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Preventing falls among older adults: No "one size suits all" intervention strategy

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Abstract—Physical activity (exercise) serves primary, secondary, and tertiary roles in the prevention of falls among older adults. In its primary role, physical activity can prevent the onset of pathology and system impairments that lead to disability and increased risk for falls. Slowing the progression of disease and system impairments is its secondary role, while its tertiary role lies in the restoration of function to a level that allows for more autonomy in the performance of essential activities of daily living. Whether used as a stand-alone strategy or a core component of a multifactorial intervention approach, exercise constitutes an effective means by which to reduce fall risk and/or fall incidence rates. At low levels of risk, many exercise choices are available to older adults. As the level of risk increases, however, more tailored and progressive exercise programs that target the physical risk factors associated with falls are more effective in lowering fall risk. Adopting a multifactorial intervention approach with exercise as an integral component may also be necessary at the highest levels of risk. Although more labor intensive, multifactorial approaches, if carefully staged, should still be considered the most effective intervention approach for older adults identified at high risk for falls.

Key words: aging, community-based exercise, exercise, fall risk, falls, home-based exercise, multifactorial interventions, older adults, physical activity, rehabilitation.

INTRODUCTION

According to the Centers for Disease Control and Prevention, the United States is on the "brink of a longevity revolution" [1]. By 2030, an estimated one in every five Americans will be 65 years or older. Mortality rates are also expected to improve, with global life expectancy reaching 76 years by 2050. As a direct consequence of this disproportionate growth in the older adult segment of the population, a 25 percent increase in healthcare spending over this same period is anticipated unless the health of older adults can be maintained or improved substantially [2]. Falls among older adults are particularly costly for the individual and society. Regardless of the medical care system that is studied, the economic burden caused by fall-related injuries is substantial for developed countries. In the United States alone, direct medical costs totaled $0.2 billion ($179 million) for fatal falls and $19 billion for nonfatal injuries sustained by adults aged 65 years and older in 2000 [3].

In an effort to address these alarming statistics, a large number of randomized controlled trials (RCTs) and quasi-randomized trials have investigated the efficacy of a number of different intervention strategies aimed at improving balance and/or reducing fall incidence rates among older adults [4–8]. Several different types of intervention strategies have been studied. These include stand-alone strategies (e.g., comprehensive fall risk

Abbreviations: FICSIT = Frailty and Injuries: Cooperative Studies on Intervention Techniques, RCT = randomized controlled trial.

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assessments [with or without follow-up], exercise, medication management, fall-risk education and behavior change, home hazard reduction) or multifactorial interventions that include two or more different strategies.

Central to the focus of this article will be a review of key research studies that have investigated the benefits of exercise (as either a stand-alone intervention strategy or a core component of a multifactorial intervention) in lowering fall incidence rates and/or injuries among community-residing older adults at different levels of fall risk. Although many more RCTs have investigated the benefits of exercise in other settings (e.g., hospital, nursing home), they will not be discussed in this article. Current and future issues related to fall-prevention research that includes exercise as an intervention strategy will be addressed, and specific recommendations related to the design and implementation of exercise-based interventions that appropriately target different levels of fall risk will be presented in the final section of this article.

MULTIPLE ROLES OF PHYSICAL ACTIVITY

Regular participation in physical activity, defined here as movement that is intentional, voluntary, and directed toward achieving an identifiable goal [9], is not only integral to the maintenance of good health and functional independence in older adulthood [10] but also serves a primary role in the prevention of numerous chronic diseases (e.g., type 2 diabetes, cardiovascular disease, osteoporosis, certain types of cancer) [11]. Conversely, physical inactivity doubles the risk of developing a disability that will adversely affect mobility and the ability to perform even the most basic activities of daily life. This downward spiral in physical function ultimately results in heightened risk for loss of functional independence as a result of declining health and/or falls, in particular [12]. Mortality risk has also been shown to be three times higher among sedentary older adults than among their older adult counterparts who engage in higher levels of everyday physical activity [13].

Depending on the level of risk identified, physical activity may serve a primary, secondary, or tertiary role in the prevention of falls [14]. In its primary role, regular engagement in physical activity can prevent the onset of pathology and system impairments that may lead to disability and heightened risk for falls. Slowing the progression of disease and system impairments is its secondary role, while its tertiary role lies in the restoration of function to a level that allows for more autonomy in the performance of daily activities.

BENEFITS OF EXERCISE IN REDUCING FALLS: OVERVIEW OF RESEARCH FINDINGS

More than 100 RCTs or quasi-experimental trials published in the past 2 decades have investigated exercise—either as a stand-alone intervention strategy or as an important component of a multifactorial intervention strategy—and its benefits in reducing fall risk and/or fall incidence rates in the older adult population. Intervention strategies have consisted of single modes of exercise (e.g., resistance exercise, walking, tai chi) or multimodal exercise programs (e.g., aerobic endurance, flexibility, strength, and/or balance training). Some interventions have adopted a general approach, while others have targeted specific fall risk factors associated with heightened fall risk (e.g., muscle weakness, balance and gait impairments, reduced flexibility, and/or aerobic endurance). In addition to the different types of exercise, the target audience (e.g., healthy but sedentary, frail), method of delivery (i.e., group-based vs one-to-one), and intervention setting (i.e., community vs home) have also differed across studies. Finally, the type of provider (e.g., physical or occupational therapists, nurses, exercise specialists) responsible for designing and/or implementing the exercise intervention has also varied across studies [15–25].

The multicenter Frailty and Injuries: Cooperative Studies on Intervention Techniques (FICSIT) RCTs represented the first systematic and large-scale attempt to investigate the efficacy of exercise (both targeted and nontargeted) on a mutually agreed upon set of performance measures related to frailty and fall incidence rates among older adults. Although the interventions varied with respect to the type of exercise used and the intensity, frequency, and duration of the intervention, the combined multisite outcomes demonstrated a significant reduction in the risk of falling for the interventions that included exercise as a core component (i.e., 13% reduction). The risk of falling was further reduced (i.e., 24% reduction) if the exercise intervention included specific balance and gait activities [22]. Five of the seven study sites included relatively healthy community-residing older adults, while two sites recruited more frail participants residing in institutional settings.

Individualized exercise programs that target specific physical impairments identified during an initial assessment have proven effective in lowering fall incidence rates. These programs have generally been designed and supervised, at least initially, by physical or occupational therapists in the home [23–24]. Campbell et al. reported a significant reduction in the rate of falling (about one-third) in a group of frail homebound older women (≥80 years) identified at high risk for falling [23]. Participants received an individualized exercise program (i.e., Otago home exercise program) designed and initially taught by a physical therapist. During the intervention period, regular telephone follow-up was conducted to maintain the participants' level of motivation. Participants who agreed to maintain the exercise program for an additional year (71% of original group) continued to experience reduced fall rates over the second year when compared with the nonexercising control group [24]. Subsequent studies conducted by the same research group with community nurses as the facilitators of the intervention proved equally effective [25–26].

The effectiveness of community-based group-structured exercise programs has also been extensively studied over the past 20 to 25 years. Here again, the content of the program and target audience have varied widely across studies. Lord et al. investigated the effect of an untargeted group-exercise program on balance, strength, and falls in a group of community-residing older adults (mean age = 79.5 years) [17]. While the 12-month intervention resulted in significantly improved physical function for the intervention group only, fall incidence rates were not significantly different between the intervention and control groups. The investigators attributed the nonsignificant reduction in falls to the untargeted nature of the intervention and the fact that the target audience was higher functioning and exhibited lower falling rates. Barnett et al. subsequently demonstrated a significant reduction in falls (40%) when a more targeted exercise intervention of similar length was implemented with community-residing older adults identified as at risk for falling [15]. Similarly, significantly fewer falls (31%) were observed in a group of frail older adults residing in retirement communities who completed a 12-month exercise program that was more specifically focused on improving their ability to perform activities of daily living [18]. In the two latter studies, greater focus was placed on teaching functional (e.g., sit-to-stand, weight transference, reaching), dynamic balance, hand-eye coordination, progressive resistance, and aerobic endurance activities. More careful attention to progressing the level of difficulty associated with the various activities also distinguished these trials from the first one conducted by Lord et al. [17].

Skelton et al. have demonstrated the efficacy of a targeted exercise intervention (i.e., the Falls Management Exercise program, or FaME) in reducing fall incidence rates among community-residing older women (mean age = 72.8 years) with a history of multiple falls [27]. The intervention consisted of group-based classes that specifically focused on dynamic balance and gait, strength, endurance, flexibility, and functional skills that were supplemented with a home exercise program based on the successful Otago home exercise program described earlier in this article [23]. A 31 percent reduction in falls was noted across the entire trial period for the targeted exercise group when compared with a control group that performed a twice weekly home exercise program. What was somewhat unique about this study was the fact that falls were monitored prospectively (3 months before start of intervention period), during the 9-month intervention period, and then for approximately 12 months after completion of the intervention.

An Eastern form of exercise known as tai chi has also emerged as a viable stand-alone exercise intervention that not only provides numerous health benefits but also appears to effectively lower fall incidence rates among certain groups of older adults [28–30]. Wolf and colleagues were the first to demonstrate the effectiveness of tai chi in reducing both fear of falling and fall incidence rates over a 4-month follow-up period in a group of relatively healthy community-residing older women (≥70 years) who participated in a 15-week group and home-based tai chi program [28]. Li et al. provided additional support for the use of tai chi as a fall-prevention strategy in a group of sedentary community-residing older adults (mean age = 77.5 years) who participated in a 6-month program [29]. In addition to demonstrating significant improvements in multiple measures of balance, physical performance, and fear of falling, older adults in the tai chi group, compared with a group that received a low-intensity flexibility program, experienced significantly fewer falls (38 vs 73, respectively) and injurious falls (7% vs 18%, respectively) during the 6-month follow-up period. The preventative benefits of tai chi training were more recently demonstrated after a 16-week, once weekly, community-based program in relatively healthy older adults (mean age = 69 years). In addition to significant

improvements in balance, the risk of falling was lowered by approximately 33 percent for the tai chi group after a 6-month follow-up period [30]. In contrast, a 48-week intense tai chi program did not significantly reduce the risk ratio for falls (3-month follow-up period) in a group of older adults (70–97 years) who were categorized as frail or transitioning into frailty [31]. These findings suggest that tai chi may not be the most effective form of exercise to use when intervening with older adults who are at much higher risk for falls. Given the likelihood that multiple risk factors are contributing to heightened fall risk in this group of older adults, a multifactorial intervention strategy that includes exercise as a component versus stand-alone strategy may be warranted. The next section will describe a number of studies that have successfully applied a multifactorial intervention strategy to lowering fall risk, particularly among older adults at high risk for falls.

MULTIFACTORIAL INTERVENTION STRATEGIES WITH EXERCISE AS CORE COMPONENT

Given that more than 60 percent of all falls experienced by older adults residing in the community result from the interaction of multiple fall risk factors [32], multifactorial intervention strategies that include exercise as a core component are, not surprisingly, considered the most effective method for reducing falls, particularly when older adults at high risk for falls are targeted [5]. The primary goal of these types of strategies is usually to identify and then ameliorate or manage known fall risk factors by using a tailored intervention approach and systematic follow-up process. The fall risk factors most frequently targeted include gait and balance impairments, muscle weakness, number and type of medications, cardiovascular risk factors, vision, and environmental hazards in and around the home.

One of the first studies to examine the efficacy of a multifactorial intervention approach to reducing falls was conducted by Tinetti and colleagues as one of the multicenter FICSIT trials [33]. Men and women living in the community and with at least one risk factor associated with falling participated in a multifactorial intervention aimed at eliminating or managing identified risk factors (e.g., medication use, gait and balance, postural hypotension, home hazards). The physical therapist provided individuals identified with gait and balance impairments with a tailored exercise program containing progressive strength and balance exercises. The exercises were to be performed twice daily for 15–20 minutes over the 3-month intervention period. When compared with a control group that received usual healthcare and social visits only, fewer participants in the intervention group fell during the 1-year follow-up period (35% vs 47%, respectively). The authors also provided evidence for the intervention's cost-effectiveness [34]. In a more recent study that compared the effectiveness of a multifactorial intervention strategy in reducing fall incidence rates among healthy older adults (≥70 years) residing in the community, the impact on fall rates was considerably lower [35]. For this study, the authors investigated the individual and combined effectiveness of three a priori selected strategies: group-based exercise, home hazard management, and vision improvement. The 15-week group exercise intervention, supplemented with a home exercise program, proved the most beneficial individual fall-reduction strategy, lowering fall incidence rates by 6.9 percent over the 18-month study period, while all three strategies combined resulted in a further reduction (i.e., 14%) in estimated fall incidence rates. Unlike the two previous studies described, the interventions provided were not individually tailored based on the risk factors identified during an initial fall-risk assessment. Rather, individuals were simply randomly assigned to one of the three possible intervention groups.

In one of the first studies to investigate the efficacy of a multifactorial intervention program conducted at a community level, Clemson et al. demonstrated a 31 percent reduction in falls in the group that participated in a 7-week program that aimed to improve self-efficacy, encourage behavior change as it related to falls, and reduce falls [36]. A small group learning environment was used to achieve these goals. In addition to completing a series of educational sessions that promoted personal control and active problem-solving, participants in the intervention group received a set of strength and balance exercises that were to be performed at least three times a week at home and a list of actions and recommendations for lowering their risk for falls following an in-home fall risk assessment. Key risk factors targeted were lower-limb strength and balance, medication use, vision, environmental and behavioral home safety, and community safety. An occupational therapist facilitated the small group sessions and completed a follow-up home visit to determine the extent to which participants had addressed the recommendations provided after the initial assessment. The investigators attributed their positive findings to the fact that they not

only targeted the recruitment of older adults who had a history of falling but also focused on changing behavior by using adult learning principles to build self-confidence, knowledge, and skills to prevent falls [36]. Conversely, a multifaceted intervention strategy that combined a comprehensive fall risk assessment with group-based exercise and fall risk education in a group of sedentary community-residing older adults (≥65 years) did not significantly reduce fall incidence rates during the 12-month follow-up period [21]. The authors concluded that the nonsignificant finding relative to fall incidence rates may have been due to their failure to target older adults who would benefit most from the intervention, an insufficiently potent intervention, or insufficient program compliance.

FUTURE RESEARCH DIRECTIONS

While the published research clearly demonstrates that exercise, whether used as a stand-alone strategy or a component of a multifactorial approach, can effectively lower fall risk and/or fall incidence rates (to a greater or lesser degree), some important research questions need to be addressed before a definitive set of recommendations can be provided to practitioners working with older adults at different levels of fall risk. In this next section of the article, I identify two fundamental research questions that need to be addressed in future research that includes exercise as an important medium for reducing falls.

Question 1: What Type of Exercise Intervention Is Most Effective and for Whom?

No clear evidence currently exists to support one type of exercise intervention over another. This is largely because few studies have directly compared the efficacy of one type of exercise intervention with another type. In one of the few studies that attempted to compare different types of exercise interventions, Nnodim et al. compared a 10-week tai chi intervention with one that combined dynamic balance and stepping activities in a sample of older adults (≥65 years) with mild balance impairments [37]. The investigators showed the latter intervention strategy to be more effective, at least as it related to dynamic balance and functional mobility indicators. The effect of either intervention on subsequent fall incidence rates was not investigated. Additional studies that directly compare different types of exercise interventions across different levels of fall risk are needed.

The dose of exercise needed to afford long-term protective benefits for older adults at different levels of fall risk also remains unclear at this time. A review of the studies described in this article and summarized in **Table 1**,

Table 1.
Characteristics of reviewed studies on use of exercise to prevent falls among older adults.

Study	Participants	Intervention Type	Outcome Measures	Results
Barnett et al., 2003 [1]	*N* = 163; ≥65 yr; M & F; at-risk for falling.	Exercise-only RCT: Group exercise (1 h once/wk for 37 wk) + home exercise; designed by PT & led by exercise specialists.	Primary: Fall rates & proportion of falls across 12 mo intervention period (fall calendar); secondary: balance, strength, RT, & health status.	Relative to control: Significant ↓ fall rate (40%), significant ↓ injurious falls, significant ↑ balance at 6 mo only.
Campbell et al., 1997 [2] (Otago home exercise program)	*N* = 233; ≥80 yr; HB F only; frail.	Exercise-only RCT: Individualized in-home exercise prescribed by PT (first 2 mo); three times/wk for 12 mo + walk three times/wk; PT provided telephone support.	Primary: # falls, # injury falls, time between falls in 12 mo f/u period (fall calendar); secondary: strength & balance.	Relative to control: Significant ↓ fall rates & injurious falls, significant ↑ balance at 6 mo.
Clemson et al., 2004 [3] (Stepping On)	*N* = 310; ≥70 yr; CR M & F; history of ≥1 fall in previous 12 mo or self-report of fall risk.	Multifactorial RCT: Small group cognitive-behavior learning (seven 2 h sessions for 7 wk + community mobility session); in-class & home exercise; f/u home visit by OT; one 1.5 h booster session after 3 mo; facilitated by OT & content experts.	Primary: Fall incidence rates over 14 mo trial period (fall calendar); secondary: perceived health, mobility & self-care efficacy, physical activity level, & protective behaviors at 14 mo.	Relative to control: Significant ↓ falls (31%), significant ↑ protective measures used, significant ↑ mobility efficacy but not self-care.
Day et al., 2002 [4]	*N* = 1,090; ≥70 yr; CR M & F; relatively healthy.	Multifactorial RCT: Combined group exercise (1 h once/wk for 15 wk + daily home exercise), home hazard management, &/or vision improvement; PT designed exercise content.	Primary: Time to first fall over 18 mo f/u period (fall calendar); secondary: strength, balance, vision, & # home hazards.	Significant ↓ annual fall rate (14%) for 3 interventions combined, exercise single most effective intervention, significant ↑ balance in exercise group.

Table 1. (Continued)
Characteristics of reviewed studies on use of exercise to prevent falls among older adults.

Study	Participants	Intervention Type	Outcome Measures	Results
Freiberger et al., 2007 [5]	*N* = 217; ≥70 yr; M & F; physically active & CR.	Exercise-only RCT: Intervention = psychomotor group exercise; fitness exercise; control = wait list; group class 1 h twice/wk for 6 wk + daily home exercise of selected exercises during & after intervention period; led by exercise specialists.	Primary: # falls, # multiple fallers, rate of falls, time to first fall over 12 mo f/u period (fall calendar); secondary: gait, balance, strength, & mobility.	Significant ↓ proportion of fallers (32%) in fitness group vs control, significant ↑ strength & mobility for both intervention groups.
Li et al., 2005 [6]	*N* = 256; ≥70 yr; M & F; CR physically inactive.	Exercise-only RCT: Intervention = tai chi 1 h three times/wk for 6 mo; control = stretching; led by exercise specialists.	Primary: # falls during intervention & 6 mo f/u period (fall calendar); secondary: balance, gait, mobility, FOF.	Relative to control: Significant ↓ falls & injurious falls; lower proportion of fallers; significant ↑ balance, gait, & mobility; significant ↓ FOF.
Lord et al., 2003 [7]	*N* = 551; ≥62 yr (mean 79.5 yr); M & F; retirement communities: self- & assisted care.	Exercise-only RCT: Group exercise 1 h twice/wk for 12 mo, led by exercise specialists; seated FR program led by yoga instructors; NEC (usual activities); combined control.	Primary: # falls over 12 mo f/u period; secondary: PP-choice stepping RT, aerobic endurance, strength, speed, & balance.	Significant ↓ in group exercise (22%) vs combined control & group-exercise subjects who had fallen in previous year (31%), significant ↑ PP in group-exercise group only at 6 mo retest.
Robertson et al., 2001 [8] (Otago home exercise program)	*N* = 240; ≥75 yr; M & F; HB.	Exercise-only RCT: Individualized in-home exercise program three times for 30 min/wk + walk twice/wk for 12 mo; led by trained nurse; control = usual care.	# falls over 12 mo trial period, # fall injuries (fall calendar), perceived health status, program implementation costs, fall-related hospital costs.	Significant ↓ falls (46%); ↓ serious injuries & hospital admissions, more cost effective for ≥80 yr old group.
Rubenstein et al., 2000 [9]	*N* = 59; ≥70 yr; fall prone men only with chronic impairments.	Exercise only: Group exercise program 90 min three times/wk for 12 wk; low-moderate intensity; strength, endurance, balance, & mobility focus; control = usual activity; led by exercise specialists.	Primary: Fall incidence rates, # falls/1,000 h of physical activity; secondary: strength, balance, endurance, gait, & perceived health.	Significant ↓ falls for experimental group per hour of physical activity at 3 mo f/u, significant ↑ endurance, gait, & right knee flexion strength only.
Shumway-Cook et al., 2007 [10] (Enhance Fitness)	*N* = 453; ≥65 yr; sedentary but relatively healthy; 75% with no fall history in previous 3 mo.	Multifaceted RCT: Intervention = group exercise class 1 h three times/wk for 12 mo, fall prevention education six times for 1 h once/mo); control = received two fall education brochures; led by certified fitness trainers.	Primary: Fall incidence rates over 12 mo (fall calendar); secondary: strength, balance, & mobility.	Nonsignificant ↓ falls (25%) vs control; small but significant ↑ balance, mobility, & strength.
Skelton et al., 2005 [11] (FaME program)	*N* = 81; ≥65 yr; F; living unassisted in home; history of ≥3 falls.	Exercise RCT: Group + home exercise program (group = 1 h once/wk for 36 wk; home = twice 30 min/wk); Control = home exercise twice/wk; led by qualified exercise-for-older persons instructor.	Primary: falls & fall-related injuries; secondary: mortality of frequent fallers, hospitalizations, change in residence.	31% ↓ fall rates in experimental group over entire trial, no significant ↓ injuries, significant group differences in secondary outcomes.
Tinetti et al., 1994 [12] (Yale FICSIT Trial)	*N* = 310; ≥70 yr CR M & F with ≥1 risk factor for falls.	Intervention: Combination of medication adjustment; individually tailored balance, gait, & transfer training &/or behavioral instructions addressing specific risk factors; control: usual care & social visits.	Primary: # falls during 12 mo f/u period (fall calendar); # medications; balance, transfer, & gait impairments at end of f/u period.	Relative to control: Significant ↓ falls & presence of identified risk factors.
Voukelatos et al., 2007 [13]	≥60 yr; relatively healthy.	Exercise RCT: Group tai chi classes in community 1 h/wk for 16 wk; control = wait-list.	Primary: Falls at 16 & 24 wk f/u; secondary: balance at baseline & 16 wk f/u.	Falls ↓ in tai chi group (29% at 16 wk, 33% at 24 wk); ↑ in 5/6 balance tests (tai chi only).
Wolf et al., 1996 [14] (Atlanta FICSIT Trial)	*N* = 200; ≥70 yr CR M & F; relatively healthy.	Exercise RCT: Tai chi 1 h/wk for 15 wk + home exercise vs computerized balance training 1 h/wk for 15 wk; control = education 1 h/wk for 15 wk.	Primary: Strength, ROM, FOF, & BC.	Significant ↓ multiple falls in tai chi group.

Table 1. (Continued)

Characteristics of reviewed studies on use of exercise to prevent falls among older adults.

Study	Participants	Intervention Type	Outcome Measures	Results
Wolf et al., 2003 [15]	*N* = 311; ≥70 yr M & F; Transitioning to frailty; ≥1 fall in previous 12 mo.	Exercise-only RCT: Intervention = 10–50 min "work time" twice/wk for 48 wk; control = Wellness Education 1 h once/wk for 48 wk.	Primary: # falls & time to first fall; secondary: balance, strength, gait, FOF, & health status.	Relative to control: No significant ↓ falls but positive trend.

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↑ = increase, ↓ = decrease, BC = body composition, CR = community-residing, F = female, FaME = Falls Management Exercise, FICSIT = Frailty and Injuries: Cooperative Studies on Intervention Techniques, f/u = follow-up, FOF = fear-of-falling, FR = flexibility and relaxation, HB = homebound, M = male, NEC = no exercise control, OT = occupational therapist, PP = physical performance, PT = physical therapist, RCT = randomized controlled trial, ROM = range of motion, RT = reaction time.

however, does suggest that a higher dose (i.e., duration, frequency, and/or intensity) of exercise that specifically targets balance and gait is needed to lower fall incidence rates among older adults at higher risk for falls [15,18,23,27]. Perhaps one way to obtain more definitive evidence relative to the actual exercise dose needed for individuals at different levels of fall risk would be to analyze fall rates at more time points during the intervention period itself so that the point at which the intervention begins to actually lower fall risk for the targeted group (e.g., low, moderate, or high risk) can be identified.

Although multifactorial risk factor assessment and intervention strategies have been shown to have the greatest effect in reducing fall rates and fall-related injuries in older adults with a history of falls, more research is needed to determine the best combination of intervention strategies and the extent to which each individual component contributes to the total reduction in fall risk. After comparing the outcomes of single and multifactorial interventions, Campbell and Robertson recently suggested that while multifactorial intervention strategies may be appropriate for individual patients, "there is no direct trial evidence that multiple or multifactorial interventions are more effective than targeted single interventions for community populations at risk" [38, p. 657]. In contrast, the authors argued that well-designed single-factor intervention programs (that may or may not include exercise) delivered to carefully selected populations may prove as effective as multifactorial programs in fostering long-term participation and reducing fall incidence rates in at-risk

groups. They further contend that targeted single interventions may be more acceptable and cost-effective for these same risk groups, because they cause less confusion, require the older adults to make fewer changes in their lives, and are simply less time and resource intensive. Certainly some support exists for this argument based on the successful outcomes of several exercise-only intervention studies described in this article that carefully matched the type and dose of exercise intervention to the level of fall risk targeted [15,18,27,29].

Little evidence currently exists for the role of exercise as either a stand-alone or an integrated component of a multifactorial intervention strategy aimed at reducing falls and/or fall risk among older adults diagnosed with dementia. The only RCT published to date did not find a multifactorial intervention approach to be effective in lowering fall incidence rates or any other fall-related measure collected (e.g., injury rates, time to first fall, hospital admission) when examined in a group of older adults with cognitive impairment and dementia [39]. Given that individuals with cognitive impairment are twice as likely to fall as their peers without cognitive impairment [40], this future line of research should receive high priority. Too few studies to date have included a sufficiently diverse sample to evaluate the benefits of a particular intervention strategy for individuals of different ethnic, cultural, and socioeconomic backgrounds. We currently know little about the type of intervention strategy that is most likely to be effective as well as feasible and practical to implement among these different segments of the older adult population. Which intervention strategies are likely to foster the highest long-term uptake among the older adult population is also unknown at this time. Some research evidence supports the inclusion of a behavioral component aimed at elevating self-efficacy and fostering long-term participation in fall-prevention activities and safe behaviors, but more research is warranted on this topic [36,41].

Question 2: How Should Effectiveness of Particular Intervention Strategies Be Assessed?

Comparing the relative effectiveness of different exercise interventions aimed at reducing falls is often difficult because of the inconsistency with which fall-related outcomes are monitored and reported. This inconsistency is in part due to the fact that the definition of what constitutes a fall varies widely across studies. While some studies use broader definitions that include slips and trips [28] or falls sustained during vigorous sporting activities (e.g., skiing, cycling) [42], other studies have adopted more stringent criteria [23,27,37]. Given that fall incidence rates often serve as the primary outcome of interest in many studies, adopting a standardized definition is critical so that the results of the different intervention strategies tested can be better compared and meaningful clinical guidelines related to fall prevention developed. Conveying clearly to the study participant what constitutes a fall is also important so that falls are accurately recorded. Zecevic et al. have previously shown that the perceptions of older adults vary widely if a clear fall definition is not provided to them [43]. In an effort to address this lack of standardization, the Prevention of Falls Network Europe recently published a consensus statement of outcome definitions that included one describing a fall (i.e., “an unexpected event in which the participant comes to rest on the ground, floor, or a lower level.”) [44].

Compounding the lack of consensus on what constitutes a fall is the lack of standardization relative to the methods used to monitor fall occurrences, the types of fall outcomes used to compare group differences, and the length of time over which falls are monitored in any given investigation. While some studies rely on retrospective self-reports of falls, others use fall diaries in which falls (and other relevant information related to the fall) are recorded daily, sometimes before and during an intervention and/or for a predetermined period following the conclusion of the intervention. A wide range of fall outcomes (e.g., number of single and/or recurrent fallers, fall rates, fall-related injuries, time to first fall) are often reported across studies, once again making comparison of the relative benefits of different intervention strategies difficult. Postintervention fall-monitoring periods have ranged from as little as 2 months to 2 years, making equating the extent of the benefits derived from one intervention strategy with another difficult [7]. In some cases, fall incidence rates have only been reported for the duration of the intervention itself, with no postintervention follow-up period included. Until such time as investigators adopt a universal definition of what constitutes a fall, near-fall, slip, or trip and a consistent method for reporting outcomes across a uniform time frame, it will not be possible to accurately determine which type of intervention, irrespective of whether it includes exercise, is superior to another in reducing the incidence of falls. In a recent review of multifactorial approaches to fall-risk reduction,

Gates et al. contend that the more important fall outcomes to report are fall injury and fracture rates, because they have the greatest impact on the individual's health and use of resources [8].

In general, the effectiveness of any exercise intervention is based primarily on whether fall incidence rates are appreciably lowered in the targeted group. Given that the best research outcomes have lowered fall risk or fall incidence rates no more than 50 percent in groups completing an exercise intervention, does that mean that the remaining 50 percent achieved less than satisfactory outcomes? Judgment concerning an intervention's effectiveness should consider additional outcome measures, such as the use of healthcare services, improvements in the overall level of disability, and psychosocial measures such as fear-of-falling, depression, and perceived quality of life. Given that a successful exercise intervention will likely lead to higher levels of physical activity, so, too, will it increase the risk for falls as a result of increased exposure to environmental hazards. To recognize this potentially offsetting phenomenon, fall incidence rates should be adjusted for physical activity levels during a postintervention follow-up period, as was done by Rubenstein et al. [20]. At the very least, physical activity levels should be monitored during the postintervention follow-up period by evaluating whether the particular exercise intervention changed the individual's exercise behavior. Finally, more studies aimed at establishing the cost-effectiveness of a particular intervention strategy should also be a priority for future research [25–26,34]. Changing existing policy or advocating for increased funding for fall-prevention research and programming is difficult in the absence of this information.

TRANSLATING RESEARCH INTO PRACTICE: DESIGNING EXERCISE PROGRAMS THAT ADDRESS DIFFERENT LEVELS OF FALL RISK

Despite the many questions and/or issues that need to be addressed in future research, what can be concluded with some level of confidence from the research published to date is that exercise, whether implemented as a single intervention strategy or a component of a multifactorial approach to fall prevention, is effective in reducing the physical risk factors associated with heightened fall risk and may also result in lower fall incidence rates among certain fall-risk groups. What the available research also suggests, however, is that there is no "one size suits all" intervention strategy. This is particularly true when one considers which type of exercise program to use. In this final section of the article, I offer several recommendations that can guide practitioners in selecting an exercise program that is best suited to the level of fall risk being addressed. These recommendations are also summarized in **Table 2**.

For older adults at low risk for falls (i.e., no history of falls in the previous year, absence of known risk factors

Table 2.
Key recommendations for clinicians and practitioners planning exercise programs for older adults at various levels of fall risk.

Patient Risk Level	Recommendation
Low*	Multimodal group exercise programs with or without home exercise. Moderate-intensity walking program. Tai chi class. Other recreational activities with strong balance component (e.g., tennis, golf, bike riding). Dancing (e.g., ballroom, line, tango).
Moderate†	Structured group exercise classes that systematically target identified physical risk factors. Well-designed and progressive home exercise programs. Behavioral component aimed at fostering long-term involvement in fall-prevention activities.
High‡	Individually tailored exercise programs led by healthcare or specially trained exercise professionals who can select and progress exercises based on individual's identified risk factors and abilities. Additional intervention strategies as indicated based on comprehensive medical evaluation (e.g., medication management, vision assessment and/or surgical intervention, home assessment and modification, and assistive device training). Behavioral component.

*No history of falls in previous year and absence of known risk factors for falls.
†History of one to two falls in previous year and presence of one or more known risk factors for falls, including comorbid conditions.
‡Injury-related fall in previous 6 months, presence of two or more risk factors for falls, and comorbid conditions that are less medically stable.

for falls), many physical activity choices are available based on their interests and skill level. Walking is one of the simplest and least resource-intensive physical activities in which the majority of older adults can participate. Engaging in a moderately intense daily walking routine at least 30 minutes a day will help an older adult maintain adequate levels of strength, aerobic endurance, balance, and coordination. This recommendation is consistent with newly published guidelines that recommend that older adults engage in 30 minutes of moderately intense activity 5 or more days a week or 20 minutes of vigorously intense activity 3 or more days a week in order to derive important health benefits [11]. Walking has also been identified as the physical activity of choice among ethnically diverse older adults and may therefore serve as an important basis on which to build fall-risk reduction programs aimed at culturally diverse groups of older adults [45]. Older adults who feel less stable when walking or are fearful of falling may also benefit, if sufficiently coordinated, from the use of walking poles to improve their overall level of stability [46–47].

Participating in multimodal group exercise classes that include aerobic endurance, muscular strength, endurance and power, balance, and/or flexibility has also been shown to effectively reduce important physical risk factors associated with falls in relatively healthy groups of older adults [48]. In addition, group-based classes provide a socially supportive activity environment and a level of supervision and structure that many older adults need to remain engaged over the long-term. Other recreational activities that incorporate many of the important functional parameters just listed include tennis, golf (combined with walking vs riding around the course), bicycle riding, and dancing to music (e.g., ballroom, line dancing, tango).

Research findings also support alternative forms of exercise, such as tai chi, as effective means by which to reduce fall incidence rates among community-residing older adults [29–30]. Certainly the delivery of tai chi programs in community settings has a number of advantages. Tai chi requires no equipment, can be performed indoors or outdoors, and can be performed in a group or individually in the home. Although tai chi is easy to initiate in community-based settings, programming must carefully consider the form of tai chi selected and the qualifications of the instructor hired to lead the class. The Li et al. study selected the Yang style of tai chi and reduced it to 24 different movements that emphasized multidirectional weight-shifting, multisegmental (arms, trunk, legs) coordinative movements, awareness of body alignment, and synchronized breathing [29]. In their earlier study, Wolf et al. used a simplified form of tai chi consisting of 10 exercise forms that "emphasized all components of movement that typically become limited with aging" [28, p. 490]. Movement components emphasized the gradual reduction in base of support, increased body and trunk rotation, and reciprocal arm movements.

For older adults identified at moderate risk for falls (i.e., a history of one to two falls in the previous year; the presence of one or more known risk factors for falls, including comorbid medical conditions), the research described earlier in this article suggests the need for structured exercise programs that systematically target the physical risk factors identified during a comprehensive fall-risk assessment. A staged approach, as recommended by Baker et al. [49], may also be appropriate when multiple physical risk factors are identified. At this level of risk, exercise programs need to combine dynamic balance and gait activities performed in changing sensory environments with functional activities designed to improve muscular strength, endurance, and power. Just as the principle of progressive overload applies when one is exercising the cardiovascular and musculoskeletal systems, systematically and progressively challenging an individual's balance abilities is important. Activities designed to improve the older adults' ability to process and integrate sensory information, anticipate and/or react quickly and efficiently to changes in the environment, allocate attention appropriately, and perform multidirectional and segmental coordination activities in a controlled manner should be considered particularly important dimensions of balance to emphasize in these programs [50–51]. Performing increasingly challenging balance activities (e.g., balancing or walking while performing a second task) is also likely to positively influence essential cognitive processes (e.g., attention, memory, problem-solving) [52]. Observable improvements in balance and mobility also positively influence the individual's level of self-confidence and more global fear of falling. Whether this type of program is implemented in a group-structured setting or as a home-exercise program does not appear to influence the outcomes. A significant reduction in fall risk and/or fall incidence rates has been shown in both settings.

Individually based exercise programs that target known intrinsic risk factors also appear to be most effective for frail older adults who are advanced in age (>80 years) and/or at high risk for falls (i.e., an injury-related fall within the past 6 months; the presence of two or more risk factors

associated with falls, including comorbid conditions that are less medically stable). A healthcare professional or a specially trained exercise specialist skilled in selecting the type of exercise based on the specific needs and abilities of the individual and progressing the difficulty level of the various exercise components is best suited to leading these types of programs. The initial focus in these types of exercise programs should be on strengthening all major muscle groups in a seated or supported standing position until sufficient strength permits the inclusion of unsupported standing exercises that emphasize dynamic balance and mobility. In addition to the improvements in physical capacity gained, these programs also positively affect the individual's perceived quality of life.

Finally, for older adults at high risk for falls (i.e., at least one injury-related fall in the previous 6 months, the presence of two or more risk factors for falls, and comorbid conditions that are less medically stable), carefully designed and longer-duration exercise programs that are included as a core component of a multifactorial intervention strategy appear to be most effective. These types of intervention strategies should begin with a comprehensive medical screening to identify the specific fall risk factors contributing to each individual's heightened fall risk. Subsequent intervention strategies should then be based on the results of the initial screening and may include such features as treatment of chronic medical conditions, an individualized exercise program, medication reviews, vision assessment, training in assistive device use, home assessment and modification, and fall-risk education aimed at changing behavior. Although multifactorial intervention strategies may be more resource-intensive and time-consuming for the recipient, careful prioritizing and/or staging of the intervention may reduce some of the confusion and resistance that Campbell et al. argue make them no more effective than single-strategy approaches [38]. Gates et al. further suggest that multifactorial interventions that "provide treatments to address risk factors rather than information and referral may be more effective" [8, p. 132].

SUMMARY AND CONCLUSIONS

Research conducted over the past 2 decades has examined the role of exercise in reducing falls among the older adult population. While important research questions must still be answered, such as what type of exercise intervention is most effective for older adults at different levels of fall risk and how best to evaluate the effectiveness of a particular intervention strategy, what can be concluded from the available evidence is that exercise, whether implemented as a single strategy or a component of a multifactorial intervention approach to fall prevention, is effective in reducing the physical risk factors associated with heightened fall risk and may also result in lower fall incidence rates among certain fall-risk groups. What the current findings also suggest, however, is that no "one size suits all" exercise intervention strategy exists. This latter finding has important implications for clinicians and practitioners who must decide which type, intensity, and dose of exercise are likely to yield the best outcomes for the patients or clients they serve. Identifying the older adults' level of fall risk is the first step in deciding which intervention strategy to use. The exercise options are many for older adults identified at low risk for falls, while the options become fewer for those older adults identified at higher levels of fall risk. The current evidence further suggests that exercise as a stand-alone strategy may not be sufficient to appreciably lower the level of fall risk in older adults identified at high risk for falls. Instead, an individually tailored exercise program that is embedded within a larger multifactorial intervention that first identifies and then prioritizes the treatment of the major risk factors contributing to the older adult's heightened fall risk is likely to be the more effective method of addressing falls in the older adult population.

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