

Table G6.A3. Summary Table of Studies Investigating Whether Regular Physical Activity Reduces Rates of Falls and Fall-Related Injuries in Older Adults Who Are at Increased Risk

Article, Study Aims, Sample, Number in Study, Duration	Intervention	Effect on Falls and Fall Injuries	Intermediate and Other Effects	Comments
<p>Wolf et al., 1996 (1)</p> <ul style="list-style-type: none"> To evaluate the effects of tai chi and computerized balance training on specified indicators of frailty and the occurrence of falls Men and women aged >70 years, living independently in the community n=200; all included in falls analysis From 7 to 20 months 	<ul style="list-style-type: none"> Intervention group: 1 group tai chi 45-minute classes 2/week for 15 weeks; also instructed to practice tai chi 2/day for 15 minutes Intervention group 2: one on one computerized balance training 1 day a week for 15 weeks Control group: 1-hour discussion of topics of interest to older people once a week for 15 weeks 	<p>Tai chi (n=72) reduced risk of falls by 47.5% compared with remainder (n=64 balance training, n=64 control group) (adjusted relative hazard ratio 0.525; 95% CI, 0.321 to 0.860)</p>	<p>At 4 months:</p> <ul style="list-style-type: none"> Grip strength declined in all groups ($P=0.025$) People in tai chi group were less afraid of falling than control group ($P=0.046$) 	<p>Authors considered tai chi warranted further investigation as an exercise treatment to improve the health of older people.</p>
<p>Buchner et al., 1997 (2)</p> <ul style="list-style-type: none"> To determine the effect of strength and endurance training on gait, balance, physical health status, falls risk, and use of health services Men and women aged 68-85 years, with at least mild deficits in strength and balance n=105; 100 (95%) included in falls analysis Up to 25 months (median, 18 months) 	<ul style="list-style-type: none"> Intervention group: Center-based, supervised 1-hour sessions 3/week for 24-26 weeks, then unsupervised: Intervention group 1: Strength training using weight machines Intervention group 2: Endurance training using stationary bicycles Intervention group 3: Combination of strength + endurance training Control group: Instructed to maintain usual activity 	<ul style="list-style-type: none"> Exercise (3 groups combined) increased time to first fall compared with control group (relative hazard 0.53; 95% CI, 0.30 to 0.91) Exercise groups had a lower fall rate (relative risk 0.61; 95% CI, 0.39 to 0.93) 	<ul style="list-style-type: none"> At 6 months: Improvement in hip and knee strength in strength-training group (knee strength only in combination training group) No effect of exercise on measures of gait, balance, or physical health status 	<ul style="list-style-type: none"> Evidence for exercise other than balance to lower falls risk in older people Evidence for lack of improvement in gait and balance with short-term strength and endurance training in people with minor deficits in gait and balance
<p>Campbell et al., 1997 (3)</p> <ul style="list-style-type: none"> To determine the effectiveness of an individually tailored home exercise program in preventing falls and injuries in elderly women Women aged >80 years, enrolled through general practices n=233; all included in falls analysis; 213 (91%) completed trial 1 year 	<ul style="list-style-type: none"> Intervention group: Muscle strengthening and balance retraining exercises (>3/week, 30 minutes), plus walking plan (>2/week, 30 minutes), individually prescribed and progressed over 4 home visits by a physiotherapist then monthly telephone contact for 1 year (Otago Exercise Programme) Control group: Equivalent number of social visits by nurse, and usual care 	<ul style="list-style-type: none"> Relative hazard for first 4 falls for exercise group 0.68; 95% CI, 0.52 to 0.90 Relative hazard for a fall resulting in moderate or severe injury 0.61; 95% CI, 0.39 to 0.97 	<ul style="list-style-type: none"> At 6 months: Balance score and chair stand test improved in exercise group At 1 year: Exercise group maintained physical activity level and falls self-efficacy score (self-confidence for daily activities without falling) 	<ul style="list-style-type: none"> Targeted high-risk group for falling Program was most effective in the prevention of recurrent falls Designed for wider implementation

Table G6.A3. Summary Table of Studies Investigating Whether Regular Physical Activity Reduces Rates of Falls and Fall-Related Injuries in Older Adults Who Are at Increased Risk (continued)

Article, Study Aims, Sample, Number in Study, Duration	Intervention	Effect on Falls and Fall Injuries	Intermediate and Other Effects	Comments
<p>Campbell et al., 1999 (4)</p> <ul style="list-style-type: none"> To determine the effectiveness of gradual withdrawal of psychotropic medication and a home-based exercise program in reducing falls Men and women aged >65 years and currently taking psychotropic medication n=93; all included in falls analysis, 72 (77%) completed trial 44 weeks 	<p>2 x 2 factorial design:</p> <ul style="list-style-type: none"> Intervention group 1: Psychotropic medication withdrawal, active ingredient gradually withdrawn over 14-week period Intervention group 2: Exercise program (Otago Exercise Programme) for 44 weeks. Control group for exercise program: No active intervention 	<ul style="list-style-type: none"> No evidence that exercise program reduced the risk of falling Relative hazard for falling in medication withdrawal group compared with original medication group 0.34; 95% CI, 0.16 to 0.74 	<ul style="list-style-type: none"> At 6-months: Exercise group improved in tests of balance and strength: functional reach ($P<0.015$), knee extensor strength ($P<0.004$), chair stand test ($P<0.010$) Exercise group improved in SF-36 mental component score 	<p>Small sample size and high dropout rate</p>
<p>Robertson et al., 2001 (5)</p> <ul style="list-style-type: none"> To assess the effectiveness of trained district nurse individually prescribing a home exercise program to reduce falls and injuries Men and women aged >75 years, recruited through general practices n=240; all included in falls analysis, 211 (88%) completed trial 1 year 	<ul style="list-style-type: none"> Intervention group: Muscle strengthening and balance retraining exercises, walking plan (Otago Exercise Programme) individually prescribed and progressed over 5 home visits and monthly telephone contact for 1 year by trained district nurse supervised by a physiotherapist Control group: No active intervention 	<ul style="list-style-type: none"> Number of falls reduced in exercise group by 46% (incidence rate ratio 0.54; 95% CI, 0.32 to 0.90) Fewer in exercise group had serious injury from a fall ($P<0.033$) 	<ul style="list-style-type: none"> Exercise group had improved in 4-test balance scale score (difference 0.3, 95% CI, 0.0 to 0.5) Higher proportion in exercise group had improved in chair stand and one foot stand tests 	<ul style="list-style-type: none"> This home exercise program is effective in reducing falls and injuries when delivered by trained nurse in usual health care service setting Program now tested in 4 controlled trials, total 1,016 participants Program manual available for health professionals
<p>Barnett et al., 2003 (6)</p> <ul style="list-style-type: none"> To determine whether a weekly group exercise program plus home exercises improves physical functioning or health status and prevents falls in at-risk community-living older people Men and women aged >65 years, >1 risk factor on standardized assessment by general practitioner or hospital-based physiotherapist N=163; 150 (92%) completing the trial included in falls analysis 1 year 	<ul style="list-style-type: none"> Intervention group: Supervised group exercise program (mean 9 per group) for 1 hour/week for 1 year (warm up then functional balance, coordination, and strengthening exercises, fast walking, cool down, all to music) with ancillary home exercises (based on class content) plus information on strategies for avoiding falls Control group: Provided with written falls prevention materials only 	<ul style="list-style-type: none"> Number of falls reduced by 40% (IRR 0.60; 95% CI, 0.36 to 0.99) Trend for lower rate of falls injuries (IRR 0.66; 95% CI, 0.38 to 1.15) 	<ul style="list-style-type: none"> At 6 months: Exercise group performed better in tests of postural sway and coordinated stability No difference in measures of strength, reaction time, walking speed, and fear of falling or on SF-36 and physical activity scale for the elderly scores 	<ul style="list-style-type: none"> Although relatively low intensity, program targeted group with reduced physical functioning “Considerable emphasis” on balance exercises

Table G6.A3. Summary Table of Studies Investigating Whether Regular Physical Activity Reduces Rates of Falls and Fall-Related Injuries in Older Adults Who Are at Increased Risk (continued)

Article, Study Aims, Sample, Number in Study, Duration	Intervention	Effect on Falls and Fall Injuries	Intermediate and Other Effects	Comments
<p>Lord et al., 2003 (7)</p> <ul style="list-style-type: none"> To determine whether a 12-month program of group exercise could improve physical functioning and reduce falls in frail older people Men and women aged 62-95 years, resident in self and intermediate care retirement villages n=551; 508 (92%) completed study and included in falls analysis 1 year 	<ul style="list-style-type: none"> Intervention group: Exercise classes (warm up, aerobic, strengthening, balance, hand/eye and foot/eye coordination, cool down) 1 hour 2 days a week for 12 months Control group: n=90, flexibility and relaxation program 1 hour 2 days a week for 12 months; n=181, no active intervention 	<p>Number of falls 22% lower in intervention group (adjusted incidence rate ratio 0.78; 95% CI, 0.62 to 0.99)</p>	<p>After 6 months:</p> <ul style="list-style-type: none"> Choice stepping reaction time ($P < 0.01$), 6-minute walking distance tests ($P < 0.05$) performed better by intervention group 	<ul style="list-style-type: none"> Exercise classes individualized to functional capabilities of participant Exercises designed to address known major risk factors for falls and to improve ability to perform activities of daily living
<p>Wolf et al., 2003 (8)</p> <ul style="list-style-type: none"> To determine whether an intense tai chi program could reduce the risk of falls more than a wellness education program in older adults transitioning to frailty Men and women aged ≥ 70 years, from congregate living facilities, use of 10 attributes to define not "vigorous" and not "frail" n=311; 286 (92%) included in analysis 48 weeks 	<ul style="list-style-type: none"> Intervention group: "Intense" tai chi (6 of the 24 forms) 60-minute progressing to 90-minute sessions ("work" time increased from 10 to 50 minutes) 2/week for 48 weeks Control group: Wellness education (general advice about falls prevention, exercise and balance, diet and nutrition pharmacological management, legal issues relevant to health changes in body function, and mental health issues) 1 hour per week for 48 weeks (comparable contact time to intervention group) 	<ul style="list-style-type: none"> No difference in risk of falling (all falls, relative hazard adjusted for center 0.75; 95% CI, 0.52 to 1.08) Tai chi group had a lower risk of falls from month 5 through month 12 (relative hazard adjusted for center 0.61; 95% CI, 0.40 to 0.94) 	<p>Not reported</p>	<ul style="list-style-type: none"> Effectiveness of "intense" tai chi in frail people may not reach the level seen in robust older adults taking part in less intense tai chi (Wolf et al., 1996). No adverse events occurred during either intervention. Wellness education program may have motivated participants to become more physically active and make other lifestyle changes affecting falls risk.

Table G6.A3. Summary Table of Studies Investigating Whether Regular Physical Activity Reduces Rates of Falls and Fall-Related Injuries in Older Adults Who Are at Increased Risk (continued)

Article, Study Aims, Sample, Number in Study, Duration	Intervention	Effect on Falls and Fall Injuries	Intermediate and Other Effects	Comments
<p>Campbell et al., 2005 (9)</p> <ul style="list-style-type: none"> To assess the efficacy and cost effectiveness of a home safety program and a home exercise program to reduce falls and injuries in older people with low vision Men and women aged >75 years, visual acuity 6/24 or worse n=391; 361 (92%) completed 1-year follow-up 	<p>2 x 2 factorial design:</p> <ul style="list-style-type: none"> Intervention group 1: Home safety assessment and modification program delivered by an occupational therapist Intervention group 2: Exercise program (Otago Exercise Programme) plus vitamin D supplementation Intervention group 3: Received both interventions Control group: Social visits 	<ul style="list-style-type: none"> Fewer falls occurred in the group randomized to the home safety program but not in the exercise program (IRR 0.59 (95% CI, 0.42 to 0.83) and 1.15 (0.82 to 1.61) respectively). Within exercise program, stricter adherence was associated with fewer falls ($P=0.001$). Neither group intervention was effective in reducing injuries from falls. 	<p>–</p>	<p>Vitamin D supplement was given to those in exercise group who were not already taking it</p>
<p>Li et al., 2005 (10)</p> <ul style="list-style-type: none"> 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. Men and women 70-92 years, inactive, independent ambulatory, free of chronic medical problems that would limit participation in low-to-moderate intensity exercise, physician's clearance, no cognitive impairments n=256 6 months, 6-month follow-up 	<ul style="list-style-type: none"> Intervention group: Classical Yang style tai chi taught by experienced tai chi instructors 2/week for 6 months. Each session included 5-10 minutes of a warm-up and cool-down and included musical accompaniment. Control group: Low-intensity stretching, controlled breathing, and relaxation exercises taught by qualified exercise instructors 2/week for 6 months. 	<p>At 6 months:</p> <ul style="list-style-type: none"> Significantly fewer falls (n=38 vs. 73; $P=0.007$), lower proportions of fallers (28% vs. 46%; $P=0.01$), and fewer injurious falls (7% vs. 18%; $P=0.03$) 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, 0.45; 95% CI, 0.30 to 0.70). Compared with the stretching control participants, the tai chi participants showed significant improvements ($P < 0.001$) in all measures of functional balance, physical performance, and reduced fear of falling. Intervention gains in these measures were maintained at a 6-month post-intervention follow-up in the tai chi group. 	<p>–</p>	<p>–</p>

Table G6.A3. Summary Table of Studies Investigating Whether Regular Physical Activity Reduces Rates of Falls and Fall-Related Injuries in Older Adults Who Are at Increased Risk (continued)

Article, Study Aims, Sample, Number in Study, Duration	Intervention	Effect on Falls and Fall Injuries	Intermediate and Other Effects	Comments
<p>Skelton et al., 2005 (11)</p> <ul style="list-style-type: none"> To investigate the impact of a 36-week individualized and tailored group and home exercise intervention, compared with a control intervention, in reducing falls and injuries in community-dwelling, independent-living, frequent falling women aged 65+ years. Women aged 65+ years, living in their own home without help, with a history of 3 or more falls in the previous year n=81 12 months 	<ul style="list-style-type: none"> Intervention group: 36 weeks of Falls Management Exercise (FaME) classes (balance specific) once a week for an hour. Followed Otago Exercise Program at home (2/week, 30 minutes). Control group: Home exercise (2/week), seated warm-up, mobility, flexibility, and cool-down exercises. 	<ul style="list-style-type: none"> There was a 31% reduction in the number of falls during the whole trial period for the exercise group compared with the control group from negative binomial regression model 0.69; 95% CI, 0.50-0.96, $P=0.029$). However, on further analysis, this reduction was totally due to the 54% reduction in falls in the follow-up period (IRR 0.46; 95% CI, 0.34-0.63). The number of fallers among exercisers decreased progressively from baseline through intervention to follow-up, while the number falling among controls did not. 	–	–
<p>Voukelatos et al., 2007 (12)</p> <ul style="list-style-type: none"> To determine the effectiveness of a 16-week community-based tai chi program in reducing falls and improving balance in people aged 60 years and older Men and women aged 60+ years, living in the community, had not practiced tai chi in previous 12 months n=702 16 weeks, 8 weeks follow-up 	<ul style="list-style-type: none"> Intervention group: Group tai chi classes (8-15 participants) led by a tai chi instructor, 60 minutes 1/week. The majority of classes (83%) involved Sun-style tai chi. Control group: Instructed not to do any tai chi. 	<ul style="list-style-type: none"> 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% CI = 0.51-1.01, $P=0.06$), and after 24 weeks it was 0.67 (95% CI = 0.49-0.93, $P=0.02$). No difference in the percentage of participants who had one or more falls. Statistically significant differences in changes in balance favoring the tai chi group on five of six balance tests. 	–	–

CI, confidence interval; IRR, incidence rate ratio; SF-36, short form health survey with 36 questions

Adapted with permission from Blackwell Publishing, 2007, Oxford, UK. Published in the book: Evidence-Based Sports Medicine. From the chapter written by Robertson M and Campbell A, (chapter 9) entitled: What type of exercise reduces falls in older people?

Reference List

1. Wolf SL, Barnhart HX, Kutner NG, McNeely E, Coogler C, Xu T. Reducing frailty and falls in older persons: an investigation of Tai Chi and computerized balance training. Atlanta FICSIT Group. Frailty and Injuries: Cooperative Studies of Intervention Techniques. *J.Am.Geriatr.Soc.* 1996 May;44(5):489-97.

2. Buchner DM, Cress ME, de Lateur BJ, Esselman PC, Margherita AJ, Price R, Wagner EH. 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 Jul;52(4):M218-M224.
3. Campbell AJ, Robertson MC, 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 Oct 25;315(7115):1065-9.
4. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Falls prevention over 2 years: a randomized controlled trial in women 80 years and older. *Age Ageing* 1999 Oct;28(6):513-8.
5. Robertson MC, Gardner MM, Devlin N, McGee R, Campbell AJ. Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 2: Controlled trial in multiple centres. *BMJ* 2001 Mar 24;322(7288):701-4.
6. Barnett A, Smith B, Lord SR, Williams M, Baumand A. Community-based group exercise improves balance and reduces falls in at-risk older people: a randomised controlled trial. *Age Ageing* 2003 Jul;32(4):407-14.
7. Lord SR, Castell S, Corcoran J, Dayhew J, Matters B, Shan A, Williams P. The effect of group exercise on physical functioning and falls in frail older people living in retirement villages: a randomized, controlled trial. *J.Am.Geriatr.Soc.* 2003 Dec;51(12):1685-92.
8. Wolf SL, Sattin RW, Kutner M, O'Grady M, Greenspan AI, Gregor RJ. Intense tai chi exercise training and fall occurrences in older, transitionally frail adults: a randomized, controlled trial. *J.Am.Geriatr.Soc.* 2003 Dec;51(12):1693-701.
9. Campbell AJ, Robertson MC, La Grow SJ, Kerse NM, Sanderson GF, Jacobs RJ, Sharp DM, Hale LA. Randomised controlled trial of prevention of falls in people aged > or =75 with severe visual impairment: the VIP trial. *BMJ* 2005 Oct 8;331(7520):817.
10. Li F, Harmer P, Fisher KJ, McAuley E, Chaumeton N, Eckstrom E, Wilson NL. Tai Chi and fall reductions in older adults: a randomized controlled trial. *J.Gerontol.A Biol.Sci.Med.Sci.* 2005 Feb;60(2):187-94.
11. Skelton D, Dinan S, Campbell M, Rutherford O. Tailored group exercise (Falls Management Exercise -- FaME) reduces falls in community-dwelling older frequent fallers (an RCT). *Age Ageing* 2005 Nov;34(6):636-9.
12. 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. *J.Am.Geriatr.Soc.* 2007 Aug;55(8):1185-91.