BEST - PRACTICE RECOMMENDATIONS FOR PHYSICAL ACTIVITY TO PREVENT FALLS IN OLDER ADULTS

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EXECUTIVE SUMMARY

Overview

- Forty-seven randomised controlled trials have evaluated the effect of exercise as a single intervention to prevent falls – 33 trials have looked at prevention in the community setting and 14 in a range of residential aged care facilities.
- Exercise which specifically challenges balance is the most effective physical activity intervention in preventing falls
- Exercise needs to be undertaken for at least 2 hours per week with the recommendation that exercise continues for life.
- Exercise can be undertaken in a group program or home-based program.
- There is strong evidence which supports exercise as a single intervention to prevent falls in community settings.
- There is limited evidence which supports exercise as a single intervention in residential aged care facilities.
- There is some evidence that exercise can be effective as part of a multifaceted approach to prevent falls in both community and residential aged care settings.

Question 1. What are the types, frequency and intensity of physical activity that are most effective in reducing the risk of falls in older adults?

- Exercise which has a focus on balance training has the greatest effect on falls.
- Programs of at least 2 hours of exercise per week for 6 months or more are more effective in preventing falls than lower dose programs.
- Walking or strength training programs as single interventions do not appear to prevent falls.
- More active people experience fewer falls but there is no evidence that we can prevent falls by simply encouraging older people to be more active.

Question 2. What are the most effective programs for delivering these recommended types and levels of physical activity?

- Falls can be prevented by a range of exercise programs which target balance and provide ongoing exercise - these include the Otago Exercise Program of home-based balance and strength training, group-based Tai Chi, and other group-based balance and strengthening exercise programs.
- Programs should be designed according to the needs of the target population to ensure they provide exercise that is challenging yet safe.

MAIN REVIEW

THE EXTENT OF THE EVIDENCE

Collating the evidence

Randomised controlled trials (RCTs) in clinical or public health settings and systematic reviews of RCTs are the optimal approach to assessing effectiveness of potential health care interventions (for both treatment and prevention) [1]. Clinical practice guidelines and health care decisions should be guided by randomised trials and systematic review findings where available. There have been many randomised controlled trials investigating the effect of exercise on falls.

A recently published systematic review of the literature in this area[2], the Cochrane collaboration review[3], the National Institute for Clinical Excellence (NICE) guideline[4] and a further updated search of the literature (up to October 2008, see Appendix 1) form the basis for the recommendations in this document. The systematic review recently published by the authors of this report is the most recent review of relevant randomised controlled trials and is included as Appendix 4[2]. Figure 1 in Appendix 4[2] shows its trial inclusion flow chart. The search criteria are available from the authors on request. The American College of Sports Medicine recommendation on "Physical Activity and Public Health in Older Adults"[5] was also consulted and its recommendations are given in Appendix 3 of this report.

A number of large methodologically-rigorous trials examining the effects of physical activity on falls are currently in progress. This highlights the need to review these recommendations on a regular basis.

Synthesising the evidence

Table 1 (Appendix 4[2]) summarises the characteristics of 44 trials investigating the effects of exercise on falls. The results of these studies were then pooled using meta-analysis and meta-regression to ascertain whether any features of study design, study population or exercise program components were associated with smaller or larger effects of exercise on preventing falls. Three recent trials (Appendix 1) published after the systematic review[2] was completed were reviewed separately for the present report with regard to their efficacy for preventing falls.

Methodological quality of included studies

Many of the trials of exercise for falls prevention have some design limitations. Twenty-eight trials in the systematic review did not report using a concealed process for allocating subjects to intervention or control groups and 22 did not use an intention to treat analysis. Both these features are likely to be associated with bias i.e. greater benefits from interventions are likely in trials which do not have these criteria [6-8.] However, our meta-regression analysis of the available exercise trials did not find that an absence of either concealed allocation to groups or the lack of an intention to treat analysis was associated with a larger effect on falls 2.

Comparing different programs

There have been few head-to-head trials directly comparing the effect of different approaches to exercise in preventing falls. The recommendations in this report are primarily from a meta-analysis of the size of the effect on falls reported in trials comparing an exercise intervention with no exercise (control group)[2].

Different settings

Fourteen of the 47 trials have been conducted in residential aged care facilities and only six of these have been conducted in high-care facilities (nursing homes). The trials in residential care settings have had fewer total participants (2463) than the trials conducted among community-dwellers (7538) and the trials in high-care residential settings have only had 1000 participants. Therefore, there is a stronger evidence base to guide practice in community settings than in residential care settings.

Single versus multiple interventions

Physical activity interventions are often a component of multifaceted fall prevention programs[3]. Exercise as a single intervention is the focus of the present review. In multifaceted interventions it is difficult to determine which components (or combination of components) are determinants of success or failure of the intervention.

SUMMARY OF THE EVIDENCE

Question 1. What are the types and intensity of physical activity that are most effective in reducing the risk of falls in older adults?

A. What types of physical activity are most effective in preventing falls in older people?

- Exercise which challenges balance is the most effective form of exercise for preventing falls.
- Walking or strength training programs as single interventions do not appear to prevent falls.

Physical activity, exercise and falls

Observational studies have shown that more active people experience fewer falls[9]. However, there is no evidence that falls can be prevented by simply encouraging older adults to be more active. It is likely that many people at risk of falls are less active as they are concerned about falling whilst undertaking physical activities. It is possible that a non-specific approach to increasing physical activity levels in frailer populations could lead to increased falls due to increased exposure to risk.

Balance training

Analysis of the existing studies shows that exercise programs which challenge balance have a 25% greater effect on preventing falls than programs which do not challenge balance[2]. The presence of balance training explained 19% of the difference between findings with regard to effectiveness in preventing falls of different trials. High level balance training for the purposes of this report means exercises conducted whilst standing in which participants aimed to:-

a) stand with their feet closer together or on one leg

b) minimise use of their hands to assist and

c) practice controlled movements of the body's centre of mass.

Combination of features

The greatest reduction in falls is seen from programs which include high level balance training, do not include a walking program and provide a higher dose of exercise. This combination of features resulted in a 42% reduction in the rate of falls (i.e. there were 42% fewer falls in the pooled intervention groups compared to the pooled control groups of studies which evaluated programs with these features, adjusted pooled rate ratio = 0.58, 95% confidence interval 0.48 to 0.69)[2].

Programs which included a high dose of exercise, a high challenge to balance and a walking program also resulted in a significant effect on falls (adjusted pooled rate ratio = 0.76, 95% confidence interval 0.66 to 0.88). However, programs which only provided a low- to moderate-challenge to balance and included a walking program did not significantly reduce falls (adjusted pooled rate ratio = 0.96, 95% confidence interval 0.80 to 1.16 for a high dose exercise and adjusted pooled rate ratio = 1.20, 95% confidence interval 1.00 to 1.44)[2].

Walking

The reason for the apparent lesser effect of exercise on fall rates when walking programs are included may be due to:

a) increased exposure to risk with walking,

b) walking taking time away from high level balance training or

c) confounding of the results as there was some correlation between walking programs and high risk populations (e.g. in residential care).

Although walking appears not to be an effective fall prevention strategy there are other benefits of walking programs for older people[5, 10]. Walking can be included in falls prevention programs if this component does not take time away from high level balance training. Programs should include a mechanism for assessing which participants would be able to safely undertake a walking program.

Strength training

The meta-regression[2] and two previous meta-analyses[11, 12] revealed that the inclusion of strength training was not associated with smaller or larger effects of exercise in preventing falls. Therefore, strength training does not appear to be an effective single intervention for preventing falls. As with walking, there are other benefits of strength training for older people[5] and it is recommended that older people undertake strength training (see Appendix 3). Strength training could be included in falls prevention programs if combined with high-level balance training.

Risk status

A smaller relative effect of exercise on falls is seen when programs are delivered to those at increased risk of falls (based on age, history of falls, risk factors for falls on assessment, or living in a residential aged care facility). Programs conducted in populations where the control group fall rate was more than 2 falls per person year had a 30% smaller effect ($p<0.02$) and this factor explained 17% of the difference between findings with regard to effectiveness in preventing falls of different trials[2].

However as people at higher risk have more falls, the absolute numbers of falls prevented by exercise programs would still be larger when programs are delivered to people at an increased risk of falls (see Appendix 2 for a table that illustrates this point).

Residential care

Fewer trials have been conducted among people in residential aged care settings. A separate meta-analysis of trials conducted in residential care settings did not find evidence of a statistically significant effect of exercise in preventing falls in residential aged care facilities. In nursing homes there was a 10% reduction in the number of falls but this was not statistically significant (i.e. the 95% confidence interval was wide and crossed 1, pooled rate ratio 0.90, 95% CI 0.55 to 1.47). In all residential care settings (i.e. hostels and nursing homes) there was a non-significant 8% reduction in fall rates (pooled rate ratio 0.92, 95% CI 0.75 to 1.13). There was an indication that programs which provided a higher challenge to balance and a higher dose of exercise prevented more falls in these settings.

Additional interventions

Exercise can also be a component of a multifaceted falls prevention program (e.g.[13]). Investigation of multi-facetted interventions to prevent falls is beyond the scope of this review. However, the Stepping On program[14] warrants attention as it was developed in Sydney, has an emphasis on exercise and has been found to prevent falls. The program involves group exercise and education sessions which aim to enhance self-efficacy and encourage participants to learn about the risk of falls and steps they can take to maintain safety.

B. For these activities, what are the minimum requirements in terms of frequency (number of times per week) and intensity (number of minutes per session) that are likely to be effective in preventing falls?

- Programs of at least 2 hours of exercise a week for a 6-month period have a bigger effect on falls.
- Ongoing exercise is likely to be the best way to prevent falls.

In the meta-analysis of exercise trials, a bigger effect of exercise on preventing falls was seen in programs which included more than 50 hours of exercise over the trial period. There was a 20% bigger effect of falls from the higher dose programs and this explained 22% of the variability between different trial results[2].

This total time was achieved in different ways in different trials and often included a combination of group and home exercise (e.g. once a week group exercise supplemented by a home program[15]. Examples of minimal weekly exercise doses would be two exercise sessions of one hour each, or three exercise sessions of 40 minutes each.

It is likely that any benefits of exercise would be lost when exercise is ceased[5]. Therefore programs would need to offer ongoing exercise, or encourage people to undertake ongoing exercise at the end of the program (see Appendix 3 for recommendation from the American College of Sports Medicine about ongoing exercise for older people).

Question 2. What are the most effective programs for delivering these recommended types and levels of physical activity?

- Falls can be prevented by a range of different exercise programs which target balance and provide ongoing exercise.
- These include: the Otago Programme of home-based balance and strength training, group based-Tai Chi and other group-based balance and strengthening exercise programs.
- Programs should be designed according to the needs of the target population to ensure they provide exercise that is challenging yet safe.

The systematic review of exercise trials found that program design features were less important in predicting the efficacy of the program than the content of the program (i.e. the inclusion of balance training and the overall dose of exercise)[2].

Effective programs have:-

- been both home and centre-based
- recruited participants through GP referral and through general advertisement
- targeted the general community and those at high risk

A. What are the characteristics (including recruitment methods, intervention components, duration, costs) of effective community-based programs?

The characteristics of some of the successful community-based fall prevention exercise programs are outlined in the table below.

Program	Recruitment methods	Intervention components	Duration/ frequency	Costs[a]
Otago Exercise Programme [16-18] http://www.acc.co.nz/otagoexerciseprogramme)	Letter from General Practitioner, followed by a phone call	Home-based balance and strength training set up in 4-5 home visits by a physiotherapist or trained nurse, plus phone calls in months where there was no visit.	12 months of home exercise, 3x/week plus a walk 2x/week if suitable.	NZ$1803 (1998 prices) when delivered by nurses[17]. Estimated current costs in Australia are $1091 per participant including travel time, staff training, program supervision by a physiotherapist and administration (using a rate of $72/hour for nurses which includes all on-costs and overheads)[b] This equates to a **monthly cost of $91 per participant**. Note that this program may need to be repeated annually for ongoing effectiveness.

Program	Recruitment methods	Intervention components	Duration/ frequency	Costs
Tai Chi [19-22] (includes Voukelatos et al[21] Australia)	Advertisements and direct contact in an independent living facility[19] Physician letter and follow-up phone call[20] Advertisements in community newspaper[21] Notices posted in community centres[22]	Group-based Tai Chi "Gradual reduction of the base of standing support until single limb stance was achieved, increased body and trunk rotation, and reciprocal arm movements."[19] Classic "Yang" style[22] which "emphasizes multidirectional weight shifting, awareness of body alignment, and multisegmental movement coordination"[20] A mixture of styles [21]	Classes 2x/week for 15 weeks plus encouragement to practice 30 mins per day (45 mins with instructor each week for each participant to individualise program)[19] 1-hour classes weekly for 16 weeks[21] 1-hour classes 3x/week for 6 [20] or 12 months[22]	Average current Australian cost of $115/class for Tai Chi instructors [c] Thus 3x/weekly Tai Chi classes would cost S17,940 to run for 12 months and x1/weekly classes would cost $5980. One study had 8-15 participants per class [21] so with an average of 12 participants the cost for a 12 month program 3x/week would be $1495 per participant. If a 30% administration fee is added the cost is $1943 per participant. **Total monthly cost of $162 per participant.** Classes could also be delivered weekly with time devoted to individualise home programs at **a monthly cost of $109 per participant.**

Group exercise Example 1 (Barnett et al, Australia) [15]	General Practitioners and public hospital physiotherapists invited clients to join if they had falls risk factors which could be addressed by exercise	Combination of group and home-based balance and strength exercises.	12 months duration, 1 class / week in school terms (37 classes) plus home exercises 1+ times per week	Classes designed by a physiotherapist[e] and delivered by a fitness leader (estimated costs $50[d] per hour) Mean class size = 9, 1 instructor / class Excluding costs of program design, supervision and leader training, the estimated cost to deliver this program for 12 months is $1850 or $206 per participant. If a 30% administration fee is added the cost would be $267 per participant. It is estimated that this amount would need to be doubled to safely prescribe and progress the home exercise program. Thus total annual cost per participant is $534 which is a **monthly cost per participant of $45** (assuming no travel costs to the venue).

Program	Recruitment methods	Intervention components	Duration/ frequency	Costs
Group exercise example 2 (Skelton et al [23])	Posters in emergency departments, fracture clinics, day centers and voluntary organizations, newspaper articles and interviews, radio interviews	Falls Management Exercise (FaME) based on the Otago Programme with group sessions including more-challenging balance exercises. Al participants had previously had multiple falls.	1-hour classes x1/ week for 36 weeks Plus home exercise 2x/week for 30 mins	Led by exercise instructors with additional training. Excluding costs of leader training, the estimated cost to deliver this program for 12 months is $1800 or $300 per participant (assuming 6 participants per class) If a 30% administration fee is added the cost would be $390 per participant. It is estimated that this amount would need to be doubled to safely prescribe and progress the home exercise program. Total cost $780 per participant which is a **monthly cost per participant of $65** (assuming no travel costs to the venue)

[a]Costs are reported here without reference to the outcomes of different programs. It is likely that the more intense programs will have bigger effects (eg the 3x/week Tai Chi programs actually prevent more falls than the 1x/week programs see Appendix 2). It may be possible to train less qualified staff to deliver these interventions but provision should be made for training and supervision of these staff members and this has not been factored into our costs. The costs of staff employment will also depend greatly on how they are employed eg a casual/contact staff members will cost more per hour than a full time staff members but on-costs would also need to be considered. In addition, we have not individually costed advertising, program administration, and costs of venue hire. Instead we have added a 30% administration fee to each of the programs. A fuller economic analysis would be required to cover each of the above aspects.

[b]This calculation includes travel to participants' homes, advertising and training and staff costs are fully-inclusive of on-costs and overheads
http://www.dhs.vic.gov.au/rrhacs/businessunits/primaryhealth/fundingapproach/faq

This figure is from draft of a report in development: Day et al Modelling the impact, costs and benefits of falls prevention measures to support policy-makers and program planners Monash University Accident Research Centre.

[c]The midpoint of a range ($80-$150) of different costs for Tai Chi instructors in Victoria from the draft of Day et al Modelling the impact, costs and benefits of falls prevention measures to support policy-makers and program planners Monash University Accident Research Centre.

[d]Information from Sally Castell (Physical Activity Co-ordinator Northern Sydney Central Coast Area Health Service) that the rate paid to trained Fitness leaders to run classes for Northern Sydney Central Coast Area Health Service Healthy Lifestyle programs as at Nov 2008 is $40-44 per hour. Ms Castell estimates that private exercise leaders currently charge approximately $50 per hour.

[e]It is estimated by Jane Louis (Physiotherapy Services Manager, Anglican Retirement Villages) that the costs of a physiotherapist would be around $50 per hour if employed by an organisation or up to $150 per hour on a contract basis. The primary health care rate from Victoria including on-costs and overheads is $81
http://www.dhs.vic.gov.au/rrhacs/businessunits/primaryhealth/fundingapproach/faq.

B. What are the characteristics (including recruitment methods, intervention components, duration, costs) of effective programs in residential aged care settings?

As indicated above, the evidence to support exercise as a single approach in residential aged care settings is limited. However our meta-analysis revealed trends indicating that in residential aged care a) exercise can prevent falls and b) programs which challenge balance and deliver ongoing exercise are more effective.

Three individual trials have found exercise to prevent falls in residential care settings. The remaining trials are smaller and/or involved interventions which did not prevent falls. Characteristics of the three successful trials are summarised below.

Program	**Recruitment methods**	**Intervention components**	**Duration/ frequency**	**Costs**
Hostel and retirement village, Lord et al (Australia) [24]	Information sessions held with each village/hostel plus individual invitations.	Group based balance and strength exercises	12-months duration, 2 x 1-hour sessions / week	Average class size- 10-15, 1 trainer per class. Excluding costs of leader training, the estimated cost to deliver this program for 12 months is $5200 or $400 per participant if an average of 13 participants (using an instructor cost of $50[d]). If a 30% administration fee is added the cost would be $520 per participant. A **monthly cost of $43 per participant**. In frailer groups a smaller group size would be required **monthly cost of $93 per participant for** groups of 6.

Program	Recruitment methods	Intervention components	Duration/ frequency	Costs
Schnelle [25]	Eligible residents identified by nursing home staff and then a direct approach was made to the resident or their designated representative	Regular supervised sessions of 8x sit-to-stand and walks or wheelchair mobilisation to the toilet and upper body strengthening daily	Each 2 hours between 8am and 4pm, 5 days a week for 8 months	Unclear who provided the intervention[d] in the study but if we use a rate of $50 per hour and a time of 20 mins per session, the intervention could cost $3333 per participant. This would be a monthly cost per participant of $417. However we may be able to train cheaper staff to deliver such interventions. If 30% administration costs are added the costs would be $4333 per participant. This would be **a monthly cost per participant of $541.**

Program	Recruitment methods	Intervention components	Duration/ frequency	Costs
Sihvonen [26]	Meeting held at residential care home	Visual feedback on movement of centre of pressure using a force platform balance measurement and training device	20-30 minute individualised sessions 3 times a week for 4 weeks	Unclear who conducted training in this study. Assuming a cost of $50[d] per hour cost for a 4 week program would be $250 per participant. If 30% administration costs are added **the monthly cost would be $325 per participant.**

[a]Information from Sally Castell (Physical Activity Co-ordinator) that the rate paid to trained Fitness leaders to run classes for Northern Sydney Central Coast Area Health Service Healthy Lifestyle programs as at Nov 2008 is $40-44 per hour. Sally estimates that private exercise leaders currently charge approximately $50 per hour.

C. Are specific types of programs more likely to be effective with particular population sub-groups? (people aged 85+ years, people with chronic diseases or functional limitations, people from culturally and linguistically diverse backgrounds, indigenous people)?

People aged 85+ and those with chronic disease or functional limitations are at an increased risk of falls. Therefore, exercise programs must be prescribed carefully to ensure they do not cause the falls they are attempting to prevent. There is evidence that falls can be prevented in people at increased risk of falls through well-designed group exercise programs or by the Otago home-based program [2].

When delivering group programs in these populations, transport and access to venues needs to be considered. A “circuit” design where participants take turns at completing more challenging

exercises with more supervision may be of use [27]. In addition, the use of more than one exercise class leader should be considered.

Home programs in this population also need to be carefully designed. The Otago Programme is carefully designed and clearly described in a published and readily available manual (http://www.acc.co.nz/otagoexerciseprogramme).

Many NSW hospitals and health services are already offering physiotherapy-led exercise for people at a high risk of falls [27]. As these usually safely challenge balance they would be expected to prevent falls.

Trials have not specifically investigated the role of exercise in people from culturally and linguistically diverse backgrounds or indigenous people. However, if offered in a culturally-sensitive manner, exercise should also be able prevent falls in these groups. An ongoing project in Sydney is currently evaluating the role of the Stepping On Program [14] which has been adapted for people from a range of ethnic backgrounds.

D. What does the evidence suggest would be the best bets for community based programs and residential aged care programs in NSW?

The best bet would be to deliver exercise programs which safely challenge balance to older people in the general community and community-dwellers at an increased risk of falls. This can be done in a group or individual basis and can be delivered in different formats in different settings.

General community

Older people in the general community should be encouraged to undertake ongoing exercise which challenges balance (i.e. which requires participants to stand with their feet closer together or on one leg, minimise use of their hands to assist and practice controlled movements of the body's centre of mass).

Guidance will need to be given to exercise instructors and to the general community about how to safely carry out these exercises (e.g. gradually increase the challenge to balance, have your hand near something to steady yourself).

In order to maximise uptake of interventions which are evidence based, people should be given choice regarding exercise setting (e.g. home- or group-based) and program type (e.g. tai chi or other group-based balance and strengthening exercise group exercises). It is likely that ongoing adherence and motivation would be better in a group setting but some individuals prefer to exercise alone.

Exercise designed to prevent falls is particularly beneficial for general populations of older people (i.e. not identified as high risk). A higher uptake of exercise in the general population of older people may also be associated with a reduction in falls in the longer term.

Community-dwellers at increased risk

For older people at an increased risk of falls, exercise needs to be carefully prescribed. It is more difficult to safely challenge balance in people at an increased risk of falls. Safe exercise prescription may require the involvement of health professionals in delivering or training others to deliver exercise.

We suggest that exercise designed to prevent falls should also be undertaken in people at an increased risk of falls. Although there is likely to be a lesser relative effect in this population, the absolute number of falls prevented is likely to be greater in this population (see Appendix 2).

Residential care

People in residential care are at a high risk of falls. However, programs which do not sufficiently challenge balance are unlikely to be effective.

- Existing evidence indicates that:
- group exercise can be safely provided for residents in hostels or retirement villages and that
- individual programs that encourage mobility may prevent falls in nursing homes.

We suggest that group programs could also prevent falls in nursing home if they are delivered with sufficient staff/participant ratios to ensure safety. Several trials of multifaceted interventions in residential care have been conducted in other countries and have found that programs including group exercise can prevent falls [28].

Question 3. Additional interpretation of existing evidence

There is a likely role of mid-life exercise in the prevention of falls among older people. This is very difficult to evaluate in randomised trials due to the long follow-up periods required. Poor balance and impaired muscle strength are associated with falls in older people in observational studies[29]. Unfortunately, both balance and strength deteriorate with age and it is likely that mid-life exercise can offer some protection against this deterioration.

Therefore we suggest that middle-aged people and "younger" older people continue to be encouraged to be as active as possible. Activities such as dancing, golf, tennis, bowls, running, bush walking and group exercise challenge balance and co-ordination and may assist in maintaining these abilities. Strength training (using exercise machines or free weights) may also protect against age-related loss of strength.

Some of these activities could be continued into older age if they are carefully designed so as not to increase the risk of falls and injury. In some countries there are programs of adaptive physical activity which aim to safely offer a range of activities for people with a range of abilities. There is an international Federation of Adaptive Physical Activity (http://www.ifapa.biz/) but such programs are not widely available in NSW.

SUMMARY OF IMPORTANT PAPERS, THEIR FINDINGS AND THEIR RELEVANCE TO AUSTRALIA

Below are published abstracts from randomised controlled trials which found exercise programs to prevent falls. Each of these trials was well-designed (included concealed allocation to groups and intention to treat analysis) and many were conducted in Australia and New Zealand. We have also included a US-based trial but we consider this to also be relevant to Australia. The published paper from our systematic review is included as Appendix 4.

1. Otago Programme meta-analysis.

This is an analysis of the 3 randomised trials evaluating the Otago home exercise Programme which were conducted in New Zealand [16, 17, 30]. In the first trial the intervention was delivered by a physiotherapist and in the second two trials the intervention was delivered by a nurse trained by a physiotherapist.

Robertson MC, Campbell AJ, Gardner MM, Devlin N: Preventing injuries in older people by preventing falls: a meta-analysis of individual-level data. Journal of the American Geriatrics Society 2002; 50(5): 905-11.

OBJECTIVES: Our falls prevention research group has conducted four controlled trials of a home exercise program to prevent falls in older people. The objectives of this meta-analysis of these trials were to estimate the overall effect of the exercise program on the numbers of falls and fall-related injuries and to identify subgroups that would benefit most from the program. DESIGN: We pooled individual-level data from the four trials to investigate the effect of the program in those aged 80 and older, in those with a previous fall, and in men and women. SETTING: Nine cities and towns in New Zealand. PARTICIPANTS: One thousand sixteen community dwelling women and men aged 65 to 97. INTERVENTION: A program of muscle strengthening and balance retraining exercises designed specifically to prevent falls and individually prescribed and delivered at home by trained health professionals. MEASUREMENTS: Main outcomes were number of falls and number of injuries resulting from falls during the trials. RESULTS: The overall effect of the program was to reduce the number of falls and the number of fall-related injuries by 35% (incidence rate ratio (IRR) = 0.65, 95% confidence interval (CI) = 0.57-0.75; and, respectively IRR = 0.65, 95% CI = 0.53-0.81.) In injury prevention, participants aged 80 and older benefited significantly more from the program than those aged 65 to 79. The program was equally effective in reducing fall rates in those with and without a previous fall, but participants reporting a fall in the previous year had a higher fall rate (IRR = 2.34, 95% CI = 1.64-3.34). The program was equally effective in men and women. CONCLUSION: This exercise program was most effective in reducing fall-related injuries in those aged 80 and older and resulted in a higher absolute reduction in injurious falls when offered to those with a history of a previous fall.

2. Tai Chi

The Central Sydney Tai Chi study by Voukelatos et al [21] found a significant effect on falls from weekly Tai Chi classes. However, larger effects were seen in this US-based study of Tai Chi conducted three times per week by Li et al [20].

Voukelatos A, Cumming RG, Lord SR, Rissel C: A randomized, controlled trial of tai chi for the prevention of falls: the Central Sydney tai chi trial. Journal of the American Geriatrics Society 2007; 55(8): 1185-91.

OBJECTIVES: To determine the effectiveness of a 16-week community-based tai chi program in reducing falls and improving balance in people aged 60 and older. DESIGN: Randomized, controlled trial with waiting list control group. SETTING: Community in Sydney, Australia. PARTICIPANTS: Seven hundred two relatively healthy community-dwelling people aged 60 and older (mean age 69). INTERVENTION: Sixteen-week program of community-based tai chi classes of 1 hour duration per week. MEASUREMENTS: Falls during 16 and 24 weeks of follow-up were assessed using a calendar method. Balance was measured at baseline and 16-week follow-up using six balance tests. RESULTS: Falls were less frequent in the tai chi group than in the control group. Using Cox regression and time to first fall, the hazard ratio after 16 weeks was 0.72 (95% confidence interval (CI)=0.51-1.01, P=.06), and after 24 weeks it was 0.67 (95% CI=0.49-0.93, P=.02). There was no difference in the percentage of participants who had one or more falls. There were statistically significant differences in changes in balance favoring the tai chi group on five of six balance tests. CONCLUSION: Participation in once per week tai chi classes for 16 weeks can prevent falls in relatively healthy community-dwelling older people.

Li F, Harmer P, Fisher KJ, et al.: Tai Chi and fall reductions in older adults: a randomized controlled trial. Journals of Gerontology Series A-Biological Sciences & Medical Sciences. 2005; 60(2): 187-94.

BACKGROUND: The authors' objective was to evaluate the efficacy of a 6-month Tai Chi intervention for decreasing the number of falls and the risk for falling in older persons. METHODS: This randomized controlled trial involved a sample of 256 physically inactive, community-dwelling adults aged 70 to 92 (mean age, 77.48 years; standard deviation, 4.95 years) who were recruited through a patient database in Portland, Oregon. Participants were randomized to participate in a three-times-per-week Tai Chi group or to a stretching control group for 6 months. The primary outcome measure was the number of falls; the secondary outcome measures included functional balance (Berg Balance Scale, Dynamic Gait Index, Functional Reach, and single-leg standing), physical performance (50-foot speed walk, Up&Go), and fear of falling, assessed at baseline, 3 months, 6 months (intervention termination), and at a 6-month postintervention follow-up. RESULTS: At the end of the 6-month intervention, significantly fewer falls (n=38 vs 73; p=.007), lower proportions of fallers (28% vs 46%; p=.01), and fewer injurious falls (7% vs 18%; p=.03) were observed in the Tai Chi group compared with the stretching control group. After adjusting for baseline covariates, the risk for multiple falls in

the Tai Chi group was 55% lower than that of the stretching control group (risk ratio,.45; 95% confidence interval, 0.30 to 0.70). Compared with the stretching control participants, the Tai Chi participants showed significant improvements (p<.001) in all measures of functional balance, physical performance, and reduced fear of falling. Intervention gains in these measures were maintained at a 6-month postintervention follow-up in the Tai Chi group. CONCLUSIONS: A three-times-per-week, 6-month Tai Chi program is effective in decreasing the number of falls, the risk for falling, and the fear of falling, and it improves functional balance and physical performance in physically inactive persons aged 70 years or older.

3. Group-based balance and strengthening exercise

This study was conducted in South West Sydney. The intervention comprised weekly 1-hour group-based exercise sessions for 12 months combined with home exercises.

Barnett A, Smith B, Lord SR, Williams M, Bauman A: Community-based group exercise improves balance and reduces falls in at-risk older people: a randomised controlled trial. Age & Ageing. 2003; 32(4): 407-14.

BACKGROUND: recent studies have found that moderate intensity exercise is an effective intervention strategy for preventing falls in older people. However, research is required to determine whether supervised group exercise programmes, conducted in community settings with at-risk older people referred by their health care practitioner are also effective in improving physical functioning and preventing falls in this group. OBJECTIVES: to determine whether participation in a weekly group exercise programme with ancillary home exercises over one year improves balance, muscle strength, reaction time, physical functioning, health status and prevents falls in at-risk community-dwelling older people. METHODS: the sample comprised 163 people aged over 65 years identified as at risk of falling using a standardised assessment screen by their general practitioner or hospital-based physiotherapist, residing in South Western Sydney, Australia. Subjects were randomised into either an exercise intervention group or a control group. Physical performance and general health measures were assessed at baseline and repeated 6-months into the trial. Falls were measured over a 12-month follow-up period using monthly postal surveys. RESULTS: at baseline both groups were well matched in their physical performance, health and activity levels. The intervention subjects attended a median of 23 exercise classes over the year, and most undertook the home exercise sessions at least weekly. At retest, the exercise group performed significantly better than the controls in three of six balance measures; postural sway on the floor with eyes open and eyes closed and coordinated stability. The groups did not differ at retest in measures of strength, reaction time and walking speed or on Short-Form 36, Physical Activity Scale for the Elderly or fear of falling scales. Within the 12-month trial period, the rate of falls in the intervention group was 40% lower than that of the control group (IRR=0.60, 95% CI 0.36-0.99). CONCLUSIONS: these findings indicate that participation in a weekly group exercise programme with ancillary home exercises can improve balance and reduce the rate of falling in at-risk community dwelling older people.

This study was conducted in 20 retirement village and hostels in the Greater Sydney and Illawarra regions. The intervention comprised a 12-month program of twice-weekly 1-hour group-based balance and strength training.

Lord SR, Castell S, Corcoran J, et al.: The effect of group exercise on physical functioning and falls in frail older people living in retirement villages: a randomized, controlled trial. Journal of the American Geriatrics Society. 2003; 51(12): 1685-92.

OBJECTIVES: To determine whether a 12-month program of group exercise can improve physical functioning and reduce the rate of falling in frail older people. DESIGN: Cluster randomized, controlled trial of 12 months duration. SETTING: Retirement villages in Sydney and Wollongong, Australia. PARTICIPANTS: Five hundred fifty-one people aged 62 to 95 (mean+/-standard deviation=79.5+/-6.4) who were living in self- and intermediate-care retirement villages. MEASUREMENTS: Accidental falls, choice stepping reaction time, 6-minute walk distance postural sway, leaning balance, simple reaction time, and lower-limb muscle strength. RESULTS: Two hundred eighty subjects were randomized to the weight-bearing group exercise (GE) intervention that was designed to improve the ability of subjects to undertake activities for daily living. Subjects randomized to the control arm (n=271) attended flexibility and relaxation (FR) classes (n=90) or did not participate in a group activity (n=181). In spite of the reduced precision of cluster randomization, there were few differences in the baseline characteristics of the GE and combined control (CC) subjects, although the mean age of the GE group was higher than that of the CC group, and there were fewer men in the GE group. The mean number of classes attended was 39.4+/-28.7 for the GE subjects and 31.5+/-25.2 for the FR subjects. After adjusting for age and sex, there were 22% fewer falls during the trial in the GE group than in the CC group (incident rate ratio=0.78, 95% confidence interval (CI)=0.62-0.99), and 31% fewer falls in the 173 subjects who had fallen in the past year (incident rate ratio=0.69, 95% CI=0.48-0.99). At 6-month retest, the GE group performed significantly better than the CC group in tests of choice stepping reaction time, 6-minute walking distance, and simple reaction time requiring a hand press. The groups did not differ at retest in tests of strength, sway, or leaning balance. CONCLUSION: These findings show that group exercise can prevent falls and maintain physical functioning in frail older people.

CONCLUSIONS

1. What are the types, frequency and intensity of physical activity that are most effective in reducing the risk of falls in older adults?

Exercise programs which included highly-challenging balance training are the most effective in preventing falls. These programs include: exercises conducted whilst standing in which participants aim to a) stand with their feet closer together or on one leg b) minimise use of their hands to assist balance and c) practice controlled movements of the body's centre of mass.

There are bigger effects of exercise on falls from programs which included a higher dose of exercise (e.g. a dose of more than 50 hours of exercise). It is likely that exercise needs to be ongoing to have a lasting effect on fall rates.

2. What are the most effective programs for delivering these recommended types and levels of physical activity?

Falls can be prevented by a range of exercise programs which target balance and provide ongoing exercise.

These include: the Otago Programme of home-based balance and strength training, group based-Tai Chi and other group-based balance and strengthening exercise.

Programs should be designed according to the needs of the target population to ensure they provide exercise that is challenging yet safe.

3. Main gaps in research in this area

The main research gaps in this area relate to a paucity of trials investigating dance, organized activities (bowls, golf etc.), walking and strength training as single interventions. There are also gaps regarding direct comparisons of different exercise interventions. It has not been demonstrated prospectively whether mid-life exercise can prevent falls in older age or whether exercise can prevent fall-related fractures in an appropriately designed and powered randomised controlled trial. There have also been few large-scale trials of exercise in residential care. The relative benefit of exercise as a single intervention versus multiple interventions also requires further investigation.

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APPENDIX 1.

UPDATED SEARCH RESULTS

1. Our updated search (October 08) found three extra randomised controlled trials investigating the effect of exercise on falls. The inclusion of these in the meta-analysis would not have significantly altered the findings.

2. Ashburn A, Fazarkarley L, Ballinger C, Pickering R, McLellan LD and Fitton C. A randomized controlled trial of a home based exercise programme to reduce the risk of falling among people with Parkinson's disease. J. Neurol. Neurosurg. Psychiatry. 2007; 78:68-684.

3. Beyer N, Simonsen L, Bulow J, Lorenzen T, Jensen DV, Larsen L, Rasmussen U, Rennie M, and Kjaer M. Old women with a recent fall history show improved muscle strength and function sustained for six months after finishing training. Aging Clin. Exp. Res. 2007; 19: 300-309.

4. Rosendahl, E., et al., A randomized controlled trial of fall prevention by a high-intensity functional exercise program for older people living in residential care facilities. Aging Clinical and Experimental Research, 2008. 20(1): p. 67-75

APPENDIX 2.

CALCULATION REGARDING FALLS PER 100 PERSON YEARS PREVENTED IN TRIALS WITH DIFFERENT COMBINATIONS OF FEATURES IN DIFFERENT POPULATION.

↓Falls per 100 person yr	Balance + high dose	Balance	Balance+ high dose + walking	Dose
General older population	**Tai Chi** 27 Woo [22] 42 Li [20] 155 Wolf [19]	**Tai Chi** 25 Voukelatos [21] **Group** 30 Suzuki [31]	**Group** 47 Madureira [32]	**Group** 15 McMurdo [33]
Study population at increased risk	**Group** 100 Skelton [23]	**Balance** 97 Sihvonen[26]	**Otago Home exercise** 43 Campbell [16] 47Robertson [17] **Group** 19 Lord [34] 39 Barnett [15]	**Strength/endurance** 32 Buchner [35]

APPENDIX 3.

THE AMERICAN COLLEGE OF SPORTS MEDICINE RECOMMENDATIONS (2007 UPDATE)[5]

1. To promote and maintain good health, older adults should maintain a physically active lifestyle. I (A)

2. They should perform moderate-intensity aerobic (endurance) physical activity for a minimum of 30 min on five days each week or vigorous-intensity aerobic activity for a minimum of 20 min on three days each week. I (A) Moderate-intensity aerobic activity involves a moderate level of effort relative to an individual's aerobic fitness. On a 10-point scale, where sitting is 0 and all-out effort is 10, moderate-intensity activity is a 5 or 6 and produces noticeable increases in heart rate and breathing. On the same scale, vigorous-intensity activity is a 7 or 8 and produces large increases in heart rate and breathing. For example, given the heterogeneity of fitness levels in older adults, for some older adults a moderate-intensity walk is a slow walk, and for others it is a brisk walk.

3. Combinations of moderate- and vigorous-intensity activity can be performed to meet this recommendation. IIa (B) These moderate- or vigorous intensity activities are in addition to the light intensity activities frequently performed during daily life (e.g., self care, washing dishes) or moderate-intensity activities lasting 10 min or less (e.g., taking out trash, walking to parking lot at store or office).

4. In addition, at least twice each week older adults should perform muscle strengthening activities using the major muscles of the body that maintain or increase muscular strength and endurance. IIa (A) It is recommended that 8–10 exercises be performed on at least two nonconsecutive days per week using the major muscle groups. To maximize strength development, a resistance (weight) should be used that allows 10–15 repetitions for each exercise. The level of effort for muscle-strengthening activities should be moderate to high.

5. Because of the dose-response relationship between physical activity and health, older persons who wish to further improve their personal fitness, reduce their risk for chronic diseases and disabilities, or prevent unhealthy weight gain will likely benefit by exceeding the minimum recommended amount of physical activity. I (A)

6. To maintain the flexibility necessary for regular physical activity and daily life, older adults should perform activities that maintain or increase flexibility on at least two days each week for at least 10 min each day. IIb (B)

7. To reduce risk of injury from falls, community-dwelling older adults with substantial risk of falls should perform exercises that maintain or improve balance. IIa (A)

8. Older adults with one or more medical conditions for which physical activity is therapeutic should perform physical activity in a manner that effectively and safely treats the condition(s). IIa (A)

9. Older adults should have a plan for obtaining sufficient physical activity that addresses each recommended type of activity. IIa (C) Those with chronic conditions for which activity is therapeutic should have a single plan that integrates prevention and treatment. For older adults who are not active at recommended levels, plans should include a gradual (or stepwise) approach to increase physical activity over time. Many months of activity at less than recommended levels is appropriate for some older adults (e.g., those with low fitness) as they increase activity in a stepwise manner. Older adults should also be encouraged to self-monitor their physical activity on a regular basis and to reevaluate plans as their abilities improve or as their health status changes.

APPENDIX 4.

PUBLISHED SYSTEMATIC REVIEW ON EXERCISE TO PREVENT FALLS

Effective Exercise for the Prevention of Falls: A Systematic Review and Meta-Analysis

– see attached PDF

Sherrington C, Whitney J, Lord S, Herbert R, Cumming R, Close J. Effective exercise for the prevention of falls – a systematic review and meta-analysis. *J Am Geriatr Soc*. 2008;Epub ahead of print 31 Oct.