and flexibility.

At the time when the NoFalls program was developed, effective programs included one by Lichtenstein et al[3] using stretching, static balance, active balance, response exercises, walking and cooling down. Lord and Castell[4] had participants exercise with a warm up, walking, flexibility and strengthening exercises, and a rest. Lord et al[5]suggested that ankle dorsiflexion and neuromuscular control correlated with improvement in dynamic stability, and that baseline measures of strength, speed and body sway were significantly associated with dynamic balance.

Based on these studies and findings from the pilot exercise program, different categories of exercises were chosen for the NoFalls program. These emphasise:

- muscle extensibility, and to a lesser degree, joint flexibility
- strength of muscles critical for posture and balance
- proprioception (through the use of rockerboards)
- visual and vestibular stimulation (eye tasks)
- reaction time (rockerboards and group work)
- relearning the elements of a balance task.

Program Design

The table below shows the exercise categories and the suggested time given to the practice of the selected exercise category. The total time for each class is 45–50 minutes. A more detailed breakdown of the timing for each exercise during the program is given at the beginning of the exercise section (pages 14–37).

Exercise category	Session when introduced	Time when unfamiliar	Time when Familiar
Warm up	1	5 minutes	5 minutes
Stretches	1	5-10 minutes	5 minutes
Strength	1	10 minutes	10 minutes
Balance	3	10 minutes	10 minutes
Eye tasks	2	6 minutes	5 minutes
Group activity	1	5–7 minutes	10 minutes
Cool down	1	5 minutes	5 minutes

A 25 minute Home Exercise Program (page 12) is also included.

The appeal of the classes is strengthened by playing suitable music during the session, by the strong emphasis on group and paired work, and by providing tea and coffee afterwards. The social time at the conclusion of sessions also provides time in which leaders are able to talk informally about balance and safety, and other activity opportunities for participants.

Participant Selection

Participants are suitable for the NoFalls exercise program if they:

- are able to walk at least 10–20 metres (with or without a walking aid) without a rest
- do not have severe heart or respiratory disorders
- are mentally alert and able to understand instructions
- have the approval of their general practitioner.

Where a group with very mixed levels of skill and mobility is formed, greater participant satisfaction can be achieved by streaming classes. The more active participants can work at a higher level by using the progressions suggested.

People already participating in moderate to vigorous exercise may find this exercise program does not provide sufficient challenge for them.

Equipment & Facilities

Weights

Have available 0.5 kg to 3 kg weights, in 0.5 increments, able to be attached around the ankle.

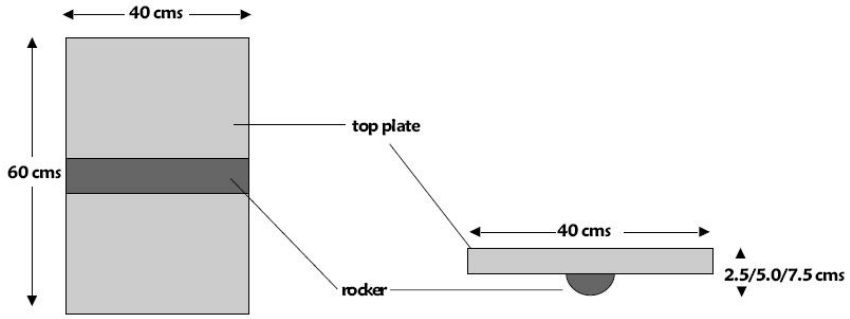
Rockerboards

Three rockerboard heights should be available for progression of difficulty: 2.5 cm, 5.0 cm, 7.5 cm.

Various heights of rockerboards are not commercially available in Australia at present. The City of Whitehorse NoFalls Program constructed rockerboards using the following instructions.

The top plate is constructed as illustrated, using 19 mm dressed pine. The top surface is finished with non-slip paint.

The rocker is constructed using interior handrail (usually hardwood or pine). The handrail must be trimmed to allow the sum of the top plate and rocker to total either 2.5 cms, or 5.0 cms, or 7.5 cms. The top plate and rocker are then securely attached using screws through the top plate into the rocker.



Steps

Steps, either in the environment or as separate equipment, of around 15 cm height need to be provided for some stretch and strengthening exercises

Group Activity

Various accessories can be used, including:

- balloons
- bean bags
- balls, suitable for throwing and catching by older people
- adhesive markers for the floor
- sundry equipment for obstacle course, e.g. chairs, steps,
- rockerboards.

Music

Play suitable music to promote movement and enjoyment.

Space

This program is designed for groups being run by one exercise Leader with a maximum of 15 participants. The space required depends on numbers in each group.

References

1. Day L, Fildes B, Gordon I, Fitzharris M, Flamer H, Lord S. Randomised factorial trial of falls prevention among older people living in their own homes. BMJ 325:128–133. 2002
2. Herdman SJ. Vestibular Rehabilitation. FA Davis Company, Philadelphia. 1994
3. Lichtenstein MJ, Shields SL, Shiavi RG, Burger MC. Exercise and balance in aged women: a pilot controlled clinical trial. Arch Phys Med Rehab 70:138-143.1989
4. Lord R, Castell S. Physical activity program for older persons: effect on balance, strength, neuromuscular control and reaction time. Arch Phys Med Rehab.75:648-652. 1994
5. Lord SR, Ward JA, Williams P, Strudwick M. The effect of a 12-month exercise trial on balance, strength, and falls in older women: a randomized control trial. JAGS 43:11. 1995

List of Exercises

Weekly Program

Exercises for each week of the program are listed below.

Exercise 1 (Warm U p), Exercise 23 (Group Activities), Exercise 24 (Cool Down) should be included every week.

Week	Stretch	Strength	Balance	Eye Task
1	2 – 4	7 – 11		19 – 22
2	2 – 5	7 – 11		19 – 22
3	2 – 5	7 – 11	12,13	19 – 22
4	2 – 5	7 – 11	12, 13 ,14,15	19 – 22
5	2 – 5	7 – 11	12 – 15	19 – 22
6	2 – 5	7 – 11	12 – 15	19 – 22
7	2 – 5	7 – 11	12 – 15	19 – 22
8	2 – 5	7 – 11	12 – 15	19 – 22
9	2 – 5	7 – 11	12 – 15, 16,17	19 – 22
10-15	2 – 5	7 – 11	12 – 17, 18	19 – 22

Home Program

Warm up	Walk on spot	… 2 minutes
Stretches	Calf Hamstrings Hip Flexion (if needed)	… 5 minutes
Strength	Dorsiflexion Quadriceps Gluteals	… 5 minutes
Vision	Head/eye movement with object	… 5 minutes
Balance	Balance recovery Sideways/backwards	… 5 minutes
Cool down	Walk on spot	… 2 minutes

Exercise Timetable

Guide to week-by-week timing of exercises

TOTAL CLASS TIME = 45–50 minutes

WEEK	EXERCISES																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	5	6	3	3			3	3	3	3	3												10	5 minutes
2	5	←	6	→	2	2	←	—	10	—	→								2	2x2	2	2	7	5 minutes
3	5	←	—	8	—	→	←	—	10	—	→	2	2							8	—	→	7	5 minutes
4	5	←	—	8	—	→	←	—	10	—	→	2	2	2						8	—	→	7	5 minutes
5	5	←	—	8	—	→	←	—	8	—	→	←	4	←	2					6	—	→	7	5 minutes
6	5	←	—	8	—	→	←	—	8	—	→	←	6	—	→					5	—	→	7	5 minutes
7	5	←	—	8	—	→	←	—	8	—	→	←	6	—	→					5	—	→	7	5 minutes
8	5	←	—	8	—	→	←	—	8	—	→	←	6	—	→					5	—	→	7	5 minutes
9	4	←	—	5	—	→	←	—	8	—	→	←	6	—	→	4	4			4	—	→	7	4 minutes
10	4	←	—	5	—	→	←	—	8	—	→	←	5	—	→	2	2	4		4	—	→	7	4 minutes
11	4	←	—	5	—	→	←	—	8	—	→	←	5	—	→	←	8	→	←	4	—	→	7	4 minutes
12	4	←	—	5	—	→	←	—	8	—	→	←	5	—	→	←	8	→	←	4	—	→	7	4 minutes
13	4	←	—	5	—	→	←	—	8	—	→	←	5	—	→	←	6	→	←	3	—	→	10	4 minutes
14	4	←	—	5	—	→	←	—	8	—	→	←	5	—	→	←	6	→	←	3	—	→	10	4 minutes
15	4	←	—	5	—	→	←	—	8	—	→	←	5	—	→	←	6	→	←	3	—	→	10	4 minutes

Warm Up

Weeks 1 – 15
5 minutes

Exercise description

Start
Standing.

Action
Walk around at a comfortable pace.

Key points

- Use music to set tempo and mood.

Modifications

Use these alternatives if the activity causes pain, is too difficult, or the use of walking frame makes gait too slow to have warm-up effect.

- In sitting, alternate knee lifts.
- In sitting, punching to the front.
- Walking with a rail, if safer and faster.

Progression

- Reverse directions.
- Walk sideways.
- Walk between obstacles.

2 Calf Stretch

Weeks 1 – 15
2 minutes

Exercise description

Start
Step stance (one foot forward as though taking a step), with both feet facing forward.
Action
Flex front knee until stretch is felt behind the knee or in the calf of the back leg.
Hold for 15–30 seconds.
Stretch each leg in turn.

Key points

- Keep back knee straight.

Precautions

- Should feel a stretch, no pain.
- Use wall/furniture for stability.

Modifications

- Stand with feet level on a slope.
- Adjust angle of slope to feel the stretch.

Progression

- Stand with front of feet on a low step (if comfortable). Drop heels till stretch is felt.

3 Hamstrings Stretch

Weeks 1 – 15
2 minutes

Exercise description

Start
Place heel of one foot on a small stool.

Action
Gently lean forward at hips until stretch is felt in back of the thigh.
Hold for 15–30 seconds.
Stretch each leg in turn.

Key points

- Keep knee straight.
- Keep back straight.

Precautions

- Should feel a stretch, no pain.
- Use wall/furniture for stability.
- Beware if participant has back pain.

Modifications

- Sit on a chair with one leg bent and the other leg straight. Keeping the back straight, lean forward until stretch is felt.

4 Hip Flexor Stretch

Weeks 1 – 15
2 minutes

Exercise description

Start
Stand with feet together, using w all or bench for balance.
Action
Move one leg back to feel a gentle stretch in the front of the hip.
H old for 15–30 seconds.
Stretch each leg in turn.

Key points

- Should feel a stretch, no pain.

Precautions

- Take care not to arch the back.

Modifications

- Sit on side edge of a chair. Keep one leg bent with foot on the floor. Move the other leg back along the side of the chair, until stretch is felt over front of the hip.

5 Quadriceps Stretch

Weeks 2 – 15
2 minutes

Exercise description

Start
Stand with support in front and a chair behind.

Action
Bend knee and lift foot up to rest on the chair.
Stretch is felt in front of the thigh.
Hold for 15–30 seconds.
Stretch each leg in turn.

Key points

- Should feel a stretch, no pain.

Precautions

- Use a lower chair or step if norm al chair is too high.

Modifications

- Sit on side edge of a chair. Keep one leg bent with foot on the floor. Bend the other knee back and grasp the ankle until stretch is felt.

6 Trunk Rotator Stretch

Weeks 2 – 15
2 minutes

Precautions

- Should feel a stretch, no pain.
- Discontinue if exercise causes back pain.

Exercise description

Start
Sit towards the front edge of a chair with arms in front of the chest.
Action
Turn first to one side, and then to the other.
H old for 15–30 seconds on each side.

7 Quadriceps Strength

Weeks 1 – 15
2 minutes

Exercise description

Start
Sitting, with weight around ankle.
Action
Straighten knee. Hold for a count of 5.

Key points

- Start gradually. Build up to two sets of 8–12 repetitions comfortably, before increasing weight.

Precautions

- Increase repetitions and weight gradually.

Progression

- Stand facing a step, near a wall or furniture for stability. Step up onto step, leading up and down with the same foot. Then start with the other leg. Move away from wall if confident.

8 Dorsiflexor Strength

Weeks 1 – 15
2 minutes



Exercise description

Start
Stand up straight with a wall behind, heels about 15 cm from the wall.
Action
Allow bottom and shoulders to move backwards, touching the wall simultaneously.
Return to standing, lifting bottom and shoulders off the wall simultaneously.

Key points

- Feel the muscles on the front of the shin tighten to control the movement.
- When done correctly the toes of both feet will lift off the ground.
- Do not use the head to press off the wall.

Modifications

- Move feet toward the wall to make it easier.

Progression

- Move feet away from the wall to make it harder

9 Gluteals Strength

Weeks 1 – 15
2 minutes

Exercise description

Start
Stand with weight around ankle, near wall/ furniture for balance.
Action
Keeping leg straight, lift weighted leg backwards.

Key points

- Focus on tightening the buttock (gluteal) muscle.
- Keep the back straight – movement is relatively small.
- Start gradually. Build up to two sets of 8–12 repetitions comfortably, before increasing weight.

Precautions

- Tighten stomach muscles to prevent back from arching.
- Increase repetitions and weight gradually.

10 Hip Abductor Strength

Weeks 1 – 15
2 minutes

Exercise description

Start
Stand side on to wall/bench with weight around the ankle. Hand on the same or opposite side can be used for stability.

Action
Lift weighted leg sideways.

Key points

- Do not allow the leg to deviate to the front or back.
- Keep body and standing leg aligned and straight.
- Start gradually. Build up to two sets of 8–12 repetitions comfortably, before increasing weight.

Precautions

- Use wall/furniture for stability.
- Increase repetitions and weight gradually.

Modifications

- If correct movement is difficult, remove weight.

Progression

- Increase weight.

11 Calf Strength

Weeks 1 – 15
2 minutes

Exercise description

Start
Stand facing wall/furniture.
Action
Rise up on the toes, lifting the heels off the floor.
Return heels to the floor.

Key points

- Use hands for extra balance only if needed.

Precautions

- Use wall/furniture for stability.

Progression

- Use one leg at a time.

12 Side-to-Side Balance

Weeks 3 – 15
2 minutes

Exercise description

Start
Stand with one foot on each side of the rocker, feet parallel.
Action
Rock the board side to side.

Key points

- Control board so edges touch the floor gently.

Precautions

- Commence the activity close to a wall/furniture.
- Start with 2.5 cm rockerboard.
- Take care the board does not slide on the floor when stepping on or off – a non-slip mat under the board will reduce slipping.
- Do not move rocker board away from support if balance remains poor.

Modifications

- If the participant finds this activity particularly difficult, stay close and give encouragement.

Progression

- Try to balance board without either edge touching the floor.
- Move the board away from support.
- Progress to 5.0 and 7.5 cm rockerboard.

13 Front-to-Back Balance

Weeks 3 – 15
2 minutes

Exercise description

Start
Stand in step stance position, with one foot at the front of the rocker, the other at the back.

Action
Rock the board forwards and back.

Key points

- Keep bottom tucked in, let legs do the work.
- Control board so edges touch the floor gently.

Precautions

- Commence the activity close to a wall/furniture.
- Start with 2.5 cm rockerboard.
- Take care the board does not slide on the floor when stepping on or off – a non-slip mat under the board will reduce slipping.
- Do not move rocker board away from support if balance remains poor.

Modifications

- If the participant finds this activity particularly difficult, stay close and give encouragement.

Progression

- Try to balance the board without either edge touching the floor.
- Move the board away from support.
- Progress to 5.0 and 7.5 cm rockerboard.

14 Forward Weight Transfer & Step

Weeks 4– 15
2 minutes

Exercise description

Start
Stand in step stance position, with one foot at the front of the rocker, the other at the back. The back edge of the rocker is touching the floor.

Action
Rock the board forwards and step off the front.

Key points

- Keep bottom tucked in, let legs do the work.
- Control board so edges touch the floor gently.

Precautions

- Commence the activity close to a wall/furniture.
- Start with 2.5 cm rockerboard.
- Take care the board does not slide on the floor when stepping on or off – a non-slip mat under the board will reduce slipping.
- Do not move rocker board away from support if balance remains poor.

Modifications

- If the participant finds this activity particularly difficult, stay close and give encouragement.

Progression

- Progress to 5.0 and 7.5 cm rockerboard.

15 Backward Weight Transfer & Step

Weeks 5– 15
2 minutes

Exercise description

Start
Stand in step stance position, with one foot at the front of the rocker, the other at the back. The front edge of the rocker is touching the floor.

Action
Rock the board backwards and step off the back.

Key points
- Keep bottom tucked in, let legs do the work.
- Control board so edges touch the floor gently.

Precautions
- Commence the activity close to a wall/furniture.
- Start with 2.5 cm rockerboard.
- Take care the board does not slide on the floor when stepping on or off – a non-slip mat under the board will reduce slipping.
- Do not move rocker board away from support if balance remains poor.

Modifications
- If the participant finds this activity particularly difficult, stay close and give encouragement.

Progression
- Progress to 5.0 and 7.5 cm rockerboard.

16 Balance Recovery Forwards

Weeks 9 – 15
2 minutes

Exercise description

Start
Stand facing a wall or bench.
Action
Allow body to sway forwards gently until a step has to be taken.

Key points

- Take as many steps as needed to retain balance.

Precautions

- Commence the activity close to a wall or bench for stability.

M odifications

- Use hands if necessary.
- If the participant finds this activity particularly difficult, stay close and give encouragement.

Progression

- As ability and confidence grows, move further away from wall.

17 Balance Recovery Sideways

Weeks 9 – 15
2 minutes

Exercise description

Start
Stand facing a wall or bench.
Action
Transfer weight sideways until a step has to be taken. Take another step in the same direction to uncross legs.

Key points

- Take as many steps as needed to save a fall.

Precautions

- Use hands if necessary.
- Commence activity close to wall/bench for stability.
- Beware if participant has a hip joint replacement.

Modifications

- If the participant finds this activity particularly difficult, stay close and give encouragement.

Progression

- As ability and confidence grows, move further away from wall.

18 Balance Recovery Backwards

Weeks 8 – 15
2 minutes

Exercise description

Start
Stand with back towards a wall, standing about 0.5 metres away.

Action
Allow body to sway backwards gently and slowly until step must be taken.

Key points

- Take as many steps as needed to retain balance.

Precautions

- Commence activity close to wall/bench for stability.

Modifications

- If the participant finds this activity particularly difficult, stay close and give encouragement.

Progression

- As ability and confidence grows, move further away from wall.

19 Point-to-Point, Head Still

Weeks 2 – 15
2 minutes

Key points

- Do activity in pairs with one person acting as a 'spotter', as it is often difficult for the participant to know when the head starts to turn.

- If participant experiences dizziness, leader should advise participant to stop the exercise and consult a physiotherapist or their general practitioner.

Exercise description

Start
Stand facing a focal point at eye level. Place two 'spot points' to each side about 1.2 m apart, or choose two fixed points in the room , such as corner of room, window frame, door frame.

Action
Keeping the head still with nose pointing straight forward, move eyes to the right 'spot point' and then to the left 'spot point'.

20 In & Out

Weeks 2 – 15
2 minutes

Exercise description

Start

Participants work in pairs, facing each other about 2 metres apart. One person holds an object to focus on, such as a paper plate with large spot marked on it.

Action

Participant keeps the spot in focus as partner steps forward and back, bringing the object closer and further away.

Precautions

- If participant experiences dizziness, leader should advise participant to stop the exercise and consult a physiotherapist or their general practitioner.

21 Eyes Still, Head Moves

Exercise description

Weeks 2 – 15
2 minutes

Start
Standing, with eyes focused on specific point at eye level.

Action
Keep eyes focused on the point and move head from side to side.

Key points

- Choose a specific feature as focal point, such as a light switch, corner of door frame.
- Do activity in pairs with one person acting as a 'spotter' to check that participant does not move eyes off target.

Precautions

- If participant experiences dizziness, leader should advise participant to stop the exercise and consult a physiotherapist or their general practitioner.

22 Tracking

Exercise description

Weeks 2 – 15
2 minutes

Start
Standing, choose one point to the left and one to the right.

Action
Turn head to move vision from one point to the other.

Precautions

- If participant experiences dizziness, leader should advise participant to stop the exercise and consult a physiotherapist or their general practitioner.

Progression

- Activity can be practised outside by following the movement of something in the environment, such as a car, a bowl at lawn bowls.

23 Group Activity

Weeks 1 – 15
5 – 7 minutes

Incorporate group decision making in choosing from a range of activities offered. The group may be divided into teams, but promote fun rather than competition.

Activities

1.Pass bean bag/ball around the circle
- in front of the body
- around own body, then pass it on
- between own legs

2.Tap balloon using ball or bat
- call out name and tap to named person
- tap from person to person around the circle

3.Step on spots on floor

4.Kick ball to one another

Modifications (1–4)
- Activities can be done sitting, or standing holding a chair.

5.Passing ball with partner
- Stand back to back. O ne person holds ball in both hands and turns to pass it to partner. Other person takes ball across front of body and passes it back to partner on other side of body.

Modifications
- use a balloon instead of a ball
- use one hand
- turn head to watch balloon pass

6.Obstacle course

For example: weaving between chairs, sit on chair then up and go, throw ball at target, walk sideways along wall. Could do this activity as a form of conga line.

24 Cool Down

Weeks 1 – 15
5 minutes

Key points

- Use music to cue reduced energy output.

Exercise description

Start
Slow walking around, then sitting down.
Action
In sitting do:

- controlled breathing
- full range movements
- muscle relaxation throughout the body

Appendix

Day L, Fildes B, Gordon I, Fitzharris M, Flamer H, Lord S. Randomised factorial trial of falls prevention among older people lilving in their own homes. *BMJ* 325:128 – 133. 2002

Randomised factorial trial of falls prevention among older people living in their own homes

Lesley Day, Brian Fildes, Ian Gordon, Michael Fitzharris, Harold Flamer, Stephen Lord

Abstract

Objective To test the effectiveness of, and explore interactions between, three interventions to prevent falls among older people.
Design A randomised controlled trial with a full factorial design.
Setting Urban community in Melbourne, Australia.
Participants 1090 aged 70 years and over and living at home. Most were Australian born and rated their health as good to excellent; just over half lived alone.
Interventions Three interventions (group based exercise, home hazard management, and vision improvement) delivered to eight groups defined by the presence or absence of each intervention.
Main outcome measure Time to first fall ascertained by an 18 month falls calendar and analysed with survival analysis techniques. Changes to targeted risk factors were assessed by using measures of quadriceps strength, balance, vision, and number of hazards in the home.
Results The rate ratio for exercise was 0.82 (95% confidence interval 0.70 to 0.97, P=0.02), and a significant effect ($P < 0.05$) was observed for the combinations of interventions that involved exercise. Balance measures improved significantly among the exercise group. Neither home hazard management nor treatment of poor vision showed a significant effect. The strongest effect was observed for all three interventions combined (rate ratio 0.67 (0.51 to 0.88, P=0.004)), producing an estimated 14.0% reduction in the annual fall rate. The number of people needed to be treated to prevent one fall a year ranged from 32 for home hazard management to 7 for all three interventions combined.
Conclusions Group based exercise was the most potent single intervention tested, and the reduction in falls among this group seems to have been associated with improved balance. Falls were further reduced by the addition of home hazard management or reduced vision management, or both of these. Cost effectiveness is yet to be examined. These findings are most applicable to Australian born adults aged 70-84 years living at home who rate their health as good.

Introduction

The prevention of falls among older people living in their own homes is an established priority in many countries. The focus of falls prevention research has most recently been on testing interventions. Randomised trials of single interventions among older people living at home have shown that exercise,[1] medication reduction,[2] support services arranged by trained volunteers,[1] and home modifications arranged by occupational therapists[3] are all effective interventions. Trials of multiple interventions among older people living at home have also shown reductions in the risk of falling.[1]

None of the designs of these trials, except one,[2] permitted examination of the effects of each component separately or of any interactive effect between components. The main aim of this randomised controlled trial was to test the effectiveness of, and to explore any interactions between, three interventions to reduce falls among older people.

Methods

Setting and subjects

The study was conducted in the City of Whitehorse, a mainly middle class area of Melbourne, the second largest city in Australia. Potential participants were people aged 70 years and over living in their own home.

Design

The targeted risk factors were strength, balance, poor vision, and presence of home hazards. The selection of the first three risk factors was justified by strong research evidence and their being amenable to intervention through local government. The widespread existence of home hazard modification programmes (albeit with no strong evidence base) justified inclusion of the fourth. A full factorial design was used, with eight distinct groups defined according to the presence or absence of each of the three interventions (fig 1). Seven groups received at least one intervention; the eighth received no intervention until after the study had ended. Participants were randomly assigned by an "adaptive biased coin" technique, rather than simple equiprobable randomisation, to ensure balance of group numbers.[4] Approval was obtained from the Monash University's standing committee on ethics in research involving humans.

Inclusion and exclusion criteria

Participants had to be living in their own home or apartment or leasing similar accommodation and

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allowed to make modifications. Potential participants were excluded if they did not expect to remain in the area for two years (except for short absences); had participated in regular to moderate physical activity with a balance improvement component in the previous two months; could not walk 10-20 metres without rest, help, or having angina; had severe respiratory or cardiac disease; had a psychiatric illness prohibiting participation; had dysphasia; had had recent major home modifications; had an education and language adjusted score >4 on the short portable mental status questionnaire[5]; or did not have the approval of their general practitioner.

Sample size

To detect a 25% relative reduction (or more) in the annual fall rate, with 5% significance level and power of 80%, 914 individuals were needed.[6] A 25% reduction was considered achievable on the basis of other multifactorial studies,[7] and would be of public health significance. The calculation assumed a non-intervention annual rate of 35 falls per 100 people and a "main effects" two-group comparison for each intervention. Allowing for a 20% dropout rate, 1143 subjects were needed.

Recruitment

We sent invitation letters and made follow up telephone calls to 11 120 people aged 70 years and over and registered on the Australian electoral roll for the area (96% of eligible voters in this age group are registered[8]). All Australian citizens aged over 18 years and "of sound mind" are required by law to be registered on the electoral roll. The electoral roll therefore includes almost all older people, some of whom would not be eligible according to our inclusion and exclusion criteria. We could not estimate the eligible number owing to the nature of these criteria. Local publicity and recruitment by general practitioners supported the main strategy.

When compared with data from the national census and health survey for Australians aged over 70 living at home, the study group differed as follows: a higher proportion (46.0% *v* 42.8%) were aged 70-74 years and a lower proportion (7.3% *v* 9.8%) aged over 85 years old; a higher proportion (77.3% *v* 66.7%) were Australian born; a higher proportion (53.8% *v* 32.7%) were living alone; and a lower proportion (46.8% *v* 52.3%) were married. Study participants rated their health status considerably higher (very good to excellent, 62.6% *v* 30.7%), and a higher proportion (13.8% *v* 9.0%) reported taking antidepressant and hypnotic medication.

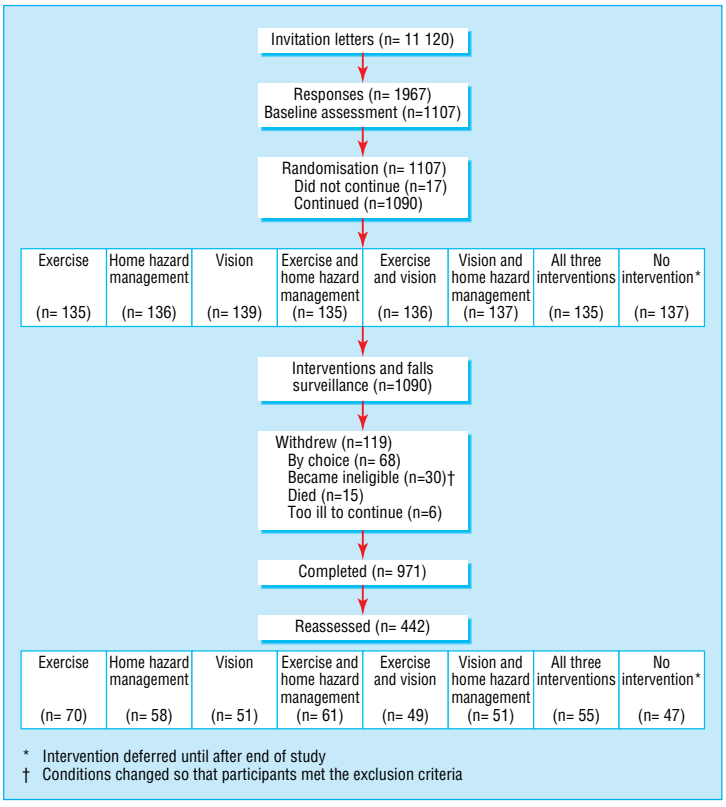

Figure 1 Flow chart showing stages in study protocol and numbers of participants

Assessment

Participants received a home visit by a trained assessor, who was initially blinded to group assignment. After informed consent was obtained, a baseline questionnaire was completed covering demographic characteristics; ability to perform basic activities and instrumental (more complex) activities of daily living[9]; use of support services; social outings and interests; the modified falls efficacy scale[10]; self rated health; and falls and medical history. Current prescription and over the counter drugs were recorded from containers at the participants' homes.

The targeted risk factors were assessed by using the methods outlined in table 1. Participants were then assigned (by computer generated randomisation) to an intervention group by an independent third party via telephone.

After 18 months, the risk factor assessments were repeated in a proportion of participants (n=442) randomly selected by an assessor blinded to the intervention group (we used only a proportion of the participants because resources to reassess the whole study group were not available and this assessment was of secondary importance to the study's main goal). Strength and balance were also measured at the final exercise class of the first 177 participants to complete the 15 week programme, 79 of whom were among the 442 subsequently selected for final reassessment.

Interventions

We sent all participants a letter outlining their assigned interventions, advising of necessary actions.

Strength and balance—Participants attended a weekly exercise class of one hour for 15 weeks, supplemented by daily home exercises. The exercises were designed by a physiotherapist to improve flexibility, leg strength, and balance, and 30-35% of the total content was devoted to balance improvement. Exercises could be replaced by a less demanding routine, depending on the participant's capability. Transport was provided where necessary.

Home hazards—Home hazards were removed or modified either by the participants themselves or via the City of Whitehorse's home maintenance programme. Home maintenance staff visited the home, providing a quotation for the work, including free labour and materials up to the value of $A100 (£37; $54; €60).

Table 1 Risk factor assessment

Risk factor and test used	Description	Measure
Quadriceps strength:		
Spring gauge[11]	Leg extension while seated, with hip and knee angles at 90° with gauge attached by strap around leg 10 cm above ankle	Weight (kg)—best of three attempts on each leg
Balance:		
Postural sway[11]	Two conditions, standing in bare feet: *(a)* on floor in bare feet and (b) on polyether-urethrane foam pad (8.5 x 70 x 62 cm, 23 kg/m^3), using Lord swaymeter to record body displacement at waist level	Log of product of maximal anterior-posterior and lateral sway in each period of 30 s
Maximal balance range[11]	Leaning forwards and backwards without bending at hips, as far as possible, using Lord swaymeter to record anterior-posterior distance moved at waist level	Distance (cm)—best of three attempts
Coordinated stability[11]	With Lord swaymeter attached at waist level and in participant's view, adjust balance by moving upper body (but not feet) to make tracing within convoluted track printed on paper on adjustable height table	Sum of number of times pen tracing failed to stay within track, plus 5 points for each corner cut
Timed "up and go"[12]	Stand from chair with no arms, walk three metres, then walk back and sit down	Time (s)
Vision:		
Visual acuity[13]	Dual visual acuity chart (Australian Vision Charts[14]); uniocular measurement with distance glasses, seated in best lit room, 2 m from chart; reading low contrast letters then high contrast letters	LogMAR calculated from smallest visual angle correctly perceived (line or part line of smallest letters correctly read)
Stereopsis:[15]		
Random dot stereo butterfly test	Identification of butterfly configuration hidden in random dot pattern	Able/not able to identify
Crossed disparity circles	Identification of decreasingly disparate circles	No of last correctly identified set of circles
Field of view[16 17]	OKP glaucoma screening test: series of numbers in spiral configuration with black stimulus spot in middle; uniocular measurement requiring reading of numbers in consecutive order, and identification of any numbers viewed where black spot disappears	Sum of the number of points where black spot disappears; the result is abnormal if any number(s) make the spot disappear
Home hazards:		
Home hazard assessment tool	Walk-through checklist for rooms used in a normal week; focus on steps and stairs, floor surfaces, lighting, bathroom fittings, furniture	Number of hazards

Vision—If a participant's vision tested below predetermined criteria and if he or she was not already receiving treatment for the problem identified, the participant was referred to his or her usual eye care provider, general practitioner, or local optometrist, to whom the vision assessment results were given. Participants not receiving the vision intervention were provided with the Australian Optometrist Association's brochure on eye care for those aged over 40.

Outcome measures

Participants reported falls using a monthly postcard calendar system to record daily falls outcome. Participants not returning their calendar within five working days of the end of each month, and those recording a fall, were followed up by telephone by a research assistant blinded to group assignment.

Analyses

We calculated changes in levels of risk factor by comparing measures at baseline with those at the end of the study for the 442 randomly selected participants. We calculated mean scores for each of the strength and balance measures, number of hazards in the home, and vision measures. Analysis followed the main effects model such that those who were assigned a particular intervention were compared with those who were not—for example, exercise versus no exercise.

We used three way and two way mixed factorial analysis of variance models to determine changes in quadriceps strength and balance measures.[18] We used Fisher's test of exact probability to determine differences in the stereopsis measure between the groups that received vision intervention and those that did not.[18] Paired samples *t* tests were used to assess changes in the remaining measures.[18]

We analysed the time from randomisation to a participant's first fall using Cox's proportional hazards model. Within the factorial design, alternative models were considered and goodness of fit checked using the Grambsch and Therneau test.[19] Effects on the annual fall rate were estimated within the Cox model, confidence intervals being determined using the bias corrected and accelerated bootstrap, with 1000 bootstrap replications for each confidence interval. Analyses were done in EGRET and S-PLUS.

All analyses were performed on an intention to treat basis.

Results

A total of 1107 participants received a baseline assessment and group assignment (fig 1). Demographic characteristics and baseline risk factor measures in the eight study groups were similar (tables 2 and 3). The distribution of group assignment among the 442 participants who were randomly selected for reassessment was representative of the combined study group (fig 1), and demographic characteristics and baseline risk factor measures were similar to those of the combined study group (tables 2 and 3).

Intervention compliance

Of the 541 participants receiving the exercise intervention, 401 started a class. The mean number of sessions attended was 10 (SD 3.8), and 328 participants attended more than 50% of their sessions. The mean

Table 2 Characteristics of participants at baseline

Characteristic	All participants (n=1090)	Range across intervention groups (n=1090)*	Reassessed participants (n=442)†
Mean (SD) age (years)	76.1 (5.0)	75.4-76.5 (4.7-5.5)	75.9 (4.9)
No (%) of women	652 (59.8)	77-93 (55.4-68.4)	261 (59.0)
No (%) of participants living alone	586 (53.8)	68-83 (50.0-61.0)	230 (52.0)
No (%) of participants who had a fall in past month	69 (6.3)	5-11 (3.7-8.1)	31 (7.0)
Mean (SD) score for activities of daily living‡	5.3 (1.1)	5.2-5.4 (0.92-1.2)	5.3 (1.1)
Mean (SD) No of medications	3.4 (2.6)	3.1-3.6 (2.4-2.9)	3.3 (2.6)

SD=standard deviation.
*Highest and lowest recorded among the eight groups. Measures for the remaining groups fall within the range.
†Participants randomly selected for reassessment at end of follow up.
‡Score for instrumental activities of daily living, plus bathing.

Table 3 Targeted risk factor measures at baseline. Values are means (standard deviation)

Measure	All participants (n=1090)	Range across intervention groups (n=1090)*	Reassessed participants (n=442)†
Quadriceps strength in stronger leg (kg)	22.6 (10.5)	21.3-24.0 (9.6-11.8)	23.2 (10.7)
Postural sway on foam pad (log)	2.8 (0.35)	2.7-2.8 (0.32-0.40)	2.7 (0.37)
Maximal balance range (cm)	13.3 (4.5)	13.0-13.7 (4.2-5.0)	13.5 (4.7)
Coordinated stability (sum of errors)	12.4 (8.4)	11.4-13.0 (7.6-9.2)	11.6 (8.0)
Timed "up and go"(s)	11.7 (5.3)	10.9-12.3 (3.6-6.2)	11.6 (5.6)
High contrast acuity in best eye (logMAR)	0.08 (0.19)	0.05-0.11 (0.18-0.21)	0.06 (0.19)
Low contrast acuity in best eye (logMAR)	0.38 (0.19)	0.34-0.42 (0.17-0.20)	0.38 (0.19)
Dot pattern (No of patterns identified)	5.8 (3.2)	5.5-6.1 (3.1-3.4)	6.0 (3.1)
Field of view in best eye (No of correct identifications)	25.2 (3.0)	24.8-25.5 (1.9-4.5)	25.4 (2.7)
Home Hazards (No identified)	9.3 (4.8)	8.3-10.1 (4.3-5.4)	9.6 (4.7)

*Highest and lowest recorded among the eight groups. Measures for the remaining groups fall within the range.
†Participants randomly selected for reassessment at end of follow up.

number of additional home exercise sessions was nine a month.

Of the 543 participants receiving the home hazard management intervention, 478 participants were advised to have modifications in their homes; 363 of these participants received help to do these modifications, which included hand rails fitted (275 participants), modifications to floor coverings (72), contrast edging fitted to steps (72), and maintenance to steps or ramps (66).

Of the 547 participants receiving the vision intervention, 287 were recommended for referral, of whom 186 had either recently visited or were about to visit their eye care practitioner. Of the remaining 101 participants, 97 took up the referral, resulting in 26 having some form of treatment—new or modified prescription glasses (20) or surgery (6).

Risk factors for falls

The measures of strength and balance undertaken at the final exercise class of the first 177 participants showed significant improvements in mean number of errors made during coordinated stability testing (12.2 v 9.7, t=4.45(df=164), $P<0.001$) and in maximal balance range (13.3 cm v 15.1 cm, t=5.26 (df=164), $P<0.001$). Quadriceps strength improved in weaker legs (18.7 v 23.6, t=8.61 (df=161), $P<0.001$) and stronger legs (21.9 v 24.6, t=5.01 (df=161), $P<0.001$). The differential improvement between weaker and stronger legs was significant (F=36.25 (df=1, 161), $P<0.001$).

After 18 months, maximal balance range showed little change in the participants receiving the exercise intervention (decrease of 0.64 cm from mean of 13.7 cm) but decreased over time among the control group (decrease of 1.8 cm from mean of 13.6 cm) (F=6.78 (df=1, 391), P=0.01). This suggests that the exercise intervention slowed the rate of age related deterioration. There were no other significant improvements in the strength and balance measures.

The mean average number of hazards in the participants receiving home hazards intervention decreased from 10.2 to 7.4, compared with a decrease from 9.1 to 7.9 in the control group (F=42.87 (df=1, 440), $P<0.001$).

Visual acuity (high contrast) improved marginally among the non-intervention group (difference in mean value of 0.046) but remained largely unchanged in the intervention group (F=4.69, (df=1, 406), P=0.03). No other differences were seen in the vision measures.

Falls outcome

Falls outcome analysis was based on Cox's proportional hazards model, with the three interventions fitted as binary factors. After fitting a main effects model, the higher order interactions between the three interventions were not significant (three way interaction: P=0.9; two way interactions, combined test: P=0.8), so only results based on a main effects model are reported. The Grambsch and Therneau goodness of fit test for the main effects model was not significant ($P>0.9$). Therefore we based our inferences on this model, in which the effects of the interventions are additive on the log hazard scale. Figure 2 shows the Kaplan-Meier curves for the intervention and non-intervention groups for the three main effects separately. Owing to the factorial design, all subjects contributed to each of the three plots in figure 2. The estimates of the rate ratios, annual fall effects, and number needed to treat to prevent one fall for the single and combined interventions are shown in table 4. For example, the use of exercise and vision correction is estimated to reduce the fall rate by a factor of 0.73 (95% confidence interval 0.58 to 0.91), and the

reduction in falls during one year is estimated at 11.1% (2.2% to 18.5%). Nine people would need to be treated with the exercise and vision intervention to prevent one fall a year.

These results show a significant benefit for exercise alone, and a significant effect ($P < 0.05$) for all interventions in which exercise was combined with other interventions. The strongest effect was observed for all three interventions together.

Discussion

This trial examined the individual contribution of, and interaction between, three interventions to reduce falls. However, no interactive effect of the interventions on falls outcome was observed; rather, the interventions were additive. A study of withdrawal from psychotropic drug treatment combined with exercise also found no interactive effect.[2]

Unlike most previous studies of exercise among unselected older people living in their own homes,[1] these results show that a supervised exercise programme for this group for one hour a week for 15 weeks, supplemented with home exercise for up to 12 months, can reduce falls. The reduction occurred despite relatively poor compliance with the home exercise sessions, which were intended to be daily, but in fact were performed twice weekly on average. This is the shortest programme of the lowest intensity shown to reduce falls. Other successful trials of exercise alone have ranged from group classes twice a week for 15 weeks (supplemented with daily exercise) to home based sessions three times a week for two years.[2 20 21] There was a greater reduction in falls in the programmes with more intense exercise regimes.

The reduction in falls among participants receiving the exercise intervention was associated with improved balance, most prominent on completion of the exercise programme. However, the falls reduction in this group may also have been mediated via social interaction or behavioural change, or both of these, as a result of heightened awareness engendered during the classes.

The limited effect of the other two interventions on falls outcome may be partly related to insufficient intensity of the interventions. The modifications of home hazards may not have been large enough, or may have been of the wrong type, to have affected falls outcome. Certainly, home modifications facilitated by occupational therapists have been shown to reduce the risk of falling among older people with a falls history who live at home.[3]

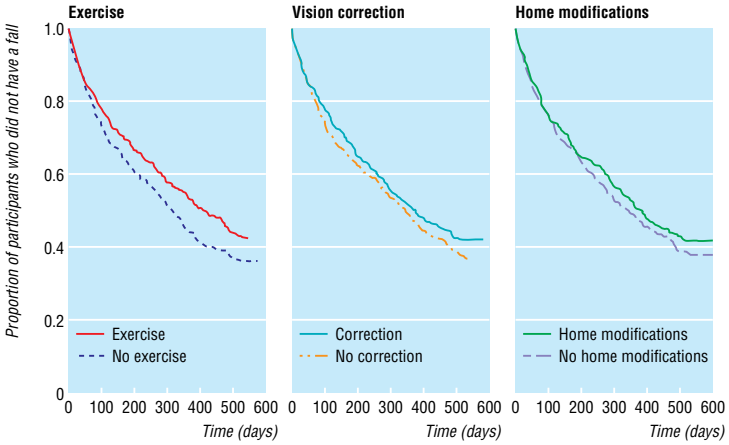

Figure 2 Kaplan-Meier plots showing the probability of remaining fall-free, for each of the three interventions separately. All participants are represented in each of the three graphs

The relatively low numbers of participants who received vision improvement treatment, and the marginal improvement in visual acuity among the non-intervention group, may explain the limited effect on falls outcome among this intervention group. The population studied may already have had many visual problems addressed in the free public healthcare system, since 48% of the intervention group did not require referral. Furthermore, study participants may have been alerted to the potential benefits of the interventions. This would be more likely to influence the results for vision and home hazard management than for exercise, which would have been difficult to replicate without detailed instructions.

As the participants were not blinded to group assignment, the possibility of differences in self reporting bias exists. Participants in the intervention groups may have under-reported falls, and those receiving a more intense intervention, such as the group based exercise programme, may have been even more inclined to under-report. The observed changes in some targeted risk factors supports the conclusion, however, that at least some of the falls reduction was mediated by the interventions.

As the participants differed somewhat from the general older population living at home, the findings are most applicable to older adults living at home with similar characteristics—namely, Australian born, aged 70-84, and rating their health as good to excellent. Other complementary trials may be needed to examine the effectiveness of falls interventions among

Table 4 Effect on falls outcome, single and combined interventions

Intervention	No (%) having at least one fall	Rate ratio		% estimated reduction in annual fall rate (95% CI)	No needed to treat to prevent 1 fall
		Estimate (95% CI)	P value		
No intervention*	87/137 (63.5)	Reference (1.00)			
Exercise	76/135 (56.3)	0.82 (0.70 to 0.97)	0.02	6.9 (1.1 to 12.8)	14
Vision	84/139 (60.4)	0.89 (0.75 to 1.04)	0.13	4.4 (–1.5 to 10.2)	23
Home hazard management	78/136 (57.4)	0.92 (0.78 to 1.08)	0.29	3.1 (–2.0 to 9.7)	32
Exercise plus vision	66/136 (48.5)	0.73 (0.58 to 0.91)	0.01	11.1 (2.2 to 18.5)	9
Exercise plus home hazard management	72/135 (53.3)	0.76 (0.60 to 0.95)	0.02	9.9 (2.4 to 17.9)	10
Vision plus home hazard management	78/137 (56.9)	0.81 (0.65 to 1.02)	0.07	7.4 (–0.9 to 15.2)	14
Exercise plus vision plus home hazard management	65/135 (48.1)	0.67 (0.51 to 0.88)	0.004	14.0 (3.7 to 22.6)	7

*No intervention until after the study had ended.

What is already known on this topic

Multiple interventions are known to prevent falls among older people, but the relative importance of the different strategies is unknown

What this study adds

A weekly exercise programme focusing on balance, plus exercises at home, can help to prevent falls among Australians aged 70 years and over living at home and in good health

Home hazard management and vision screening and referral are not markedly effective in reducing falls when used alone but add value when combined with the exercise programme

people living at home who are aged over 85, in poorer health, or from non-English speaking backgrounds.

The combined effect of all three interventions produced the largest outcome observed. However, the results for the single and dual intervention groups indicate that the exercise programme made the major contribution. On the basis of this and the results of a t'ai chi trial,[1] exercise programmes with a balance improvement component could be considered for wider implementation among unselected older people living at home. Vision correction and home hazard management may be less effective interventions or may be more effective among specifically targeted groups. Cost effectiveness studies of exercise and other successful interventions would provide important information on which to base resource allocation for the prevention of falls among older people living at home.

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Contributors: BF and LD conceived the study and secured funding. BF oversaw implementation of the interventions and LD oversaw the research design and methods. IG selected the factorial design, performed the higher level statistical analyses, and provided overall statistical advice. MF was the data manager, implemented the falls calendar and surveillance system, and conducted statistical analyses, under supervision of LD and IG. HF provided medical advice on study protocols and clinical significance of participant falls and helped with recruitment. SL chose the strength and balance tests and gave advice on their administration and interpretation, in addition to advice on the vision tests. All authors were involved in interpreting the results and drafting and revising the paper. LD and BF are the guarantors.

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1 Feder G, Cryer C, Donovan S, Carter Y on behalf of the guidelines' development group. Guidelines for the prevention of falls in people over 65. *BMJ* 2000;321:1007-11.
2 Campbell AJ, Robertson CM, Gardner MM, Norton RN, Buchner DM. Psychotropic medication withdrawal and a home based exercise programme to prevent falls: a randomised controlled trial. *J Am Geriatr Soc* 1999;47:850-3.
3 Cummings RG, Thomas M, Szonyi G, Salkeld G, O'Neill E, Westbury C, et al. Home visits by an occupational therapist for assessment and modification of environmental hazards: a randomised trial of falls prevention. *J Am Geriatr Soc* 1999;47:1397-402.
4 Smith J, Laidlaw C, Matthews J. *RANDOM.* Computer program. Melbourne: Statistical Centre, Peter MacCallum Cancer Institute, 1996.
5 Pfieffer E. A short portable mental status questionnaire for the assessment of organic brain deficit in elderly patients. *J Am Geriatr Soc* 1975;23:433-41.
6 Casagrande JT, Pike MC, Smith PG. An improved approximate formula for calculating sample sizes for comparing two binomial distributions. *Biometrics* 1978;34:483-96.
7 Tinetti ME, Baker DI, McAvay G, Claus EB, Garrett P, Gottschalk M, et al. A multifactorial intervention to reduce the risk of falling among elderly people living in the community. *N Engl J Med* 1994;331:821-7.
8 Hallett B. *Youth participation in Australia.* Stockholm: Institute For Democracy And Electoral Assistance, 1999. (International forum on youth and democracy.)
9 Lawton MP, Moss M, Fulcomer M, Kleban MH. A research and service oriented multilevel assessment instrument. *J Gerontol* 1982;37:91-9.
10 Hill KD, Schwarz JA, Kalogeropoulos AJ, Gibson SJ. Fear of falling revisited. *Arch Phys Med Rehabil* 1996;77:1025-9.
11 Lord SR, Ward JA, Williams P. The effect of exercise on dynamic stability in older women: a randomised controlled trial. *Arch Phys Med Rehabil* 1996;77:232-6.
12 Podsialdo D, Richardson S. The timed "up and go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1981; 39:142-8.
13 Lord SR, Clark RD, Webster IW. Visual acuity and contrast sensitivity in relation to falls in an elderly population. *Age Ageing* 1991;20:175-81.
14 Verbaken J. *Dual contrast visual acuity chart, chart 5.* Melbourne, Victoria: Australian Vision Charts, 1986.
15 *Random dot stereo butterfly test.* Chicago: Stereo Optical, 1988.
16 *OKP glaucoma screening test.* Hoddesdon, Hertfordshire: Merck Sharp and Dohme Ophthalmic Services, 1989.
17 Domato BE, Ahmed J, Allen D, McClure E, Jay JL. The detection of glaucomatous visual field defects by oculokinetic perimetry: which points are best for screening? *Eye* 1989;3:727-31.
18 Maxwell SE, Delaney HD. *Designing experiments and analysing data.* Belmont, CA: Wadsworth, 1990.
19 Grambsch P, Therneau T. Proportional hazard tests and diagnostics based on weighted residuals. *Biometrika* 1994;81:515-26.
20 Buchner DM, Cress ME, de Lateur BJ, Esselman PC, Margherita AJ, Price R, et al. The effect of strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. *J Gerontol A Biol Sci Med Sci* 1997;52:M218-25.
21 Campbell AJ, Robertson CM, Gardner MM, Norton RN, Tilyard MW, Buchner DM. Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *BMJ* 1997;315:1065-9.

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