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ACADEMIC LITERATURE REVIEW

Characteristics of optimum falls prevention exercise programmes for community-dwelling older adults using the FITT principle

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Abstract This review aims to identify the optimal exercise intervention characteristics for falls prevention among community-dwelling adults aged 60 years and over. Articles for inclusion were sourced by searching the Academic Search Premier, AMED, Biomedical Reference Collection: Expanded, CINAHL Plus, MEDLINE and SPORTDiscus databases with the key words 'falls', 'prevention', 'exercise' and 'community' and via reference lists of relevant articles. Only articles of level 1 or level 2 evidence (Howick et al. 2011) were included. Other inclusion criteria included recording falls incidence as an outcome measure, examining a community-dwelling population aged 60 years or over and implementing exercise as a single intervention in at least one group. Exercise programme characteristics from 31 articles were examined according to their frequency, intensity, time and type and their effects on falls incidence were reviewed. Exercising for a minimum of 1 h/week for at least 40 h over the course of an intervention is required to successfully reduce falls incidence. The optimal exercise frequency is three times per week, but the optimal duration per bout remains unclear. Specific balance training of sufficiently challenging intensity is a vital programme component, and strength training is most effective when combined with balance training. Flexibility and endurance training may also be included as part of a comprehensive programme. A combination of group and individual home exercise may be most effective for preventing falls and promoting exercise adherence.

Keywords Exercise · Falls prevention · Older adults · Community · FITT principle

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Introduction

Falls are prevalent among community-dwelling older adults. Approximately one in four people aged 65 years and over fall annually, with this proportion increasing to almost one in two among those aged 85 years and over [36]. Approximately 5 % of falls result in fractures or hospitalisation [46], and the long-term consequences of falling can be severe: a single fall can increase an older person's risk of admission to a nursing home within 12 months by four to five times, while multiple falls can more than double the risk of death within 12 months [18, 59].

Falls are a global concern. In the USA, falls are the leading cause of fatal and non-fatal injuries to those aged over 65 years [11]. European data indicate that the economic burden owing to falls is substantial. In the UK, the annual cost of falls among those aged 60 and over was estimated at £981 million in 1999 [49]. In Ireland, the cost of falls to the Health Service Executive was estimated to be €400 million in 2006 and is projected to increase to €1 billion by 2020 [24]. As such, it is clear that effective, low-cost interventions to prevent falls must be implemented.

A range of single interventions, including exercise [9], environmental modification [15] and psychotropic medication withdrawal [7], as well as multifactorial interventions [12, 16], has been found to prevent falls. Exercise is the most widely investigated and effective single intervention for reducing both the rate and risk of falls [6, 14, 21]. Exercise alone is as effective as multifactorial intervention in reducing falls incidence and is frequently included as a component in effective multifactorial programmes [16, 34, 58].

However, exercise programme characteristics vary between studies and are often not clearly described in studies of multifactorial interventions. Recent guidelines from the American and British Geriatrics Societies [54] state that exercise is an essential intervention for preventing falls in community-dwelling older adults, but do not recommend precise exercise characteristics for this purpose. This presents a challenge to clinicians wishing to design and implement an effective evidence-based exercise programme for an individual that is at risk of falling. As identified by Arnold et al. [1], there is a need to clarify the optimum frequency, intensity, type and duration of exercise for falls prevention.

Sherrington et al. [50, 51] have conducted systematic reviews and meta-analyses to determine the effects of exercise on falls and to identify determinants of these effects. Their findings produced valuable recommendations concerning the type, dose and settings of exercise which are associated with greater effectiveness, but these recommendations are based on evidence from older adults both in the community and in residential care. Since older adults' fall risk profiles and levels of physical function vary according to residential status [48], this review aims to examine the literature pertaining to community-dwelling older adults only in order to identify the optimum features of an exercise intervention to target that group's specific risk factors [54]. These features will be described in terms of the FITT principle, i.e. the frequency of exercise, the target intensity, the time spent exercising and the type(s) of exercise undertaken [25]. Exercise adherence was also not addressed in previous reviews. Since poor uptake and adherence will render an intervention ineffective regardless of the programme design and content [40], factors relating to exercise programme adherence will be identified and discussed in this review also. By emphasising practical factors relating to exercise programme content, delivery and adherence, the overriding goal of this review is to facilitate clinicians who wish to design and implement an effective, evidence-based, targeted intervention for clients in this population.

Method

The literature search was conducted in June 2011. The databases searched for articles for inclusion were Academic Search Premier, AMED, Biomedical Reference Collection: Expanded, CINAHL Plus, MEDLINE and SPORTDiscus with the key words 'falls', 'prevention', 'exercise' and 'community'. Reference lists of relevant articles were also searched. The initial search yielded 518 articles. A seven-step screening process was used to determine the eligibility of articles for review (Fig. 1). The seven exclusion criteria were as follows:

1. Duplicate articles
2. Articles of lower than level 1 or level 2 evidence, as determined by the Oxford Centre for Evidence-Based Medicine [26]
3. Articles that were not full-text peer-reviewed publications

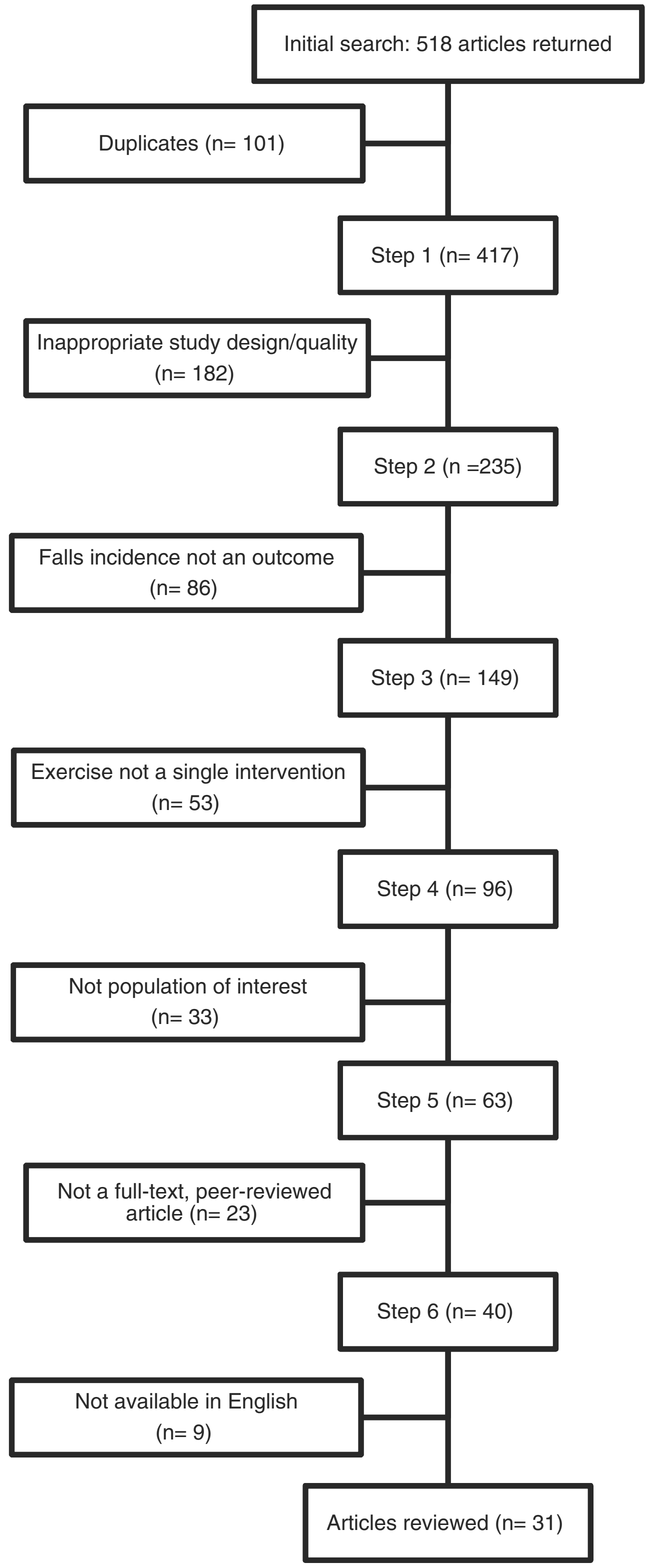

Fig. 1 Flow chart illustrating the literature search and screening process

4. Articles not available in English
5. Studies that did not include falls as an outcome measure

6. Studies of populations with specific medical conditions only or populations other than community-dwelling older adults
7. Studies that did not employ exercise as a single intervention in at least one group

Although the purpose of this review was to examine the evidence relating to exercise interventions only, studies in which falls prevention education was provided in the manner of a population-based health promotion intervention, i.e. posters, pamphlets, etc., were also included, as it is not possible to categorically state that any group would not be exposed to such information.

Results

Table 1 lists the 31 studies reviewed and provides detail on study design and aspects of methodological quality. Two papers [17, 19] have been summarised as one throughout this review, as they describe the same trial, but reported using differing statistical methods. Table 2 summarises the characteristics of the exercise programmes studied and their influences on falls. Table 3 provides details of the types of exercise included in each programme according to the ProFaNE taxonomy [31].

Discussion

Frequency

Exercise frequency in the studies reviewed predominantly ranged from once per week to daily exercise. Exercising once per week appears to be inadequate for falls prevention, with only one pilot study reporting a short-term reduction in falls incidence at that frequency [65], although it may be sufficient to produce some balance and functional improvements [39]. The minimum effective frequency reported was twice per week [61], although this effect was noted in the short term only and was not supported by studies of longer duration [10, 22, 35]. Exercising three times per week was the most commonly adopted and most consistently effective approach across the studies reviewed [4, 8, 9, 27, 33, 37, 43, 44, 47, 53, 56, 64]. Where effects were non-significant, some instances of trends towards reductions in falls rates were observed [52, 63]. In other cases, additional factors such as exercise type and intensity may have been influential [29, 32, 42].

Mixed evidence was observed for programmes involving more frequent exercise. Studies aiming for daily exercise reduced falls rates by approximately 21–47 % [2, 17, 28, 30, 62], although adherence to the desired frequency was poor. After 1 year, Barnett et al. [2] found that only 13 % of participants were exercising daily at home, with the vast majority (91 %) exercising just once per week outside of group exercise classes. Similarly, the participants of Day et al. [17] reported exercising approximately twice per week outside of group sessions. This suggests that very high exercise frequencies may not be acceptable to older adults, but further supports the finding that exercising three times per week is effective. These findings confirm those of Costello and Edelstein [14] by indicating that the optimum frequency of exercise for falls prevention is three times per week, since it allows significant benefits to be attained while remaining acceptable to this population.

Intensity

Clear guidelines exist describing appropriate strength and endurance training intensities for older adults [38]. Many studies stated that their programmes met these guidelines in relation to one or both types of training [4, 30, 32, 35, 47], but most did not provide sufficient detail of exercise intensity. All studies in which guideline intensities were explicitly not met did not significantly reduce falls incidence [28, 29, 42, 55]. This highlights that strengthening and endurance exercise must be of an appropriate intensity to achieve training effects and the ensuing clinical benefits.

Defining an optimal intensity for balance training is problematic, since there is currently no standard measure by which to express the balance training intensity. Thus, its reporting in the studies reviewed was vague and inconsistent, with descriptions including ‘demanding’ [17], ‘challenging’ [53] and of ‘appropriate and increasing levels of difficulty’ [9] being used. Sherrington et al. [51] categorised balance training intensity according to the presence or absence of certain components: moving the body’s centre of mass, reducing the base of support and minimising upper limb support. Based on these criteria, the majority of reviewed studies which included balance training may be classified as ‘highly challenging’.

Progression of intensity is vital for continuing training gains to be obtained, but maintaining safety while providing adequate challenge is essential. Costello and Edelstein [14] proposed that balance training should therefore be conducted at the highest possible level of difficulty without falling or near-falling to ensure sufficient training intensity, and that each exercise should be mastered before progressing to ensure safety. Structured programmes such as the Otago Exercise Programme (OEP) [8, 9, 43, 44] provide a useful framework for clinicians to prescribe and progress balance training, although these principles have been adopted effectively in less rigidly structured programmes without adverse events [17, 19, 37, 61].

Table 1 Summary of factors influencing the methodological quality of reviewed papers

Reference number	Study design	Groups similar at baseline	Blinding	Falls reporting
[9]	RCT	Yes	Assessors	Prospective, postal report
[17, 19]	RCT (factorial)	Yes	Assessors	Prospective, postal report
[65]	Pilot RCT	Yes	Assessor	Prospective, diary, interview
[39]	Pilot RCT	Yes	Assessors	Prospective, calendar
[61]	RCT	Yes	None	Prospective, postal report
[10]	RCT	Yes	Assessors	Retrospective, recall at 3, 6 and 12 months
[22]	RCT	No	Assessors	Prospective, falls log, telephone follow-up
[35]	RCT	No	Assessors	Prospective, calendar, interview
[8]	RCT	Yes	Assessors	Prospective, postal report
[43]	RCT	Yes	Assessors	Prospective, calendar, telephone
[44]	RCT	Yes	Assessors	Prospective, calendar, telephone
[4]	RCT	Yes	Assessors	Prospective, postal report
[27]	Cluster RCT	No	Unspecified	Prospective, report at baseline, 5 months and 1.5 years
[33]	Cluster RCT	No	Unspecified	Prospective, postal/telephone report, injurious falls only
[37]	RCT	Yes	Assessors	Prospective, postal report
[47]	RCT	Yes	None	Retrospective, interview/telephone
[53]	RCT	Yes	Assessors	Prospective, diary
[56]	RCT	Yes	Assessors	Retrospective, 1-year recall
[64]	RCT	Yes	Unspecified	Retrospective, 15-week recall
[52]	RCT	Yes	Assessors	Prospective, calendar, telephone
[63]	RCT	No	Unspecified	Not specified
[29]	RCT	Yes	Assessors	Retrospective 6-month recall
[32]	RCT	Yes	Assessors	Prospective, diary and reminders
[42]	Cluster RCT	Yes	Unspecified	Prospective, weekly interview, monthly diary
[2]	RCT	Yes	Assessors	Prospective, postal survey
[62]	RCT	No	Unspecified	Prospective, calendar/telephone
[28]	Multi-centre controlled trial	No	Unspecified	Prospective, monthly diary, weekly report
[30]	RCT	Yes	Assessors and participants	Retrospective at baseline (6-month recall), prospective calendar, monthly telephone
[55]	RCT	Yes	Unspecified	Prospective, diary, telephone
[20]	Semi-RCT	Yes	Assessors	Prospective, postal report, telephone interview
[13]	Pilot RCT	Yes	Assessors	Prospective, diary

RCT randomised controlled trial

Time

Time spent exercising may be considered in numerous ways: the duration of each exercise bout, the duration of the intervention or the total exercise volume, i.e. the cumulative time spent exercising throughout an intervention. The duration of a single bout of exercise varied from approximately 15 to 120 min in the studies reviewed. No consistent relationship between bout duration and the effectiveness of an intervention was observed, although the majority of effective interventions included some bouts of at least 60 min or more. Bouts of longer durations, i.e. 90–120 min in length, were all conducted in group settings—including time for explanation, demonstration, etc.—rather than as single, continuous bouts of exercise.

The total duration of the exercise programmes varied greatly. Effective interventions lasted from 5 weeks [61] to 2 years [8]. The most commonly observed programme durations were from 15 weeks to 12 months. Most interventions of approximately 4 months duration were reported to reduce falls [17, 19, 28, 62], while 12-month interventions reduced—or showed trends towards reducing—falls incidence [2, 9, 33, 43, 44, 52, 64, 65], with some exceptions [35, 42, 63]. The length of follow-up must be considered as a potential source of bias in short-term studies. Reporting the immediate effects of short-term interventions

Table 2 Summary of exercise programme characteristics and effects on falls

References	Format	Frequency	Intensity	Duration per bout	Total volume	Volume per week	Effect on falls
[9]	Independent	HEP 3×/week Walking 3×/week	Variable levels	HEP, 30 min	Approximately 72 h over 12 months	1.4 h	Lower annual falls rate in IG than CG, difference=0.47; 95 % CI [0.04, 0.90]
[17, 19]	Combination	Group, 1×/week HEP, 7×/week	Unspecified	Group, 1 h	Approximately 15 h plus unspecified HEP over 15 weeks	1 h	IRR for exercise alone=0.79, 95 % CI [0.67, 0.94]
[65]	Group	1×/week	Aerobic: 'moderate' Strength: 'progressive resistive exercises' Balance: progressive in difficulty	1.5 h	Approximately 24 h over 16 weeks	1.5 h	At 6 months, IRR=0.20, 95 % CI [0.04, 0.91] at 12 months, IRR=0.45, 95 % CI [0.16, 1.77]
[39]	Group	1×/week	Balance group: specific, progressive balance task workstations CG: non-specific balance exercise with increasing speed and combinations	1 h	Approximately 10 h over 10 weeks	1 h	Significant reductions in falls in balance group (p=0.000) and CG (p=0.024) at 3 months
[61]	Group	2×/week	'Low intensity'	1.5 h	Approximately 15 h over 5 weeks	3 h	IRR at 7 months=0.54, 95 % CI [0.36, 0.79]
[10]	Group	2×/week	Unspecified	40 min	Approximately 26.6 h over 20 weeks	1.3 h	During intervention, IG had 7 falls, CG had 8 falls
[22]	Independent	2×/week	Variable levels	Approximately 15 min	Approximately 12 h over 6 months	0.5 h	IRR=0.72, 95 % CI [0.33–1.57]
[35]	Group	Extensive intervention, 2×/week Minimal intervention, 1 HEP training class	Extensive intervention: progression according to RPE and ACSM guidelines Minimal intervention: unspecified	Extensive intervention, 40–50 min Minimal intervention: unspecified	Extensive intervention: approximately 60–72 h over 12 months Minimal intervention: unspecified	Extensive intervention, 1.2–1.4 h minimal intervention: unspecified	Extensive intervention: RR=1.03, 95 % CI [0.78, 1.35] minimal intervention: RR=0.90, 95 % CI [0.69, 1.17]
[8]	Independent	HEP, 3×/week Walking, 3×/week	Variable levels	HEP, 30 min	Approximately 144 h over 2 years	1.4 h	RH for all falls in IG=0.69, 95 % CI [0.49, 0.97]
[43]	Independent	HEP, 3×/week Walking, 2×/week	Variable	HEP, 30 min	Approximately 78 h over 12 months	1.5 h	IRR=0.54, 95 % CI [0.32, 0.90]
[44]	Independent	HEP, 3×/week Walking, 2×/week	Variable	HEP, 30 min	Approximately 78 h over 12 months	1.5 h	IRR=0.70, 95 % CI [0.59, 0.84]
[4]	Group	3×/week	Endurance group, 75 % HR reserve ×30–35 min Strength group, 2 sets × 10 reps; 1st set 50–60 % 1RM, 2nd set 75 % 1RM E + S group, 20 min endurance, 1 set 75 % 1RM	1 h	Approximately 72–78 h over 24–26 weeks	2.8–3.3 h	RH of time to first fall=0.53, 95 % CI [0.30, 0.91]
[27]	Group	3×/week	Unspecified	40 min		1.9 h	At 1.5 years, OR=0.13, 95 % CI [0.06, 0.273]

Table 2 (continued)

References	Format	Frequency	Intensity	Duration per bout	Total volume	Volume per week	Effect on falls
					Approximately 40 h over 5 months		
[33]	Group	6×/week	Unspecified	1 h	Approximately 312 h over 12 months	6 h	Injurious falls reduced by 44 % in CG, 75 % in tai chi villagers and 94 % in tai chi practitioners
[37]	Group	3×/week	Low intensity for 1st week (RPE=11), moderate thereafter (RPE=13)	1.5 h	Approximately 27 h over 6 weeks	4.5 h	Baseline fallers reporting no falls at follow-up: IG=87 %; CG=34.5 %
[47]	Group	3×/week	Strength, 12 reps, sets and resistance increased Endurance: up to 70 % HR reserve Balance: 'increasing in difficulty'	1.5 h	Approximately 54 h over 12 weeks	4.5 h	Lower activity-adjusted 3-month fall rate in IG than CG (6 falls/1,000 h activity vs. 16.2 falls/1,000 h, p=0.03)
[53]	Combination	IG: class, 1×/week HEP, 2×/week CG: HEP ×2/week	IG: variable levels in HEP; more challenging in class CG: low-intensity HEP	IG: class, 1 h HEP, 20–40 min CG, unspecified	IG: approximately 72 h over 36 weeks CG: unspecified	2 h	IRR=0.46, 95 % CI [0.34, 0.63]
[56]	Combination	Group, 1×/fortnight HEP, 3×/week	Resistance training: 'moderate' Tai chi: progressive duration, up to 30 min	Group, 1 h HEP, 30 min	Approximately 49 h over 6 months	1.9 h	After 20 months 13.6 % in IG fell vs. 54.5 % in CG
[64]	Combination	3×/week	Unspecified	1 h	Approximately 45 h over 15 weeks	3 h	Mean number of falls and injurious falls reduced in telecommunication and community groups, p<0.01 (values not given)
[52]	Group	3×/week	Aerobic: 'moderate' Strength: 'progressive resistance training' Balance: progressive difficulty	1 h	Approximately 156 h over 12 months	3 h	IRR=0.75, 95 % CI [0.52, 1.09]
[63]	Group	3×/week	Tai chi: unspecified resistance group: 'medium'	Unspecified	Unspecified over 12 months	Unspecified	Numbers of falls during study period: tai chi group, 15/60; resistance group, 24/60; CG, 31/60 (non-significant differences)
[29]	Independent	3×/week	Strength, 1–2 sets × 15 reps, 'moderate intensity'	Unspecified	Unspecified over 6 months	Unspecified	At 12 months, 0 falls in IG, 1 fall in CG
[32]	Independent	3×/week	3 sets × 8 reps, 60–80 % 1RM	Unspecified	Unspecified over 10 weeks	Unspecified	RR=0.96, 95 % CI [0.67, 1.36]
[42]	Group	Exercise group, 3×/week Exercise and CBT group, 2×/week	'Low intensity'	Both groups, 1 h	Exercise group: approximately 156 h over 12 months Exercise and CBT group: approximately 104 h over 12 months	Exercise group, 3 h exercise and CBT group, 2 h	No significant difference in the number of fallers between all groups at 12 months (p=0.53)
[2]	Combination	Group, 1×/week HEP, variable	Unspecified	Group, 1 h	Approximately 37 h plus HEP over 12 months	0.7 h (excluding HEP)	IRR=0.60, 95 % CI [0.36, 0.99]
[62]	Combination					4.3 h	

Table 2 (continued)

References	Format	Frequency	Intensity	Duration per bout	Total volume	Volume per week	Effect on falls
		Tai chi: group, 2×/week HEP, ×7/week Balance, 1×/ week	Tai chi: progressively more difficult forms Balance: sway targets progressed; floor movements added	Tai chi: group, 22.5 min HEP, 30 min Balance, 45 min	Tai chi: approximately 64 h over 15 weeks Balance: approximately 11.25 h over 15 weeks		RR of multiple falls for tai chi group=0.53, 95 % CI [0.32, 0.86]
[28]	Combination	Group, 1×/week HEP, 7×/week	Strength: gravity-resisted	Group, 2 h HEP, 15–20 min	Approximately 64 h over 17 weeks	3.8 h	Mean number of falls significantly lower in IG than CG, p=0.036
[30]	Combination	IG: group, 2×/ week HEP, 2×/week	IG: aerobic, 70–80 % HRmax Strength, 1–3 sets × 8–15 reps	IG: group, 1 h HEP, 20 min	IG: approximately 203 h over 18 months	IG, 2.6 h CG, 1 h	RR of falls=0.54, 95 % CI [0.35, 0.84] RR of injurious falls=0.33, 95 % CI [0.15, 0.74]
		CG, 1×/week	HEP, 1–2 sets × 6–15 reps CG, 5–10 min walking at 50–60 % HRmax	CG, 1 h	CG: approximately 78 h over 18 months		
[55]	Combination	Class, 1×/month; unspecified HEP	Class: unspecified HEP: 'gentle'	Class, 1 h	Approximately 17 h group exercise over 17 months	Unspecified	Hazard ratio for time to first fall in exercise group=0.67; 95 % CI [0.42–1.07]
[20]	Combination	Group, 2×/week HEP, 7×/week	Unspecified	Group, 1 h	Approximately 32 h over 16 weeks	2 h	Falls in fitness group: RR=0.64, 95 % CI [0.38, 1.06]
[13]	Independent	Unspecified	Individualised	Unspecified	Unspecified over 6 months	Unspecified	RR=0.21, 95 % CI [0.06, 0.67]

Ref reference number, *HEP* home exercise programme, *reps* repetitions, *HR* heart rate, *HRmax* maximum heart rate, *IRR* incidence rate ratio, *RH* relative hazard, *1RM* 1-repetition maximum, *IG* intervention group, *CG* control group, *95 % CI* 95% confidence interval, *RR* relative risk, *SD* standard deviation, *p* significance value, *RPE* rate of perceived exertion, *ACSM* American College of Sports Medicine, *CBT* cognitive behavioural therapy

Table 3 Type(s) of exercise undertaken in each programme based on the ProFaNE taxonomy [31]

Reference number	Gait, balance and functional training	Strength/ resistance	Flexibility	3-D	General physical activity	Endurance	Other training
[9]	✓	✓	✓		✓		
[17, 19]	✓	✓	✓				
[65]	✓	✓	✓		✓	✓	
[39]	✓		✓			✓	
[61]	✓						Martial arts fall techniques
[10]	✓	✓	✓				
[22]	✓	✓					
[35]	✓	✓					
[8]	✓	✓	✓		✓		
[43]	✓	✓	✓		✓		
[44]	✓	✓	✓		✓		
[4]		✓				✓	
[27]				✓			
[33]				✓			
[37]	✓	✓	✓				
[47]	✓	✓				✓	
[53]	✓	✓	✓ (CG)		✓ (CG)	✓	
[56]	✓	✓	✓	✓			
[64]				✓			
[52]	✓	✓	✓			✓	
[63]		✓ (RT)		✓	(TC)		
[29]	✓	✓	✓				Impact training
[32]		✓					
[42]	✓	✓					
[2]	✓	✓	✓			✓	
[62]	✓ (CBT)			✓	(TC)		
[28]	✓	✓	✓				
[30]	✓	✓	✓	✓	✓ (CG)	✓	
[55]	✓	✓					
[20]	✓	✓	✓			✓	Competence, perceptual (PG)
[13]	✓	✓					

PG psychomotor group, *CG* control group, *TC* tai chi group, *CBT* computerised balance training group, *RT* resistance training group

✓ Included in exercise intervention

may show reductions in falls incidence, but falls may occur infrequently, thus participants must be observed over an extended time period to detect true changes. Some evidence suggests that the effects of shorter interventions may be carried over to long-term follow-up [56, 61], while the results of Yamada et al. negate this [65]. Further research investigating participants' continuing exercise behaviours upon completion of short-term interventions is required.

Total exercise volume also varied; even among interventions of equal duration, e.g. tai chi group of Wolf et al. [62] spent 64 h exercising compared to approximately 11 h for the balance training group, despite both interventions lasting 15 weeks. To overcome the challenge this presents in comparing interventions, it may be helpful to consider the exercise volume per week for each intervention (Table 2). When considered in this manner, all effective interventions were found to involve at least 1 h of exercise per week. Ineffective interventions that exceeded this volume were noted to have insufficient exercise frequency [10, 22, 35], questionable exercise intensity [20, 42, 55, 63] or involve exercise of an inappropriate type [29, 32], with the exception of the intervention of Shumway-Cook et al. [52] which displayed a trend towards significant falls reduction. Overall, effective interventions comprised of at least 40 h of exercise over the course of the intervention, slightly less than the cutoff of 50 h suggested previously [50, 51]. Interventions with high exercise volumes [33, 52] were reasonably successful, but cited poor adherence as a barrier to further success. The OEP involves approximately half the volume of exercise of that prescribed by Shumway-Cook et al. [52] and is successful in both preventing falls and gaining adherence [57]. Thus, while no definitive total exercise volume can be recommended, it is apparent that exercise programmes must meet certain minimum requirements while remaining acceptable to participants to be effective.

Type

Guidelines recommend a comprehensive programme of balance, strength, endurance and flexibility training for all adults aged 65 and over [38]. A number of the studies reviewed implemented such a programme with the effect of reducing falls incidence [2, 20, 30, 65], including the OEP which reduced fall rates and fall-related injuries by approximately 32 % [57]. Similarly, the 36-week FaME programme [53] delivered a home programme based on the OEP combined with a supervised exercise class which included more challenging balance exercises. This intervention produced a similar immediate reduction in falls rates, increasing to 54 % after 1 year, suggesting additional benefits from group classes and more challenging balance training.

Freiberger et al. [20] investigated the optimum amount of emphasis to place on each component of a comprehensive programme. Although it did not reach significance, their fitness group—in which strength/flexibility, balance and endurance training each comprised 33 % of the programme—experienced a trend towards a reduction in falls incidence, while the psychomotor group—in which strength and balance combined comprised just 40 % of the programme—did not. Similarly, Day et al. [17] observed a reduction in falls incidence and improvements in balance with a comprehensive programme which is comprised of 30–35 % balance training. These results suggest that balance training should constitute at least one third of the total programme content and be given at least equal emphasis compared to other components for optimum fall prevention.

The nature of balance training undertaken varied between studies, although training principles remained similar. Exercises which encouraged reducing or leaning beyond the base of support, shifting the body's centre of mass, minimising upper limb support, coordinating single or dual-task movements, altering sensory feedback and functional activities were commonly used in balance training. Some effective novel approaches included computerised balance training [62], group games [39, 47] and obstacle courses [47, 61]. Tai chi was also consistently successful in preventing falls and appears to be an effective method of integrating many principles of balance training into one accessible programme [27, 33, 56, 62–64].

Certain characteristics were common to ineffective programmes: firstly, the lack of a balance training component [32, 63]. Secondly, programmes which lacked functional relevance were ineffective [29, 32]. Finally, programmes which lacked exercise progression were also ineffective in preventing falls [42].

The inclusion of walking in falls prevention exercise programmes has been identified as a contentious issue, with suggestions that walking may increase fall-risk exposure and reduce the emphasis on vital balance training [51]. In the studies reviewed which included a walking component [2, 8, 9, 20, 30, 43, 44, 47, 65], walking was not consistently associated with the effectiveness of the intervention. However, Rubenstein et al. [47] showed some association between exercise—which included walking—and increased falls risk. Clinicians may identify individuals who are at high risk of falling and would be unsafe undertaking a walking programme independently and chose not to recommend walking in such cases, an approach adopted in the OEP and supported by Sherrington et al. [50]. Other lower risk forms of endurance training, e.g. stationary cycling, swimming, etc., may be substituted if desired.

Delivery and adherence

Shumway-Cook et al. [52] demonstrated the importance of adherence to the success of a falls prevention programme, with those who attended more than 75 % of exercise classes having 41 % fewer falls than those who attended less than 33 % of classes. How best to ensure adherence remains unclear, although methods of exercise programme delivery may be influential.

Although a uniform population was targeted, various settings were observed for the exercise interventions reviewed, most commonly community centres and participants' homes. Exercise in either location was effective, as were combined centre- and home-based programmes. A convenient location and accessibility via transport links are vital, as these were cited by participants as major contributing factors to dropping out of a programme [39]. However, Day et al. [17] provided transport for their participants to attend exercise classes, yet 26 % of participants never attended a class, and only 61 % attended more than half of their sessions. In addition, participants' adherence to the recommended daily home exercise programme was poor despite being able to complete this in their own homes. It is clear, therefore, that although location is undoubtedly influential, other factors strongly influence exercise uptake and adherence.

Supervision and format (i.e. individual/group sessions) may be two such factors. Supervised group exercise is thought to facilitate uptake and adherence due to the leadership, social support and social outlet provided [5]. However, empowering individuals and encouraging self-regulated behaviour change are recommended to gain long-term motivation and exercise participation [3, 45]. In the studies reviewed, a combined approach with supervised group exercise supplemented by an individual home exercise programme appeared to be a common and effective choice of intervention, potentially providing a beneficial mix of both approaches. Providing individualised home exercise programmes with limited one-on-one supervision, as in the OEP, may also allow similar benefits to be attained, but the cost-effectiveness of this approach does not compare well to group programmes [41]. A novel approach that aimed to achieve adherence and long-term behaviour change by embedding training activities into everyday tasks was also investigated in one pilot study with promising results [13]. Larger trials of this approach are required to determine its acceptability to older adults.

Programme characteristics can also influence adherence. A strong negative correlation between exercise bout duration and adherence has recently been demonstrated in older women [60] and must be considered when designing an exercise programme for older adults. Low exercise frequency and intensity have been cited as facilitators to programme participation [5], although—as discussed—minimum requirements must be attained for a programme to be effective. Interventions of 5–12 weeks duration achieved excellent uptake and adherence, while longer interventions were associated with poorer uptake and adherence. However, as already stated, no studies examined long-term exercise behaviours of older adults following completion of short-term falls prevention programmes; thus, it is not possible to ascertain whether shorter interventions can bring about long-term positive changes in exercise behaviour.

Limitations

Since this review focused on identifying optimum exercise programme characteristics, only studies which examined exercise as a single intervention were included. Thus, the effect of exercise as part of a multifactorial intervention has not been considered. However, a factorial study [17] demonstrated that exercise was effective singly and in combination with home hazard modification and vision correction. In fact, combining all three interventions was found to bring about the greatest reduction in falls rates. This indicates that—while effective alone—a comprehensive exercise programme is also a vital component of a successful multifactorial intervention.

In terms of outcome measurement, not all studies reviewed utilised prospective falls diaries or calendars to record falls incidence, despite this being the current gold standard in falls data collection [23]. This may lead to inaccuracy in reports of falls incidence rates where retrospective methods are used. It may also render comparison with studies using prospective methods invalid. Statistical methods used to report changes in falls incidence also varied, making direct comparison between studies challenging.

Conclusions

The findings of this review agree with current falls prevention guidelines which state that older adults at risk of falling should be offered an exercise programme incorporating balance, gait and strength training, with flexibility and endurance training as adjuncts [54]. Our findings agree with those of previous reviews [1, 14, 50, 51] on a number of aspects. Three times per week appears to be the optimal exercise frequency. Specific balance training at a sufficiently challenging intensity is vital for falls prevention. Strength training in combination with balance training is effective in preventing falls. Walking may expose older adults to greater fall-risk; thus, we recommend that clinicians consider other endurance training activities for individuals at high risk of falling. As in previous reviews, current evidence remains strongest for interventions involving on-going exercise for approximately 12 months.

However, a number of original findings and findings that differ from those of previous reviews were also identified. This review identified that balance training should constitute at least one third of the total programme content. The optimal duration of individual exercise bouts remains unclear, although some evidence to support the inclusion of bouts of approximately 60 min duration was noted. Longer bouts, e.g. 90–120 min, are most acceptable in group settings. Exercise volumes of at least 1 h per week, with a minimum of approximately 40 h of exercise accumulated over the course of an intervention, were found to significantly reduce falls incidence. We found mixed evidence as regards the effects of shorter interventions on long-term falls incidence; thus, further research into how such interventions affect long-term exercise behaviour and motivation is recommended. As noted in previous reviews, exercise can be effective when delivered in a variety of methods and settings. Our findings advocate that a combination of supervised group exercise in a convenient centre and individual home-based exercise is optimal for preventing falls while achieving psychosocial benefits which may support uptake and adherence. Adherence may be further supported by implementing programmes which incorporate the exercise characteristics discussed while minimising time demands for participants.

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