

Update on falls prevention for community-dwelling older adults: Review of single and multifactorial intervention programs

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Abstract—The incidence of falls, fall-related injuries, and fall-associated costs continue to rise along with the increase in the aging population. Community-based fall prevention programs for the elderly are proliferating in an attempt to address this health problem. Prevention programs vary widely in their scope, ranging from single intervention strategies to comprehensive multifactorial approaches. Programs have been offered to targeted groups of elderly individuals at high risk for falls and to nonselect groups of community-dwelling elderly adults. This article presents a review of randomized controlled trials that investigated the effectiveness of fall prevention programs for community-dwelling older adults. Following a comprehensive critical analysis of the literature, we present the following guidelines: (1) multifactorial fall prevention programs appear to be more effective for older individuals with a previous fall history versus a nonselect group; (2) medication and vision assessment with appropriate health practitioner referral should be included in a falls screening examination; (3) exercise alone is effective in reducing falls and should include a comprehensive program combining muscle strengthening, balance, and/or endurance training for a minimum of 12 weeks; and (4) home hazard assessment with modifications may be beneficial in reducing falls, especially in a targeted group of individuals.

Key words: aging, exercise, fall prevention, falls, home hazard assessment, medication assessment, multifactorial, rehabilitation, single intervention, vision assessment.

INTRODUCTION

As the average age of the current U.S. population continues to rise, so does the incidence of fall-related

injuries and deaths. More than one-third of adults aged 65 years and older fall each year [1–2], and half of these individuals experience multiple falls [3–4]. The Centers for Disease Control and Prevention report that falls are the leading cause of injury-related deaths in individuals 65 years and older [5]. Twenty to thirty percent of seniors who fall suffer moderate to severe injuries, which in turn increase the risk of premature death [6]. In 2002, more than 1.8 million people were treated in hospital emergency rooms for fall-related injuries [5]. Twenty percent of all older adults who fracture a hip die within a year [7], and twenty-five percent of all fallers are in nursing homes within a year [8]. Costs for the 2.6 million medically treated nonfatal fall-related injuries in 2000 were \$19 billion and for fatal injuries \$0.2 billion [9]. These costs are estimated to increase to \$240 billion by 2040 [10].

A variety of fall prevention programs targeting community-dwelling elderly adults have been established and critically evaluated. These prevention programs vary widely in their approach. Some have used single

Abbreviations: 1RM = one repetition maximum, ADL = activities of daily living, FICSIT = Frailty and Injuries Cooperative Studies of Intervention Techniques (study), OT = occupational therapist, PT = physical therapist, RCT = randomized controlled trial.

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interventions such as health and risk assessment with referral to other healthcare practitioners to optimize health, polypharmacy assessment with medication management, home hazard assessment with modifications, individual or group exercise programs, or vision assessment with correction. Other programs have used a combination of some or all of the aforementioned interventions in a multifactorial approach.

Approaches to retrospective reviews of fall prevention programs have also varied because of the diverse nature of the programs. Some reviews targeted single intervention approaches [11–12], while others have assessed both single intervention and multifactorial programs [13–14]. Because of additional published research, the clinician may benefit from an updated review that assesses both types of fall prevention programs. On the basis of critical analyses of the current research, essential components of both single intervention and multifactorial approaches to falls prevention will be discussed and summarized in user-friendly tables. Key points and general guidelines for clinical practice will also be presented.

METHODS

Studies were identified by searching the electronic databases PubMed, Medline, Proquest, CINAHL, Cochrane Controlled Trials, Science Citation Index, and ERIC for citations between 1996 and 2007. In addition, through snowballing, citations from identified publications were hand-checked to find additional studies. Key search terms included fall\$, elder\$, community dwelling, aged, older, intervention, exercise program, prevent\$, program\$, injur\$, home, hazard, residence, and any combination of these words. Study subjects in publications had to meet the following inclusion criteria to be included in this review: 60 years or older, ambulatory with or without an assistive device, and community dwelling. Prevention programs could offer single or multifactorial interventions. Outcomes of interest were number of falls and/or number of fallers or rate of falls. Falls were defined as “unintentionally coming to rest on the ground, floor, or other lower level” [15]. Studies reporting only intermediate outcome measures such as balance, strength, and self-efficacy were excluded from the analysis. Excluded also were studies that targeted nursing homes, hospitals, or supervised living environments, such as assisted living facilities, or those that were meta-analyses or follow-up studies of previously published primary research. In addition, studies that targeted individuals with identified

disabilities (e.g., vestibular dysfunction, neurological dysfunction, cognitive impairment, cardiac pacing dysfunction) were excluded from this review.

The initial broad inclusion criteria were met by 781 studies. On the basis of the exclusion criteria, this number was reduced to 522. Two reviewers independently assessed the abstracts. Study quality was assessed using Sackett’s criteria for level of evidence [16]. Only randomized controlled trials (RCTs) were chosen for this review. Whenever the two reviewers disagreed regarding appropriateness of an article, a dialogue ensued until consensus was met. Studies were grouped according to the following types of intervention programs: home hazard assessment with modification only, exercise and/or physical therapy only, and programs that offered multifactorial intervention programs.

MULTIFACTORIAL INTERVENTION PROGRAMS

Twelve multifactorial intervention studies met our described criteria. Participants included community-dwelling ambulatory adults over the age of 60, resulting in 4,251 participants. Comorbidities were described in four studies [17–20] and included stroke, arthritis, previous fractures, cardiovascular disorders, peripheral neuropathy, diabetes mellitus, depression, incontinence, and visual impairments. Recruitment methods varied and included individuals presenting to a hospital emergency room following a fall [20–22], health insurance database [17], residential database [23], voter registration database [24], flyers [18], senior centers and meal sites [25], health professional referrals [25–26], local media advertising [18,24], and referrals from general medical practices using a screening process [18–19,27]. The multifactorial programs included the following intervention strategies: health and fall risk assessment with referral to other healthcare practitioners who could address specific needs of the patient, medication assessment with education and/or modifications, vision assessment with appropriate health practitioner referral and/or correction, home visit assessment with education and/or modifications of hazards, client education on fall risk factors, diet and exercise guidelines for healthy aging, exercise and balance training programs, and psychotropic medication withdrawal. Studies included in the analysis of multifactorial prevention programs are found in **Table 1**. A comparison of specific intervention programs used in each multifactorial approach appears in **Table 2**.

Table 1.
Studies included in analysis of multifactorial falls prevention programs.

Study	Study Type	Population		Losses (%)	Resultant Sample Size	Measured Outcome	Control Outcome		Exp Outcome		Direction of Effect
		Age (yr)	Sample Size				No. Falls	No. Fallers	No. Falls	No. Fallers	
Campbell et al., 1999 [1]	RCT, double blind, factorial design	>65	N = 93	23	Unable to determine	No. falls in 11 mo	29	—	15, 17, 18	—	+Medication withdrawal, +exercise, +medication withdrawal & exercise
Clemson et al., 2004 [2]	RCT, block design	>70	N = 310	8	n exp = 147, n control = 138	No. falls in 12 mo	255	—	179	—	+
Close et al., 1999 [3]	RCT	>65	N = 397	23	n exp = 141, n control = 163	No. falls in 12 mo; No. fallers in 12 mo	510	111	183	59	+
Coleman et al., 1999 [4]	RCT, cluster design	>65	N = 169	33	n exp = 62, n control = 51	% fallers in 12 mo; % fallers in 24 mo	—	37.9%; 35.6%	—	43.5%; 43.5%	No effect
Davison et al., 2005 [5]	RCT	>65	N = 313	10	n exp = 141, n control = 141	No. falls in 12 mo; No. fallers in 12 mo	617	102	387	94	+
Day et al., 2002 [6]	RCT, factorial design	>70	N = 1,107	1.5 (442 subjects chosen for posttest)	n exp = 395, n control = 47	% subjects with ≥1 fall in 18 mo	—	63.5%	—	54.5% (mean for all groups)	+Exercise; +exercise & vision correction; +exercise & home hazard management; +exercise, vision correction, & home hazard management
Huang & Acton, 2004 [7]	Randomized, no true control	>65	N = 120	6	n exp = 55, n comparison = 58	No. falls in 2 mo	4	—	0	—	No effect
Kingston et al., 2001 [8]	RCT	>65*	N = 109	16	n exp = 51, n control = 41	% fallers in 3 mo	—	2%	—	2%	No effect
Lightbody et al., 2002 [9]	RCT	>65	N = 368	10	n exp = 155, n control = 159	No. falls in 6 mo; No. fallers in 6 mo	145	39	89	35	No effect
Lord et al., 2005 [10]	RCT, 3-group design	>75	N = 620	6.7	n all exp = 381, n control = 197	No. falls in 12 mo	175	—	Exp 1 = 183, Exp 2 = 152	—	No effect
Mahoney et al., 2007 [11]	RCT	>65	N = 349	19	n exp = 139, n control = 143	Falls rate in 12 mo	2.31/yr	—	1.88/yr	—	No effect
van Haastregt et al., 2000 [12]	RCT	>70	N = 316	26	n exp = 120, n control = 115	No. subjects with ≥1 fall in 12 mo	—	57	—	60	No effect

*Females only.

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- Mahoney JE, Shea TA, Przybelski R, Jaros L, Gangnon R, Cech S, Schwalbe A. Kenosha County falls prevention study: A randomized, controlled trial of an intermediate-intensity, community-based multifactorial falls intervention. *J Am Geriatr Soc.* 2007;55(4):489–98. [PMID: 17397425]
- van Haastregt JC, Diederiks JP, Van Rossum E, De Witte LP, Voorhoeve PM, Crebolder HF. Effects of a programme of multifactorial home visits on falls and mobility impairments in elderly people at risk: Randomised controlled trial. *BMJ.* 2000;321(7267):994–98. [PMID: 11039967]

Exp = experiment(al), RCT = randomized controlled trial.

Table 2.

Interventions used in multifactorial prevention programs.

Study	Health & Risk Factor Ass. w/ Referral	Medication Ass. w/ Education (Incl. Medication Modification [X])	Vision Ass. (Incl. Correction [X])	Home Visit:	Education Regarding Fall Risk Factors (Incl. Diet & Exercise [X])	Exercise & Balance Training	Medication Withdrawal (Psychotropic Only)
				Environmental Ass. w/ Education (Incl. Home Modifications [X])			
Campbell et al., 1999 [1]	—	—	—	—	—	X	X
Clemson et al., 2004 [2]	X	X	X	X	X	X	—
Close et al., 1999 [3]	X	[X]	X	[X]	X	—	—
Coleman et al., 1999 [4]	X	X	—	—	[X]	—	—
Davison et al., 2005 [5]	X	X	X	[X]	—	—	—
Day et al., 2002 [6]	—	—	[X]	[X]	—	X	—
Huang & Acton, 2004 [7]	—	—	—	[X]	X	—	—
Kingston et al., 2001 [8]	—	X	—	X	[X]	—	—
Lightbody et al., 2002 [9]	X	X	X	[X]	X	—	—
Lord et al., 2005 [10]	—	—	X	—	X	X	—
Mahoney et al., 2007 [11]	X	X	X	X	—	X	—
van Haastregt et al., 2000 [12]	—	X	—	[X]	X	—	—

- Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Psychotropic medication withdrawal and a home-based exercise program to prevent falls: A randomized, controlled trial. *J Am Geriatr Soc.* 1999;47(7):850–53. [PMID: 10404930]
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- Kingston P, Jones M, Lally F, Crome P. Older people and falls: A randomized controlled trial of a health visitor (HV) intervention. *Rev Clin Gerontol.* 2001;11(3):209–14.
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- Lord SR, Tiedemann A, Chapman K, Munro B, Murray SM, Gerontology M, Ther GR, Sherrington C. The effect of an individualized fall prevention program on fall risk and falls in older people: A randomized, controlled trial. *J Am Geriatr Soc.* 2005;53(8):1296–1304. [PMID: 16078954]
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Ass. = assessment, Incl. = including, w/ = with.

Six studies employed a health and fall risk factor assessment with appropriate health practitioner referral as part of the multifactorial approach [18,20–21,25–26,28]. Of these studies, changes made to the participant's plan of care and subsequent follow-up and adherence based on referrals were evident in only two studies [25,28]. All six studies used multiple intervention strategies in addition to the comprehensive health assessment. Most programs offered five different intervention strategies. Three of the six studies demonstrated a significant decrease in falls outcomes in the intervention group

[18,20–21]. Although Lightbody and colleagues reported fewer falls in the intervention group, the results were not significant [28]. However, the intervention group was significantly more functionally independent and mobile posttreatment than the control group. Increased mobility posttreatment may increase the opportunities for falls and related injuries and has been reported by other authors [29–30].

Eight of the twelve multifactorial prevention studies employed a review of the participants' medications with education [18,20–22,25–28], and one additional study

used psychotropic medication withdrawal in a factorial design [19]. All nine of these investigations employed multiple intervention strategies in addition to medication assessment with modifications. Three study groups [18,25,27] reported changes in medication based on study recommendations. Clemson et al. stated that subjects in the intervention group reported no changes in their medication regime based on study recommendations; however, subjects in the intervention group were less likely to start taking a new psychotropic medication than the control group [18]. Van Haastregt and colleagues reported a 46 percent adherence to recommendations made during the course of the study; however, this represented all changes made (home modifications, exercise, medication changes) [27]. Mahoney et al. reported adherence rates of 51 to 67 percent regarding medication changes at 1-year follow-up [25].

Of the nine studies that addressed the issue of polypharmacy, four demonstrated a significant decrease in the number of falls or fallers compared with the control group [18–21]. The remaining five studies with no effect on the measured outcome had a number of limitations [22,25–28]. These limitations included a high dropout rate [27], reduced power associated with sample size [28], a limited follow-up period (3 months) [22], and poor adherence for referrals to other healthcare professionals [25].

Campbell and colleagues conducted a study with a rigorous randomized factorial design [19]. In their study, psychotropic medications (associated with an increased risk of falls [31]) were withdrawn. Additionally, exercise was used as an intervention strategy. Individuals in the medication withdrawal group, exercise alone group, and combination group demonstrated a significant decrease in the number of falls compared with the control group. Despite the positive results, the authors reported a 45 percent dropout rate due to complaints of “not sleeping.” In addition, 47 percent of individuals taking the placebo during the course of the study had restarted their psychotropic medications within a month of study completion.

Vision assessment was conducted as part of the comprehensive health assessment [20–21] or as an additional arm of the study in 7 of the 12 multifactorial investigations. All studies using vision assessment and correction also included other intervention strategies. Close and colleagues reported that 18 percent of subjects were referred to a vision specialist; however, no adherence or treatment information was presented [20]. Nor did Davison et al.

report health practitioner referral rates or adherence data as a result of their vision assessment [21]. The most comprehensive adherence data were reported by Day and colleagues [24]. Ninety-six percent of subjects needing a referral to a vision specialist complied with the recommendations, which resulted in twenty-seven percent of the subjects requiring new glasses or other treatment. Other authors reported significant differences in visual acuity in the intervention group upon following study recommendations [17] and greater compliance in follow-up based on study recommendations [18].

Four of the seven studies that included vision assessment and correction demonstrated positive results [18,20–21,24]. Of the remaining three studies that found no effect, limitations in sample size were noted in two [17,28]. Lord and colleagues suggest that inadequate screening may have resulted in a sample with fall rates only slightly higher than the general population of similarly aged individuals, thus reducing the number of high-risk fallers who may have benefited from the program [17].

The effect of a home visit with education and/or home modifications as part of the multifactorial intervention was investigated in nine studies [18,20–25,27–28]. Participants in these studies received between one and five home visits within a year. Educational information regarding environmental hazards in and around the home was included in all programs. Additionally, all nine prevention programs included at least one other intervention strategy. Four of the programs demonstrated an improvement in fall outcomes in the treatment group [18,20–21,24], and five found no effect [22–23,25,27–28]. Only four of the studies reported some data relating to specific home modifications made as a result of study recommendations [18,23–24,27]. In six of the studies, clinicians actually made modifications in the home during the assessment [20–21,23–24,27–28].

An educational program was a frequent intervention arm used in a multifactorial approach. The educational program was delivered in a group setting [18,26], in individual sessions [17,20,22–23,27], or by brochure [23] and included information regarding fall-related risk factors, environmental hazards, medication management, coping with visual loss, and importance of visual screening and community safety. No measure of knowledge postintervention was reported in six of the eight studies [17–18,20,22,25,27]. Only Huang and Acton noted a significant difference in knowledge following an individualized educational session on fall-related risk factors compared

with the comparison group who received a brochure [23]. One study also included additional information relating to healthy diet and exercise [22].

Five studies incorporated an exercise and/or balance training component in the multifactorial intervention program [17–19,24–25]. The programs varied in nature and incorporated flexibility activities, generalized strengthening exercises, balance and gait training, and a walking program. Three of the five studies offered group exercise programs ranging from 7 to 52 weeks and most encouraged a home exercise component. Of the five programs using exercise and/or balance training as an intervention, three demonstrated positive results [18–19,24]. Adherence to the program recommendations was documented in all programs and varied widely. Mahoney et al. reported poor adherence to follow-up referral for physical therapy [25]. A third of the subjects refused recommended physical therapy, stating concerns regarding travel, cost, and disbelief in its efficacy.

Comparisons between multifactorial programs are challenging as none of the programs utilized the same intervention strategies. Additionally, only two studies used a factorial design [19,24], making definitive support of the component intervention strategies impossible. The studies with strong factorial designs that were randomized and included a true control group had a positive effect on falls outcomes [19,24]. These studies included a combination of psychotropic medication withdrawal plus exercise and a combination of exercise, vision correction, and home hazard management. However, for Campbell et al.'s study, a high dropout rate and an inability to determine the resultant sample size may limit its generalizability [19].

Limitations in recording data (e.g., specific referrals, adherence to recommendations) and high attrition rates have been noted both in programs that demonstrated significant improvement in fall outcomes and in those with no effect. Three studies with no treatment effect may have been limited by the length of time until follow-up [22–23,28]. Additionally, sample size and power may have been the limiting factors in two studies with no effect [17,28].

EXERCISE AS SINGLE INTERVENTION APPROACH

Tinetti has suggested that some studies using a single or multifactorial intervention approach to falls prevention

may have found no treatment effect because of design limitations [32]. That is, recruited subjects were at either too high or too low a risk for falls to benefit from the intervention and/or the treatment lacked sufficient intensity to effect changes in fall-related outcomes. Consequently, the trend in falls prevention research is to target those individuals who would most likely benefit from the intervention. In this review of prevention programs that use a separate exercise intervention arm, 5 of the 10 studies targeted individuals at high risk for falls [19,33–36]. Fall risk factors identified in previous epidemiologic studies and frequently used as inclusion criteria included muscle weakness, history of falls, gait deficits, balance deficits, use of an assistive device, visual deficits, arthritis, impaired activities of daily living (ADL), depression, cognitive impairment, use of psychotropic medication, and an age of 80 years or older [31,37].

Ten intervention studies that used some form of exercise as a separate intervention arm met the criteria for inclusion in this review (**Table 3**). Participants in these studies included community-dwelling ambulatory individuals over the age of 60, resulting in 2,443 participants. Recruitment methods varied and included individuals with identified fall risk factors from general practices [19,34–35], individuals with identified fall risk factors who previously received physical therapy [34], individuals with fall risk factors from a health maintenance organization [36], individuals selected via a voter registration database [24], individuals classified as “frail older adults” recently discharged from a hospital [38], individuals with identified fall risk factors from the Department of Veterans Affairs [33], individuals from a previous longitudinal study of elderly individuals [39], and individuals responding to flyers at an independent-living community for older adults [40].

For ease of analysis, we identified and grouped components of the exercise programs as follows: exercise to improve strength, exercise to improve balance, and exercise to improve endurance and/or aerobic capacity. All 10 studies included some type of identified strengthening program except the Atlanta Frailty and Injuries Cooperative Studies of Intervention Techniques (FICSIT) study [40]. Tai chi was chosen by this group as a balance training strategy. However, research has demonstrated significant strength gains with its use [41–42], thus tai chi may be considered both a balance and strengthening program.

Although some authors attempted to describe the exercise and balance programs, most of the descriptions lacked sufficient detail to enable replication of the exercise

Table 3.
Studies using exercise as separate intervention arm.

Study	Study Type	Age (yr)	Sample Size	Losses (%)	Resultant Sample Size	Measured Outcome	Control Outcome			Exp Outcome			Direction of Effect
							No. Falls	No. Fallers	Fall Rate	No. Falls	No. Fallers	Fall Rate	
Barnett et al., 2003 [1]	RCT, matched block design	>65	N = 163	8	n exp = 76, n control = 74	No. fallers in 12 mo	—	37	—	—	27	—	+
Buchner et al., 1997 [2]	RCT, 4 groups	Between 68–85	N = 105	14	n endurance = 19, n strength = 20, n endurance & strength = 22, n control = 29	% fallers in 12 mo	—	60%	—	—	42% for all 3 exercise groups combined	—	+
Campbell et al., 1997 [3]	RCT	>80*	N = 233	9	n exp = 103,	No. falls in 12 mo	152	—	—	88	—	—	+
Campbell et al., 1999 [4]	RCT, double blind, factorial design	>65	N = 93	23	Unable to determine	No. falls in 11 mo	29	—	—	15, 7, 18	—	—	+Medication withdrawal, +exercise, +medication withdrawal & exercise
Day et al., 2002 [5]	RCT, full factorial design	>70	N = 1,107	1.5 (only 442 subjects chosen for posttest)	n all exp = 395, n control = 47	% subjects with ≥1 fall in 18 mo	—	63.5%	—	—	54.5% (mean for all groups)	—	+Exercise, +exercise & vision correction, exercise & home hazard management, +exercise, vision, & home hazard management
Latham et al., 2003 [6]	RCT, stratified block 2 × 2 factorial design	>65	N = 243	17	n exercise = 112, n Vit D = 108, n placebo = 114, n control = 110	No. fallers in 6 mo	—	Placebo = 60, Social control = 64	—	—	Exercise = 60, Vitamin D = 80	—	No effect
Robertson et al., 2001 [7]	RCT	>75*	N = 240	12	n exp = 113, n control = 98	No. falls in 12 mo	109	—	—	80	—	—	+
Rubenstein et al., 2000 [8]	RCT, block design	>70†	N = 59	7	n exp = 28, n control = 27	No. falls in 3 mo, fallrate/100h of activity	14	—	16.2	13	—	6.0	+For fall rate
Suzuki et al., 2004 [9]	RCT	>73†	N = 52	15	n exp = 22, n control = 22	No. falls in 20 mo; No. fallers in 8 and 20 mo	17	8 mo = 9, 20 mo = 12	—	6	8 mo = 3, 20 mo = 3	—	+For No. fallers in 20 mo
Wolf et al., 1996 [10]	RCT	>70	N = 200	20	n tai chi = 61, n CBT = 53, n control = 54	No. falls in 7 mo	77	—	—	56, 76	—	—	+For tai chi only

*Females only.

†Males only.

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- Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Psychotropic medication withdrawal and a home-based exercise program to prevent falls: A randomized, controlled trial. *J Am Geriatr Soc*. 1999;47(7):850–53. [PMID: 10404930]
- 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*. 2002;325(7356):128. [PMID: 12130606]
- Latham NK, Anderson CS, Lee A, Bennett DA, Moseley A, Cameron ID; Fitness Collaborative Group. A randomized, controlled trial of quadriceps resistance exercise and vitamin D in frail older people: The Frailty Interventions Trial in Elderly Subjects (FITNESS). *J Am Geriatr Soc*. 2003;51(3):291–99. [PMID: 12588571]
- Robertson MC, Devlin N, Gardner MM, Campbell AJ. Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 1: Randomised controlled trial. *BMJ*. 2001;322(7388):697–701. [PMID: 11264206]
- Rubenstein LZ, Josephson KR, Trueblood PR, Loy S, Harker JO, Pietruszka FM, Robbins AS. Effects of a group exercise program on strength, mobility, and falls among fall-prone elderly men. *J Gerontol A Biol Sci Med Sci*. 2000;55(6):M317–21. [PMID: 10843351]

Table 3. (Continued)

Studies using exercise as separate intervention arm.

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9. Suzuki T, Kim H, Yoshida H, Ishizaki T. Randomized controlled trial of exercise intervention for the prevention of falls in community-dwelling elderly Japanese women. *J Bone Miner Metab.* 2004;22(6):602–11. [PMID: 15490272]
10. 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;44(5):489–97. [PMID: 8617895]
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- CBT = computerized balance training, exp = experiment(al), RCT = randomized controlled trial.
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program. Of the 10 studies that used some form of exercise as a separate intervention strategy, half used a group-based exercise program and half had the subjects exercise at home. Four of the studies using a group-based exercise regime required the subjects to supplement the group program with an independent home exercise program. Six of the ten studies tailored the exercise program to meet the individual needs of each subject [19,35–36,38,40,43]; however, guidelines for progressing the subject were inadequate in all but two studies [36,38]. Both of these studies describe the use of one repetition maximum (1RM) (the maximum weight that can be lifted once while maintaining good form) [44] as a criterion for determining initial resistance for exercise. Latham et al. also used this guideline to progress the intensity of their subjects' quadriceps strengthening program [38]. The use of 1RM to guide exercise prescription and progression is well documented in physical therapy and exercise-related literature [45–46]. **Table 4** illustrates the different components of each exercise regimen.

The exercise programs to improve strength were diverse in nature. Variations included targeted muscle groups (e.g., upper and lower limb, lower limb only, quadriceps only); use of resistance (cuff weights, rubber resistance bands, isokinetic machinery); and frequency, intensity, duration, and progression of exercise. The duration of the exercise programs varied from a minimum of 10 weeks to a maximum of 1 year.

Eight programs used a balance (re)training component; of these eight, four provided some general description. Three studies used some form of tai chi [34,39–40]. Other balance interventions mentioned were one-legged standing exercises, tandem walking, weight-shifting, positional changes during ADL, dancing, toe and heel walking, bending to pick up objects, walking over obstacles, turning, and stair climbing. The Atlanta FICSIT group also used a computerized balance training system.

An endurance or aerobic element was a component of the exercise program in six studies. Walking was the most frequently used approach (five studies). A stationary bicycle and treadmill walking were also used as training approaches. Duration of these aerobic activities was

not well documented. Additionally, the use of target heart rates to determine an appropriate training level to induce true aerobic change was only reported in one study [36]. No mention was made of using ratings of perceived exertion as a rudimentary guideline for aerobic training and/or progression [47]. Rubenstein and colleagues described some guidelines for use and progression on the stationary bicycle (e.g., 5 min at 30 W progression up to 15 min at 80 W); however, target heart rates were not reported [33]. Frequency of the aerobic activity varied between two [19,43] and three times a week [33,36,39]. These guidelines appear to loosely coincide with current literature that states improvement in aerobic capacity requires a minimum of 20 minutes of cardiovascular exercise [48], 3 to 5 days per week [45]. One study met once weekly and used a home exercise program to supplement the exercise regime; however, expectations for the frequency of the home program were not noted [34]. Compliance, a significant factor in any exercise program, was documented in some fashion in all 10 studies and varied from 42 to 91 percent of subjects still participating regularly in their exercise regimen at the completion of the study.

Limitations regarding specific description of exercise frequency, intensity, duration, and progression make study comparisons difficult. Nevertheless, 9 out of the 10 studies in this review demonstrated a positive effect of exercise on fall-related outcomes. Seven studies offered at least two out of three of the exercise components (strengthening, balance training, aerobic/endurance training). The study by Latham and colleagues was designed to address the effectiveness of strengthening only one muscle group (quadriceps) without any balance or conditioning component [38]. Latham et al. found no effect of a quadriceps muscle strengthening program on fall-related outcomes.

The Seattle FICSIT group used a single exercise strategy (strengthening only or endurance training only) and a combination strategy (strengthening and endurance training) in their design [36]. The aggregate data of all of the exercise groups (all three arms) were compared with the control group (no exercise). The results demonstrated

Table 4.
Components of each exercise program.

Study	Individually Tailored	Personnel	Setting	Strengthening Program	Aerobic/Endurance Training	Balance Training	Time Frame	Compliance
Barnett et al., 2003 [1]	No	Designed by PT, administered by exercise instructor	Group based with HEP	UL + LL using resistance bands	Walking & fast walking	Modified tai chi & functional activities (sit to stand, weight shift with reaching, dance steps, throwing ball)	1 h/wk for 12 mo (maximum of 37 classes)	Median No. classes attended 23/37; 91% in exercise group still performing HEP; 1× weekly
Buchner et al., 1997 [2]	Yes	Unclear who designed & administered	Home based	Cybex isokinetic resistance for UL & LL	Stationary bicycle for UL & LL at 75% heart rate reserve (30–35 min/session)	None offered	1 h/3× wk for 24–26 wk	95% of all scheduled sessions were attended by those who did not drop out
Campbell et al., 1997 [3]	Yes	Designed & administered by PT	Home based	Moderate intensity with weights for LL	Walking 3×/wk	Toe & heel walking, walking backwards, sideways & turning, stepping over objects, bending & picking up objects, stair climbing	PT visit 4× in first 2 mo; HEP 30 min exercise 3×/wk + walk outside home 3×/wk for 12 mo	42% still participating ≥ 3 per week
Campbell et al., 1999 [4]	Yes	Designed & administered by PT	Home based	Not detailed; no. of exercise reps & no. of ankle weights increased with subsequent visits	Walking	Not detailed	PT visit 4× in first 2 mo; HEP 30 min exercise 3×/wk + walk outside 2×/wk × 11 mo	63% still exercising 3×/wk & 72% still walking at least 2× wk at end of study
Day et al., 2002 [5]	No	Designed by PT, unclear who administered	Group based with HEP	LL strengthening not detailed	None offered	Not detailed	1 h exercise class/wk × 15 wk & HEP	Mean No. sessions attended = 10; mean no. home exercise sessions = 9/mo
Latham et al., 2003 [6]	Yes	Designed and administered by PT	Exercise started as inpatient & continued in home with PT	Resistance exercise using ankle cuff weights; 60%–80% 1RM quadriceps only	No	No	3×/wk × 10 wk	82% of sessions attended
Robertson et al., 2001 [7]	Yes	Designed & administered by RN	Home based	Graduated cuff weights	Walking 2×/wk	Not detailed	5 home visits by RN at wk 1, 2, 4, 8, & 24; HEP 3×/wk × 12 mo	Yes
Rubenstein et al., 2000 [8]	No	Administered by exercise physiology graduate students	Group based	LL strengthening with weights	Bicycle (5 min at 30 W progress to 15 min at 80 W), treadmill & indoor walking (5 min progress to 15 min)	Not detailed	90 min 3×/wk × 12 wk	Up to 91% of sessions attended
Suzuki et al., 2004 [9]	No	Not reported	Group based with HEP	LL AROM with light weights & resistance bands	No	Weight shifting, one-legged standing, tai chi	10 1 h sessions every other wk supplemented by HEP (3×/wk for 30 min) for 6 mo	Mean rate of group attendance 75.3%
Wolf et al., 1996 [10]	Yes	Credentials not reported	Group based and HEP (tai chi), individual sessions at facility (CBT)	No	No	Tai chi, CBT	Tai chi: 2×/wk × 15 wk + home practice; CBT: 1×/wk × 15 wk	Yes, but adherence to home program not monitored

- 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;32(4):407–14. [PMID: 12851185]
- 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;52(4):M218–24. [PMID: 9224433]
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6. Latham NK, Anderson CS, Lee A, Bennett DA, Moseley A, Cameron ID; Fitness Collaborative Group. A randomized, controlled trial of quadriceps resistance exercise and vitamin D in frail older people: The Frailty Interventions Trial in Elderly Subjects (FITNESS). *J Am Geriatr Soc.* 2003;51(3):291–99. [PMID: 12588571]
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 10. Wolf SL, Bamhart 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;44(5):489–97. [PMID: 8617895]
- IRM = one repetition maximum, AROM = active range of motion, CBT = computerized balance training, HEP = home exercise program, LL = lower limb, PT = physical therapist, RN = registered nurse, UL = upper limb.
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a positive effect of exercise on fall-related outcomes. Separate exercise strategies (strength vs endurance training) were not analyzed.

Rubenstein's group [33] chose to look at falls sustained per hour of activity level based on previous evidence that suggests an increase in activity level for the very old can result in more falls because of an increased exposure to environmental hazards [49]. Rubenstein and colleagues found no significant difference in the absolute number of falls between the exercise and control groups following the intervention program; however, the fall rate based on activity level demonstrated a significant difference.

In summary, evidence suggests that a sustainable exercise program alone can decrease the number of falls and fall risk for a targeted group of older individuals. Programs that have been effective in this targeted population use at least two out of three exercise components: strengthening, balance training, and aerobic/endurance training. The strengthening program can involve a variety of devices (e.g., cuff weights, dumbbells, resistive bands, isokinetic machinery) and can be administered in a group session or individually at home. Multiple muscle groups need to be targeted in the lower limb during the strengthening program. Balance (re)training can use a variety of techniques. Tai chi appears to have both a strengthening effect in addition to producing changes in balance. Other effective balance training techniques include a combination of practicing weight shifting, sit-to-stand activities, tandem walking, one-legged standing, and toe and heel walking. In one study, a computerized balance training program was not effective in reducing fall-related outcomes. The aerobic or conditioning program can be as simple as community walking three times a week for 30 minutes or can employ treadmill walking or bicycle ergometry. The minimum duration of an effective fall prevention comprehensive exercise program appears to be 12 weeks.

HOME HAZARD ASSESSMENT WITH MODIFICATIONS AS SINGLE INTERVENTION APPROACH

Studies using home hazard assessment with modifications as a separate intervention arm were identified using the aforementioned criteria. Abstracts were independently assessed, resulting in four RCTs (**Table 5**). Participants in these four studies included community-dwelling ambulatory individuals over the age of 60, resulting in 2,687 participants. Subject recruitment varied and included individuals from recent hospital inpatients [50–52], outpatient clinics and day hospitals [50], and a voter database crossed with a telephone directory [53]. Of these four studies, only one study specifically recruited subjects at high risk for falls (history of previous falls) [52].

All home hazard assessments were conducted in the subject's home by a combination of one or more of the following: physical therapist (PT), occupational therapist (OT), nurse, physiatrist, or ergotherapist. Nikolaus and Bach also used a comprehensive geriatric assessment in addition to the home hazard assessment as part of the screening [51]. An educational component specific to falls prevention in the home was incorporated in all studies. Topics included removing, modifying, or living with current environmental hazards; safe footwear; and the use of technical and mobility aids. The length of follow-up after the home assessment for all four studies was 1 year.

The study team carried out modifications in the home, based on the assessment with additional modifications made by the subjects and their families. Simple modifications included moving furniture, removing loose carpets, moving electrical cords, using nonskid bath mats, and adding night-lights. More extensive modifications included installing grab bars, repairing damaged floors, and adding step rails. Adherence to recommendations was documented in three studies [50–51,53]. Adherence to

Table 5.
Studies using home hazard assessment with modifications as separate intervention.

Study	Type of Study	Population Community-Dwelling Elderly		Losses (%)	Resultant Sample Size	Measured Outcome	Control Outcome			Exp Outcome			Direction of Effect
		Limitations	N				No. Falls	No. Fallers	Fall Rate	No. Falls	No. Fallers	Fall Rate	
Cumming et al., 1999 [1]	RCT, stratified block	>65 yr	530	22	n exp = 208, n control = 205	No. falls in 12 mo	324	—	—	226	—	—	+Only for those with fall history
Nikolaus and Bach, 2003 [2]	RCT	No age exclusion noted; mean age = 81	360	23	n exp = 140, n control = 139	No. falls in 12 mo	204	—	—	163	—	—	+Only for frail older frequent fallers
Pardessus et al., 2002 [3]	RCT	>65 yr	60	No losses	n exp = 30, n control = 30	No. fallers in 12 mo	—	15	—	—	13	—	No effect
Stevens et al., 2001 [4]	RCT, cluster design with 2:1 ratio of control to exp	>70 yr	1,737*	14	n exp = 534, n control = 1,091	No. falls in 12 mo	—	—	17.15 person-yr	—	—	18.12 person-yr	No effect

*51 subjects chosen randomly for follow-up home hazard assessment.

1. Cumming RG, Thomas M, Szonyi G, Salkeld G, O'Neill E, Westbury C, Frampton G. Home visits by an occupational therapist for assessment and modification of environmental hazards: A randomized trial of falls prevention. *J Am Geriatr Soc.* 1999;47(12):1397–1402. [PMID: 10591231]
2. Nikolaus T, Bach M. Preventing falls in community-dwelling frail older people using a home intervention team (HIT): Results from the randomized falls-HIT trial. *J Am Geriatr Soc.* 2003;51(3):300–305. [PMID: 12588572]
3. Pardessus V, Puisieux F, Di Pompeo C, Gaudefroy C, Thevenon A, Dewailly P. Benefits of home visits for falls and autonomy in the elderly: A randomized trial study. *Am J Phys Med Rehabil.* 2002;81(4):247–52. [PMID: 11953541]
4. Stevens M, Holman CD, Bennet N. Preventing falls in older people: Impact of an intervention to reduce environmental hazards in the home. *J Am Geriatr Soc.* 2001;49(11):1442–47. [PMID: 11890581]

Exp = experiment(al), RCT = randomized controlled trial.

recommendations 1 year following the home assessment ranged from 19 to 82 percent. Study descriptions are found in **Table 6**.

Two of the four studies demonstrated a significant improvement in falls outcomes using a home assessment with modifications [50–51]. However, in both of these studies, a reduction in falls was specific to a subgroup of individuals at high risk for falling: individuals with a previous fall history. This finding is consistent with previous studies [32,54–55] that suggest that a targeted high-risk group is more likely to benefit from a falls prevention program. In contrast, Stevens et al. also looked at a subgroup of frequent fallers and found no difference in the fall rate of frequent fallers compared with the whole group following the intervention [53]. These study results may in part depend on the clinician performing the home assessment. Cumming and colleagues address this issue in their findings [50].

Cumming et al. found a significant difference in the number of falls in the home following a home assessment with hazard modifications; however, they also noted that falls were decreased away from home [50]. They concluded the reduction in falls in the intervention group could not be attributed to the home hazard modifications alone.

Instead, they suggested the reduction in falls might also depend on the individual conducting the assessment, in this case the OT. They concluded the OT may have addressed the subject's general functional limitations by providing specific strategies that resulted in an overall improvement in safety regardless of the environment, hence the improvement in number of falls away from home. This may also be the case in the study by Nikolaus and Bach [51]. A two-member team, a nurse or a PT with an OT, performed the home assessment. Both the OT and PT are trained to evaluate home hazards, suggest modifications, and suggest strategies to address the subjects' functional limitations. Cumming et al. suggest the success of the home hazard assessment may in part depend on the individual doing the assessing.

The research conducted by Pardessus and colleagues failed to find an effect on fall-related outcomes [52]. Whether an OT participated in the home hazard assessment in this study is unclear; however, an OT was available to offer advice on how to address hazards in the home. Although these authors found no detectable improvement in fall outcomes, the subjects' level of functional autonomy did improve. However, improving an older person's activity level has been associated with

Table 6.
Components of home hazard assessment programs.

Study	Home Hazard Assessment Personnel	Education	Types of Modifications	Adherence to Recommendations
Cumming et al., 1999 [1]	OT; 1 h home visit with supervision of recommended home modifications, including further home visits.	Advice on footwear & instruction on how to complete tasks safely in home.	Removal of mats/rugs, change footwear, use of nonslip bath mat, behavioral changes, use of night-light, add rail to external stairs, move electrical cord.	Compliance at 12 mo ranged from 19%–75%.
Nikolaus & Bach, 2003 [2]	RN or PT with OT; comprehensive geriatric assessment & minimum of 2 follow-up home visits by home intervention team.	Advice on fall risks & possible changes in home; instruction in use of technical & mobility aids.	Assistance in ordering equipment & making modifications, removal of mats/rugs/obstructions in walkways, use of assistive devices (rollator, grab bars, shower seat, call bell), use of night-light, elevation of bed, use of nonslip bath mat.	Compliance at 12 mo 75.7% for maintaining 1 change.
Pardessus et al., 2002 [3]	Physiatrist & ergotherapist; unclear if OT involved.	Advice on how to live more safely with hazards that could not be removed.	Simple modifications such as removal of loose carpets, moving obstacles/furniture; OT provided advice on how to live more safely if obstacles could not be removed.	None noted.
Stevens et al., 2001 [4]	RN.	Pamphlet emphasizing general fall hazard reduction & methods to reduce identified home hazards.	Installation of free safety devices (grab rails), removal of obstacles, removal or stabilization of rugs/mats, repair damaged flooring, improve height of chairs, improve lighting, wear safer shoes, use of nonslip tape.	Maintained significant reduction in 4 out of 5 most prevalent home hazards.

1. Cumming RG, Thomas M, Szonyi G, Salkeld G, O'Neill E, Westbury C, Frampton G. Home visits by an occupational therapist for assessment and modification of environmental hazards: A randomized trial of falls prevention. *J Am Geriatr Soc.* 1999;47(12):1397–1402. [PMID: 10591231]

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OT = occupational therapist, PT = physical therapist, RN = registered nurse.

an increase in fall risk as they spend less time sitting [29,56–57]. This may explain some of the study findings. Additionally, the population was small ($n = 60$), which limits the study's power.

Previous review studies found inconclusive evidence that home hazard assessment with modifications produced a reduction in falls or fall-related injuries in elderly individuals [11,13]. Limitations in study designs were cited; the majority of the studies reviewed used a multifactorial intervention approach without the use of a factorial design. Thus, analysis of the individual intervention effect was not possible. In this current review, only studies using home hazard assessment with modification as a separate intervention arm were analyzed. Some benefits were noted in a targeted group of older individuals with a fall history. Additional benefits may be gained if an OT or a PT performs the assessment.

SUMMARY OF FINDINGS

Two rigorous reviews of multifactorial prevention trials concluded community-based multidisciplinary health and

risk assessment programs with targeted treatment strategies were effective in reducing the number of falls sustained by community-dwelling older adults [13–14]. These authors also stated that multifactorial programs were effective for both an unselected population of older people and a population of older people with a history of falls or known fall-risk factors. These findings appear to differ from the current review, which found less than half of the programs that offered multifactorial health and risk assessment in conjunction with various targeted treatment strategies were successful. One possible reason for the disparity is the addition of new studies to the current review [18,21,25,28]. Of the additional studies reviewed, only two demonstrated a significant reduction in fall-related outcomes [18,21]. Moreover, these subjects were targeted individuals with a history of falls. In the two studies with no effect on falls outcomes [25,28], subjects were drawn from a nontargeted population of elderly individuals. Of the remaining multifactorial programs in this review, three demonstrated a positive effect on falls outcomes. Two of these studies had particularly strong factorial designs that resulted in positive findings related to interventions such as psychotropic medication withdrawal

alone [19]; exercise alone [19,24]; medication withdrawal and exercise [19]; exercise and vision correction; exercise and home hazard management; and exercise, vision correction, and home hazard management [24]. Hence, multifactorial falls prevention programs that offer no comprehensive health and risk assessment should at least include a review of medications and vision assessment with appropriate health practitioner referral, in addition to an exercise program and home hazard assessment.

An additional factor to consider when comparing the outcomes of fall prevention programs is the method used to document the fall itself. It has been reported that older individuals do not recall falls that occurred during specific time periods and that more frequent reporting of falls (daily if feasible) is optimal [58]. Although most of the studies in the current review used daily self-report calendars, which have excellent compliance rates [59], accuracy (underreporting or overreporting falls) remains difficult to ascertain [24,58]. Hence, some of the variation in outcomes between individual studies and comprehensive reviews may be due to variations and inaccuracies in fall data collection. **Tables 7–9** describe the data collection methods for studies included in this review. Studies were grouped based on their design: multifactorial programs, exercise as a separate intervention arm, and home hazard assessment as a separate intervention.

The effectiveness of exercise alone as a falls prevention intervention is clearly supported in this review and previous meta-analyses [12–14,60]. The current review suggests additional guidelines and parameters to use while designing the exercise program in order to ensure maximum benefits. The most effective programs incorporate at least two different types of exercise (strengthening, balance training, endurance training); are group based or individually administered; and are conducted at least three times per week for 30 minutes, for a minimum of 12 weeks.

Home hazard assessment and modification as a separate intervention arm may be beneficial in a targeted group of elderly adults at high risk for falls. The expertise of an OT or PT during the home hazard assessment may provide additional benefits.

KEY POINTS

- Multifactorial falls prevention programs appear to be more effective for individuals with a previous history of falls.
- Medication and vision assessment with appropriate health practitioner referral should be included as part of a falls screening examination.

Table 7.

Fall data collection method: Exercise as separate intervention.

Study	Method for Collecting Fall Data
Barnett et al., 2003 [1]	Postal surveys sent to subjects at end of each calendar month. If not returned, further contact was made by telephone.
Buchner et al., 1997 [2]	Self-report monthly postcards reporting occurrence of falls. Additionally, if subjects had a fall, they were asked to inform study staff by mail immediately. Subjects not returning postcards were telephoned.
Campbell et al., 1997 [3]	Daily self-report by participants using prepaid monthly postcard calendars. Participants contacted by telephone if postcards not returned.
Campbell et al., 1999 [4]	Daily self-report by participants using return-addressed, postage-paid, tear-off monthly postcards. Participants were contacted by telephone if postcard was not returned. When subject reported fall, research assistant telephoned subject to determine circumstances and injuries, if any, related to fall.
Day et al., 2002 [5]	Daily self-report using monthly postcard calendar system. Telephone call by research assistant if no postcard returned within 5 days. When fall was reported, research assistant telephoned to determine circumstances.
Latham et al., 2003 [6]	Daily self-report diary using customized calendar. Subjects received weekly reminders from physical therapist to complete diary for 10 weeks; received reminder telephone calls periodically. Details of each fall were investigated at 3- and 6-month home visits.

Table 7. (Continued)

Fall data collection method: Exercise as separate intervention.

Study	Method for Collecting Fall Data
Robertson et al., 2001 [7]	Self-report using preaddressed prepaid postcard monthly calendars. If fall occurred, research assistant telephoned subjects to determine circumstances and injuries, if any, related to fall.
Rubenstein et al., 2000 [8]	Questioned subjects every 2 weeks either by telephone (controls) or in exercise class for 12 weeks.
Suzuki et al., 2004 [9]	By interview 8 and 20 months after intervention.
Wolf et al., 1996 [10]	Self-report monthly calendar with fall information or by monthly telephone calls from staff. If fall was reported, staff telephoned subject to verify.

1. 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;32(4):407–14. [\[PMID: 12851185\]](#)
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Table 8.

Fall data collection method: Home hazard assessment as separate intervention.

Study	Method for Collecting Fall Data
Cumming et al., 1999 [1]	Daily self-report using preaddressed prepaid monthly calendars. Recorded “F” if they fell and “N” if they did not. Follow-up telephone call if no calendar received and if fall had occurred to determine circumstances and injuries if any.
Nikolaus and Bach, 2003 [2]	Self-report diary and monthly telephone calls to obtain information on falls, fall-related injuries, and their circumstances.
Pardessus et al., 2002 [3]	Telephone contact every month for 6 months and at 12 months.
Stevens et al., 2001 [4]	Daily self-report using preaddressed prepaid monthly calendars. Follow-up telephone interview if fall was reported to determine circumstances and injuries if any.

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Table 9.

Fall data collection method: Multifactorial prevention program.

Study	Method for Collecting Fall Data
Campbell et al., 1999 [1]	Daily self-report by participants using return-addressed, postage-paid, tear-off monthly postcards. Participants were contacted by telephone if postcard was not returned. When subject reported fall, research assistant telephoned subject to determine circumstances and injuries, if any, related to fall.
Clemson et al., 2004 [2]	Self-report falls schedule with monthly tear-off postcard calendar. Subjects recorded “N” on each day that they did not fall and “F” if they fell. If fall was recorded, research assistant telephoned to ascertain whether fall met study definition. If calendar not returned in 2 weeks at end of month, research assistant telephoned subject.
Close et al., 1999 [3]	Follow-up data were collected every 4 months for 1 year by postal questionnaire. Requested information included subsequent falls, fall-related injury, and details of doctor and hospital visits or admissions and degree of function.
Coleman et al., 1999 [4]	Self-report using health status survey at 12 and 24 months. Detailed questions relating to fall not included.
Davison et al., 2005 [5]	Self-report using fall diary with 4 weekly cards per diary returned every 4 weeks over 12 months. Telephone call prompting to maximize compliance. Subjects were asked to detail frequency and circumstances of each fall.
Day et al., 2002 [6]	Daily self-report of falls using monthly postcard calendar system. Telephone call by research assistant if no postcard returned within 5 days. When fall was reported, research assistant telephoned to determine circumstances.
Huang & Acton, 2004 [7]	Self-report using fall record checklist with calendar for subject to circle date of fall and note seriousness of fall. Checklist returned every 2 months for 4 months.
Kingston et al., 2001 [8]	Data collection method not detailed. Differentiated between falls indoors and falls outdoors.
Lightbody et al., 2002 [9]	Self-report using daily diary for 6 months with follow-up postal questionnaire that asked about total number of falls.
Lord et al., 2005 [10]	Self-report using monthly fall calendars. When fall occurred, specific details about fall injuries were obtained from telephone interviews. If falls calendars were not returned at end of each month, prompting by telephone.
Mahoney et al., 2007 [11]	Self-report and caregiver assist, if necessary, using 12 monthly falls diaries and calendars. If calendars not returned, research assistant called to prompt. When fall was reported, research assistant telephoned to determine circumstances and injuries if any.
van Haastregt et al., 2000 [12]	Self-report using a weekly diary.

1. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Psychotropic medication withdrawal and a home-based exercise program to prevent falls: A randomized, controlled trial. *J Am Geriatr Soc.* 1999;47(7):850–53. [PMID: 10404930]
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Table 9. (Continued)

Fall data collection method: Multifactorial prevention program.

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12. van Haastregt JC, Diederiks JP, Van Rossum E, De Witte LP, Voorhoeve PM, Crebolder HF. Effects of a programme of multifactorial home visits on falls and mobility impairments in elderly people at risk: Randomised controlled trial. *BMJ.* 2000;321(7267):994–98. [PMID: 11039967]

- Exercise alone is effective in reducing the number of falls. It should include a comprehensive program combining strengthening, balance, and/or endurance training for a minimum of 12 weeks.
- Home hazard assessment with modifications may be beneficial in reducing falls, especially in a targeted group of individuals. Additional benefits may be obtained if an OT or a PT conducts the assessment.

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