

Effect of home-based exercise on falls in community-dwelling older adults: an umbrella review

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Title: Effect of home-based exercise on falls in community-dwelling older adults: An umbrella review

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Abstract

Aims: The aim of this review study was to examine the effectiveness of home-based and community-based exercise programmes effective in on the rate of falls and improving physical functioning in community-dwelling older adults.

Methods: All types of home-based and community-based exercise interventions were searched. From 1186 studies identified, 14 studies were selected for the umbrella review. Most studies had high methodological quality. The types of interventions were multi-functional programmes (n=11 studies) and Otago Exercise Programme (n=3 studies).

Results: The results showed that home-based and community-based exercise interventions can reduce falls by 22-32%. Studies that included meta-analysis showed that the clinical significance of home-based interventions in fall prevention and improving physical function was moderate to high.

Conclusions: In conclusion, home-based and community-based exercise interventions are a safe, effective, and feasible method of fall prevention that could be implemented with minimum supervision by allied health professionals to maximise autonomy, self-efficacy, and adherence in community-dwelling older adults. **Keywords:** exercise, home intervention, physical function, community.

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Introduction

COVID-19 pandemic forced a large number of older people to quarantine indoors for long periods. The enforced social isolation and lack of access to health and exercise professionals has had a significant impact on the health and wellbeing of older adults. Reduced physical activity over a long period increases the risk of physical deconditioning; losing muscle mass, poor strength, reduction in activities of daily living (ADL) and impaired balance in older adults [1]. Another concern in elderly population is frailty and risk of fall that could be increased due to changes in the active lifestyle or restrictions to access the specialised facilities for fall prevention intervention during the pandemic period. In fact, falls are common in older adults due to physical and functional changes affecting their balance and perception of their surrounding environments [2]. The estimated rate of falls in people above the age of 65 years living in the community in the United States and the United Kingdom were approximately 29% and 30%, respectively [3]. Five per cent of older adults who experienced falls had fractures and injuries that required hospitalisation [4]. Falls also have a significant financial impact on public health resources through the cost of hospitalisation and after-care [5].

During such special circumstances, home-based exercises that can be delivered remotely are crucial to prevent physical deconditioning and other adverse effects on cardiorespiratory systems, neuromusculoskeletal system and physical function [6]. Home exercise programmes are activities that a person completes at home as a stand-alone intervention or along with other interventions (e.g. multi-factorial interventions) in a generic or individualised routine [7]. The amount of supervision required is dictated by the person's needs and is usually conducted by allied healthcare professionals through a mixed approach of occasional face-to-face home visits and remote monitoring [8]. When access to qualified exercise professionals is limited, remote delivery of these programmes is pivotal for fall prevention.

There are several benefits from home-based exercise programmes for community-dwelling older adults such as increased physical function, self-efficacy [9, 10] and empowering participants to become active partners in managing their health. These programs are also cost-effective interventions for health care organisations [11]. Home-based exercise interventions as a model for fall prevention

programmes have been extensively studied and their effectiveness on the rate of falls and fall-related risk factors have been proven [10].

Interventions for fall prevention should focus on both individual and environmental factors. Individual risk factors in older people increasing the risk of falls include physical and perceptual changes such as diminished sensory-motor function [12], neuromusculoskeletal impairments [13] sarcopenia and frailty [14]. Environmental risk factors relate to safety and hazards at home or in urban and public places [15]. Several randomised controlled trials (RCT) have reported the effectiveness of different interventions on falls risk and falls rate in community-dwelling older adults. The scope of these interventions was broad and included single-factor interventions such as physical exercise [16] or multi-faceted interventions that included exercise, education, health check, vitamin D supplementation, medications, hazard assessment and environmental modifications [17].

Exercise programmes for fall reductions should emphasise on key fitness components delivered with enough challenges and in a specified dose [18-21, 16]. For example, the Otago Exercise Programme (OEP) that encompasses strength, balance and walking exercises is an effective home-based intervention for older adults [22] with a significant reduction in falls risk (RR=0.68) over 12 months [23]. Key factors for the effectiveness of fall-reduction programs are adherence to the fall-reduction interventions for the total duration of these interventions to achieve long-term benefits. Exercise programmes should be continued for a considerable period and are embedded in daily routines to maintain neurophysiological adaptations [24]. According to the WHO guidelines [25], older adults should take part in daily moderate-intensity exercises for 30 minutes and undertake strength and balance training twice a week to improve ADL, independent living [26] and prevent falls [20].

Compliance to home-based exercise programmes depends on the characteristics of these programme as well as personal factors. The main features of such programmes are a) type of exercise (e.g. fitness components); b) mode of delivery (e.g. group vs. individual; face-to-face vs. remote); c) amount of supervision (e.g. supervised vs. unsupervised sessions) and d) exercise location (e.g. centre-based vs. home-based) [27]. Important personal factors are self-efficacy, motivation and the level of frailty [28].

There are two main types of review studies exploring the effectiveness of home-based exercise

interventions on fall prevention, namely systematic review and meta-analysis. Both have their limitations due to variations in programme protocols and settings which makes it difficult to implement them in decision-making processes [29]. However, an umbrella review, which is a comprehensive synthesis of systematic reviews and meta-analyses, provides a rapid, holistic and broader view on high-quality evidence with the added advantage of supporting decision-making in health sectors [30]. The number of umbrella reviews on fall prevention is limited and only one study focused on general fall interventions in older adults [29] and reported that exercise and individually tailored multifactorial interventions are effective in reducing falls in community-dwelling older adults. Our proposed umbrella review is novel in several ways. First, the previous umbrella review was limited to meta-analyses of RCT and did not include review studies (systematic reviews and meta-analyses). Second, in Stubbs et al. [29] review, the scope of interventions was physical (exercise and environment modification) and non-physical (e.g. vitamin D supplements, education and surgery, etc.). Third and most importantly, the location of interventions was not limited to the home environment. Hence, to get better insight into the nature and effectiveness of home-interventions that could be delivered with minimum supervision, this umbrella review aims to re-examine the effects of home-based exercise interventions on fall rates and fall-related risk factors in older adults.

Methods

This umbrella review followed a published protocol that was registered in PROSPERO (registration number: CRD42020199754).

Study selection

Eligibility criteria for studies to be included in this umbrella review were a) systematic review and meta-analysis, b) the study sample included only older adults (>65 years), c) studies focused on fall and balance interventions, d) the setting was home/ community and individually delivered and e) studies were peer-reviewed and published in English between 1990 and July 2020. The exclusion criteria from this umbrella review were a) case reports, descriptive studies, cross-sectional studies, randomised controlled trials, epidemiology and protocol design, b) the intervention setting was in care

homes or clinics, c) the mode of exercise delivery was group exercises, d) the types of interventions were other than physical interventions including exercise and environmental modification and e) conference, abstract and unpublished thesis and dissertation.

Search strategy

The following databases were searched: Cumulative Index to Nursing and Allied Health Literature (CINHAL), MEDLINE, Health Source: Nursing/ Academic Edition (HSNAE), SPORTDiscus, Scopus, Pubmed, Cochran Library and Allied and Complementary Medicine Database (AMED). The search strategy involved 4 steps, with a combination of key terms used at each step. Step 1: "home exercise" AND "fall", step 2: "home exercise "AND "strength, balance", step 3: "home interventions" AND "fall", step 4: "home interventions" AND " strength, balance". In all steps, these keywords were added to the search: older adult, systematic review and meta-analysis. Abstracts and full texts were screened independently by two reviewers to ensure they met the inclusion criteria.

Data extraction and synthesis

Studies were organised in a Microsoft Excel worksheet. Two reviewers independently extracted the data from the selected articles. The extracted data included authors and publication date, the type of study, intervention setting, participant information, intervention, outcome measure and findings. The study information included the type of review and the number of studies. Study participant information included age, gender and sample size. Information about the study intervention included the type of intervention, types of tasks, place of intervention, and length and frequency of the intervention. Key information on outcome measures included whether the study reported fall metrics (e.g. fall rate, risk of fall) or fall-related risk factors (e.g. strength, balance, etc.). The narrative synthesis of the studies was only carried out for meta-analysis studies (random or fix effects) and only pooled effect sizes were reported in this umbrella study.

Study quality assessment

The Assessment of Multiple Systematic Reviews (AMSTAR) [31] was used to assess study quality. Two reviewers screened the full texts and assessed their quality independently and agreed on the final

score. Discrepancies in quality rating were resolved by discussion. The AMSTAR is a reliable and valid tool to assess the quality of methods in systematic reviews and meta-analyses. It has 11 items and 3 rates (met, unclear or unmet). The possible total score in each study ranges between 0 (low quality) and 11 (high quality). Scores are graded as high quality (8-11), medium quality (4-7) and low quality (0-3) [31].

Clinical significance was determined by Cohen's classification [32]: standardized effect size of less than 0.2 was considered trivial, 0.2-0.5 was considered small, of 0.5-0.8 was considered moderate and above 0.8 was considered large.

Results

Search results

The search results yielded 1186 articles that reported exercise and fall in older adults. The titles, abstracts and full texts were read and retrieved (see Figure 1). After reading the titles, 1152 articles were excluded according to the above inclusion and exclusion criteria. The abstracts of 34 articles were reviewed, following which only 20 articles were included. After retrieving the full text of those 20 articles, 14 articles were selected for this umbrella review [33-36, 20, 10, 37-39, 24, 40, 23, 41, 42].

Description of studies

Most of the included studies were published between 2016-2020 (n=7 studies). Four studies were published between 2011-2015, and 3 studies were published between 2000-2010.

The types of studies were meta-analysis (n=4 studies), systematic review (n=2 studies) and mixed (n=8 studies).

The physical intervention settings were at home (n=6 studies), community (n=2 studies) or both (n=6 studies).

The population of studies were community-dwelling older adults. Three review studies included frail

older adults or older adults with balance problem [20, 38, 40].

The majority of interventions were multi-functional programmes (n=11 studies) and OEP (n=3 studies). The total number of studies and the total sample size in multi-functional programme review studies were 369 studies with 87264 participants, in the OEP review there were 27 studies with 2979 participants and in the environment modification review there were 98 studies with 26333 participants.

The multi-functional programmes included home-based functional activities such as stairs climbing, walking, balance activities, resistance training, Tai chi, body transfer, stepping, weight-bearing exercises, stretching, chair-based exercises, working with obstacles and uneven surfaces. The OEP included balance and strength training along with walking.

The quality of included studies

The quality of most studies was high and scores ranged between 10 and 11. Only two studies had medium quality scoring 4 [35] and 6 [41].

Effectiveness of physical interventions

Table 1 summarised the key findings of the included studies. The outcome measures of some review studies were related to fall or functional performances. The studies that measured fall-related outcomes reported the positive and significant effects of physical interventions on reduction of fall rate and fall risk [34, 35, 20, 10, 37, 24, 40, 23, 42]. The reductions in fall rate were between 22 and 32%. The pooled effect sizes in the reported meta-analysis studies were small [40], moderate [34, 20, 23] and large [10, 37].

The studies that measured functional performance outcomes reported positive and significant effects of physical interventions on walking speed, strength, balance and ADLs [36, 10, 38, 43, 40, 41]. The pooled effect sizes in the reported meta-analysis studies were moderate [10, 38, 43] to large [40, 41]. Only one study did not report any significant change [33].

Discussion

The aim of this umbrella review was to examine the effects of home-based exercise interventions on the rate of falls and fall-related risk factors in older adults. The findings of this umbrella review showed that exercise interventions are effective in reducing the number of falls, the risk of falling and improving physical function in community-dwelling older adults. Our findings showed that the interventions were effective in reducing falls by 32%. Meta-analysis studies that reported effect size showed that the exercise interventions were clinically meaningful in reducing the fall rate or improving physical functions that are associated with falls risk such as balance, strength, endurance and mobility. The effectiveness of home-based exercise interventions on fall prevention could be explained by the characteristics of the programme and the nature of tasks. However, the main finding in these programmes was that the fall risk was reduced by improving muscular strength, balance and gait [21]. It has been shown that falls can be prevented by appropriate exercise programmes that have appropriate challenges and dose [20, 16].

Characteristics of home-based interventions for fall prevention

Variations in tasks

One of the main characteristics of home-based exercise interventions was the variety of tasks and their emphasis on fall-related risk factors such as strength, balance and mobility. For example, in the OEP, the main tasks were strength, balance and walking. The nature of multi-functional interventions was practising the tasks that are mainly used in everyday life situations such as manoeuvring, postural stability, upper and lower body strength, walking in different surfaces, stairs walking, step training and tai chi [33, 34]. We use “structured variations” in the tasks instead of “random variations” to emphasise on specific neurophysical adaptations that are required for falls prevention. In other words, the organisation of the task variations according to the fall-risk factors, task specificity, is a better way to avoid the risk of fall, tripping and losing balance in everyday life situations because they more directly prepare the body [44]. Perceptual-motor skills such as anticipation, reaction, quickness,

balance recovery, obstacle negotiation and coordination are associated with falls risk after postural perturbations and could be improved through a task-specific training method [40]. It was also evident that the effectiveness of fall prevention programmes, to some extent, is improved through exercises that challenge balance [45]. The similarity between the types of task and individual lifestyle preferences [46] and practice in enriched environments [47] has neurophysiological benefits for older adults and additional motivational qualities that foster autonomy and self-efficacy in dealing with the challenges in the surrounding environments [10].

Dose and duration

The effectiveness of a fall programme is also determined by the dose and the amount of exercise. It is recommended that a higher total dose of exercise per week (minimum 3h/ week) is a key factor for fall prevention [45]. In this umbrella review, we found that studies that were effective in reducing the rate of falls had more variations in the number of tasks, carried out for at least 1 month and continued for 48 months [37]. The weekly dose of the intervention was between one to six sessions per week. The same quantity of exercise was reported in the studies that reported improvements in physical functions such as strength, balance and gait [36, 38, 43]. It is apparent that the prescription of a specific dose of exercise to reduce falls rate and improve physical function is not straight forward and may depend on the nature of adaptations and the complexity of the training tasks. For example, in the step training that only focused on footwork [40] the duration of intervention was between 1 day and 6 months representing the shortest intervention in our selected studies, but still resulted in fall reduction (RR=0.48) and balance improvement. Martins et al. [24] also carried out a short-term intervention (6 months) with the modified OEP and reported a reduction in fall rates of 31% and improvement in balance.

Individually tailored programme and amount of supervision

A key feature of home-based interventions is the delivery of programmes in the community and at home which makes them different from other types of fall prevention programmes [48]. Interventions such as home assessment and modifications are mainly client-centred methods that are delivered in the person's home environment to increase safety and independence and to minimise risk factors in

daily living situations [36]. Some advantages of home-based exercises including individualisation of tasks (matching the tasks to the person's needs), more freedom in timing and training schedule, less cost to the individual due to travel and membership fee in community exercise centres and more autonomy in choosing exercises [10].

However, the criticism aimed at these studies argued that reducing the amount of supervision through home-based programmes can affect the exercise benefits (dose-response relationship) because the quality of execution and intensity of tasks are negatively affected [43, 39]. To maximise the benefits of home-based interventions, it is necessary to adopt a balanced approach through occasional visits by health carers to monitor progress, online and face-to-face feedback provision to build up self-efficacy and correction of errors and remote support throughout the intervention period to enhance adherence [49, 46]. Another limitation of home-based interventions is the level of frailty and cognitive function of participants; the level of frailty and muscle weakness might limit the feasibility of home-based interventions as more supervision is required [50]. However, our findings showed that even in moderate frail older adults or older adults with falls, the home-based fall prevention programmes were effective in reducing the fall rate [20, 40] and improved physical function [36, 38, 40]. The results of other review studies also showed that community-based multi-functional interventions reduced the fall rate by 32% [51] and improved balance [50] in older adults with dementia.

Adherence rate

Lack of self-discipline and motivation might be potential barriers for implementing home-based interventions in community-dwelling older adults [10]. The findings of our study reported high and acceptable adherence rates amongst participants in following the intervention [36, 38, 43]. For example, Lacroix et al. [43] showed that supervised interventions were not different from unsupervised interventions on exercise adherence (80.9% vs. 76.8%). In other review studies, adherence rates to home exercises approximately ranged between 68-83% [10] and 70-87% [24, 23] in the OEP. Adherence rates were similar to other studies involving less independent older adults; range was between 85-87% [33, 38].

Adverse effects

Theoretically minimal supervision during execution of physical exercise at home might increase the risk of injuries and other adverse effects. The review studies that included adverse effects did not report any injurious falls, fractures and musculoskeletal pains in the intervention groups [36, 10, 38]. These findings are contrary to common beliefs that older adults do not enjoy structured home-based exercise and physical activity because they feel too old to exercise or are in so much pain to be active or exercise [51]. Based on the findings of our review, home-based exercise interventions are safe and did not result in harm in community-dwelling older adults including frail populations.

Implications to applied health professions

This umbrella review provides comprehensive updated evidence on the effect of home-based exercise interventions on falls risk and physical performance in community-dwelling older adults. The review studies that were included had high methodological quality. Our umbrella review showed that the provision of home exercises is an effective intervention in reducing the risk of falls through improvement in physical function such as balance, strength, mobility and body transfer skills. These findings have important implications for health practitioners delivering exercise interventions at home. First, home-based exercise interventions are a safe and efficient method for older adults and reduce fall rate in the long term. Activities that improve postural balance, foot works (e.g. stepping, stairs climbing, etc.), body transfer (e.g. sit to stand, turning, walking, etc.) along with physical fitness components such as strength, flexibility and endurance are recommended for maximum benefit. Second, a balance between structured and unstructured sessions is recommended to ensure the quality of exercise execution, to monitor individual progress over time and to increase motivation and exercise adherence. This approach could be delivered through online support and other remote methods of providing feedback. Remote delivery is particularly relevant to COVID-19 times when the provision of home-based interventions can be safely delivered to prevent physical deconditioning in older people staying indoors. Allied health practitioners could check an older person's home environment and identify appropriate tools (e.g. space, equipment) to individualise the exercises according to the person and environmental demands. For example, using furniture, stairs and other

appropriate objects that are available in any home environment could be used effectively to maximise exercise safety and adherence. Finally, this high-ranked evidence could be used to encourage health policymakers to invest in innovative fall prevention programmes that empower older people to exercise within their home environments and improve their physical function. Health sectors should invest more in home-based fall reduction programmes to reduce additional cost of centre-based initiatives.

Limitations

We acknowledge some limitations in this umbrella review. The format of reporting in selected studies was not similar throughout which limits our interpretation of some aspects of the home-based interventions. For example, not all studies reported adverse effects and adherence in their findings. The physical function in selected studies only classified participants based on the presence or absence of frailty and fall experience rather than the status of physical fitness, hence limiting full assessment of the dose-response associations in home-based exercise interventions.

Conclusions

This umbrella review is the first comprehensive synthesis of existing systematic review and meta-analysis studies on home-based exercise programmes in older adults. Our findings showed that these interventions are safe, effective and feasible for long-term neurophysical adaptations and fall reduction in older adults with a range of physical conditions who live in the community. Policymakers and allied health practitioners should advocate these interventions for their clinical-effectiveness, long-term benefits and as an alternative method during periods of limited access to health centres.

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Conflict of interest:

There is no conflict of interest to report.

Authors contributions:

MS and SP contributed to studies searching and data processing. MS and KA contributed to manuscript preparation.

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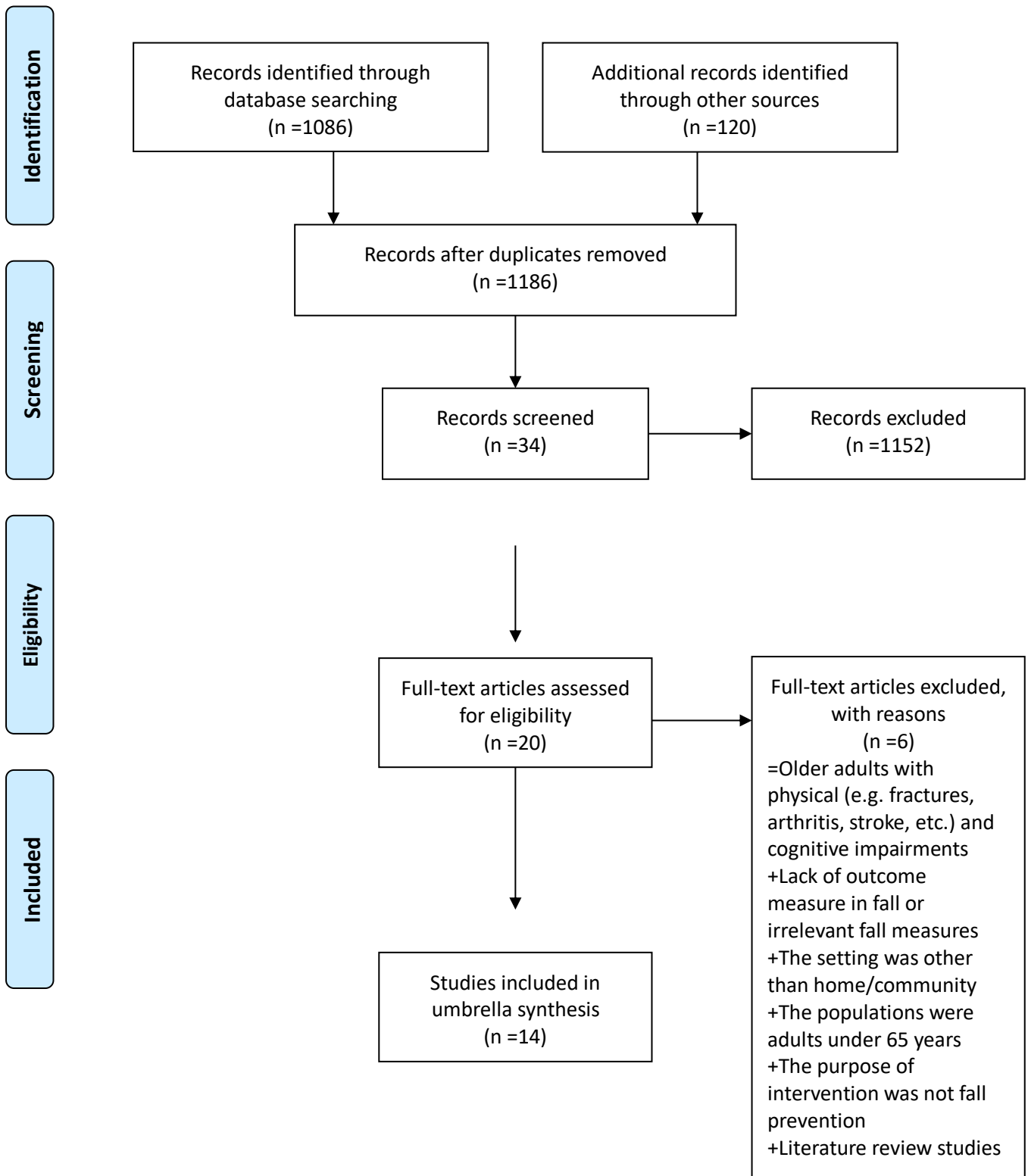


Figure 1- PRISMA flow diagram for home-based exercise in older adults

Table 1- Characteristics of review studies on the type of intervention, population and findings.

Study	Studies included (n=number of participants)	Type of study	Intervention	Setting	Topic	AMSTAR	Findings
Burton, Farrier, Galvin, Johnson, Horgan, Warters, Hill ³³	18 (n=1118); female and male community dwelling older adults	Systematic review and meta-analysis of RCTs	Home-based structured exercises included balance and transfer training, weight-bearing exercises strength training, functional mobility, stairs climbing, indoor and outdoor walking and transferring. The interventions ranged between 3 and 12 months and varied from once a week or five times a week.	Home	Multi-functional	11	The intervention did not affect the functional performance such as strength, balance and mobility.
Campbell, Robertson ³⁴	14 (n=5968); female and male community dwelling older adults	Meta-analysis of RCTs	The interventions were categorised into single-component (exercise or home safety) and multi-component. Home-based strength and balance training, tai chi was the widely investigated interventions in the exercise category.	Home and community	Multi-functional	10	Single-component and multi-component interventions reduced the falls by 23% (RR=0.77) and 22% (RR=0.77), respectively. There was significant heterogeneity in the single intervention among studies.
Chase, Mann, Wasek, Arbesman ³⁵	33; female and male community dwelling older adults	Systematic review of RCTs	Exercise programme included functional walking, tai chi, balance, flexibility and lower-limb strength training. Home assessment and modification included hazard identification, structural changes inside/outside of the home and assistive devices.	Home	Multi-functional	4	Regardless of the type of study, a significant decrease in falls and fall risk were reported. A decrease in fear of fall also reported.

Clegg, Barber, Young, Forster, Iliffe ³⁶	6 (n=987); frail female and male older adults	Systematic review of RCTs	Exercise programmes included home-based progressive resistance training, balance training, motion exercises like walking and complex interventions with occupational intervention and electronic devices. The duration of programmes was between 6 weeks and 18 months and ranged 3-21 sessions per week.	Home	Multi-functional	10	No significant improvement was reported towards reduced long-term care admission. Moderate effect was reported on the gait speed and low effects on ADL, strength and QoL.
Hill, Hunter, Batchelor, Cavalheri, Burton ¹⁰	12 (n=872); female and male community dwelling older adults	Meta-analysis of RCTs	The types of exercise programme were Otago exercise programme, weight-bearing exercise for better balance, lower-body strength, balance and mobility exercises. Exercises that were incorporated into daily activity such as standing on tip toes and bending knees. The programmes ranged from 6 weeks to 2 years. The frequency ranged from 3-6 days per week.	Home	OEP	10	A significant effect of the interventions on the number of falls (RR=0.84). A significant improvement in functional measures such as strength (RR=0.16) and balance (RR=0.88) was also reported.
Gillespie, Robertson, Gillespie, Sherrington, Gates, Clemson, Lamb ²⁰	159 (n=79193); female and male community dwelling older adults with and without fall experience	Meta-analysis of RCTs and quasi-randomised trials	The exercise intervention was gait/balance/functional training, strength training, 3D repetitive training/tai chi and square stepping and walking. The home assessment and modification for prevention of falls at home. The interventions were delivered as a single intervention or multifactorial interventions.	Home and community	Multi-functional	11	Home-based containing multiple components interventions significantly reduced the rate of falls (RR=0.68) and risk of falls (RR=0.78). Embedded balance exercises to the daily life activities also significantly reduced the rate of falls (RR=0.21).

Hopewell, Adedire, Copsey, Boniface, Sherrington, Clemson, Close, Lamb ³⁷	62 (n=19935); female and male community dwelling older adults	Meta-analysis of RCTs	Multifactorial interventions that included supervised exercise and environmental assessment and modifications. The length of interventions ranged from 1-48 months with variations in the follow-up period (up to 12 months).	Home and community	Multi-functional	11	Rate of fall was reduced after the interventions compared to usual care (RR=0.77). Maybe a little or no difference between the interventions and the usual care on the risk of people sustaining one or more falls (RR=0.96). There were no differences between the interventions and exercise alone on the rate of fall (RR=0.13) and number of people who sustained one or more falls (RR=0.26).
Kis, Buch, Stern, Moran ³⁸	12 (n=1160); female and male community dwelling older adults with frailty and functional limitations	Meta-analysis of RCTs	Most studies included progressive resistance training programs using body weight and elastic band exercises, and other interventions were some type of balance exercises. The intensity of exercises was low to high. Total workout sessions ranged 36 to 364 sessions.	Home	Multi-functional	10	Lower-limb strength was significantly increased after the interventions (MD=0.6 kg). Other significant qualities of programmes that affected the strength were high-intensity mode, long-term duration, high contact time with the staff and high-volume exercise programme. TUG test result was improved following the

							intervention (MD=0.62 sec).
Lacroix, Hortobagyi, Beurskens, Granacher ⁴³	11 (n=621); female and male community dwelling older adults	Systematic review and meta-analysis of RCTs	Supervised (66% weekly sessions were supervised by an instructor) vs. unsupervised (33% weekly sessions were supervised by an instructor) balance training including walking, tai chi, dancing, single-leg stand, tandem walking and resistance exercise such as lower-limb strength training. The length of intervention ranged from 4 to 44 weeks.	Home and community	Multi-functional	11	Supervised compared with unsupervised exercise interventions induced larger effects in measures of static balance (MD=0.28), dynamic balance (MD=0.35) and proactive balance (MD=0.24).
Martins, Santos, Silva, Baltazar, Moreira, Tavares ²⁴	8 (n=604); female and male community dwelling older adults	Systematic review of RCTs, quasi-experimental and qualitative	Modified Otago exercise programme in different formats involved additional vestibular exercises, augmented reality, group exercise, additional multi-sensory balance exercises. The length of the interventions ranged from 2 to 6 months. The frequency ranged from 1 session to 3 sessions per week.	Community centre (group) and home (individual)	OEP	11	The results suggest that modified OEP can be beneficial for physical functioning improvement especially on balance outcomes if delivered by video/DVD (individual at home or in group). Both community and home exercises reduced the risk of falls between 27-31% and

							increased balance in TUG, BBS and one-leg balance tests.
Okubo, Schoene, Lord ⁴⁰	16 (n=835) female and male healthy, frail older adults and with balance problems	Systematic review and meta-analysis of RCTs	The intervention period ranged from 1 day to 24 weeks. The type of exercise was volitional step training with mats, squares, exergame pads and reactive step training with movable platforms, treadmill with tripping obstacles and sudden speed changes.	Community and institutional settings	Multi-functional	11	The stepping interventions reduced the number of falls (RR=0.48) and proportion of fallers (RR=0.51). The balance also was improved in one-leg stance (MD=2.46sec) and BBS (MD=2.71 score).
Thomas, Mackintosh, Halbert ²³	7 (n=1503); female and male community dwelling older adults	Systematic review and meta-analysis of RCTs	The Otago exercise programme that included strength and balance training and walking activity. The interventions lasted for 12 months.	Home	OEP	11	The home-based Otago exercise programme significantly reduced fall rates (RR=0.68).
Yeun ⁴¹	19 (n=649); female and male community dwelling older adults	Systematic review and meta-analysis of RCTs and non-randomised controlled trials	Resistance exercises using elastic bands alone or in combinations with another intervention.	Community	Multi-functional	6	The resistance exercise using elastic bands significantly increased the functional reach test score (MD1.18) and TUG test time (MD: 2.89 sec).

Zijlstra, Van Haastregt, Van Rossum, Van Eijk, Yardley, Kempen ⁴²	19 (n=152); female and male ambulatory community dwelling older adults	Systematic review of RCTs	The types of interventions were fall-related multifactorial interventions, balance exercises, hip protector interventions and tai chi. The length of intervention ranged from one home visit to exercising 1hr per week for one year.	Home and community	Multi-functional	11	The majority of studies reported a significant reduction in fear of falling.
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