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External Validity of Physical Activity Interventions for Community-Dwelling Older Adults with Fall Risk: A Quantitative Systematic Literature Review

Siobhan McMahon, MSN, MPH, GNP-BC, PhD¹ [Student] and Julie Fleury, PhD RN FAAN² [Director, PhD in Nursing and Healthcare Innovation Program]

Arizona State University, College of Nursing and Health Innovation, 500 N. Third Street, Phoenix, AZ 85004, Phone: 218-290-3422 Siobhan.McMahon@asu.edu

College of Nursing and Health Innovation, Arizona State University, Phoenix, Arizona, USA

Abstract

Aim—To appraise the external validity of physical activity interventions designed to reduce falls among community-dwelling older adults, using the reach, efficacy/effectiveness, adoption, implementation, and maintenance framework.

Background—Falls are a globally common, significant, and preventable problem. The efficacy of physical activity interventions to reduce falls among older adults is well established. Translation of this research into practice is slow as evidenced by persistently low proportions of older adults who engage in physical activities and the rising incidence of falls.

Data Sources—Four electronic databases were searched for relevant studies published between 2000 and 2010. Studies that examined the effects of physical activity interventions designed to reduce falls among community dwelling older adults were included in this review (n = 46).

Review Methods—This was a quantitative systematic review with narrative synthesis. The reach, efficacy/effectiveness, adoption, implementation, and maintenance framework guided the identification, appraisal, and synthesis of indicators representing study validity.

Results—The majority of studies in this review described indicators representing internal validity. Details about indicators representing external validity were reported infrequently, limiting the generalizability of fall-preventive physical activity interventions in diverse cultures and social contexts over time.

Conclusions—To foster translational research in real world settings, additional programmatic intervention research is needed that: (a) targets diverse populations; (b) incorporates theories of behavioural change; (c) describes and operationalizes critical content that enables replication and translation; (d) tests innovative measures of fall risk and physical activity; and (e) evaluates feasibility and acceptability.

Conflict of interest:

No conflict of interest has been declared by the authors.

Author Contributions:

All authors meet at least one of the following criteria (recommended by the ICMJE*) and have agreed on the final version:

- 1) substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data;
- 2) drafting the article or revising it critically for important intellectual content.

* http://www.icmje.org/ethical_1author.html

Keywords

falls; fall prevention; physical activity interventions; older adults; systematic review; nursing

INTRODUCTION

Despite knowledge of the causes and correlations of fall occurrence and the efficacy of preventive interventions, falls continue to be the leading cause of injurious deaths among older adults, and their incidence is increasing in many areas (Centers for Disease Control and Prevention [CDC], 2011; National Center for Health Statistics [NCHS] 2009; WHO, 2007). Approximately 28–35% of people 65 years old and older fall each year (World Health Organization [WHO], 2007). Rates of injurious and fatal falls in the U.S., since 2005, have increased 16% and 12% respectively (CDC, 2011).

Among the modifiable risk factors, leg weakness, gait changes, and imbalance are the most significant (American Geriatrics Society [AGS], British Geriatrics Society [BGS], American Academy of Orthopaedic Surgeons, and Panel of Falls Prevention, 2001; AGS, 2010). Age-related musculoskeletal changes that predispose older adults to decreased leg strength and imbalance may be attenuated with regular physical activity (Singh, 2002). Further, the benefits of multi-component physical activities and Tai Chi on the risk and occurrence of falls are well documented (Gillespie et al., 2009). Translation of this research into practice, however, is slow as evidenced by the persistently low proportion of older adults regularly engaging in physical activities and the continually rising incidence of falls.

The negative impact that falls and related injuries have on quality of life and cost is significant. Twenty to thirty percent of older adults who fall suffer moderate to severe injury, such as traumatic brain injury and fractures (Sleet et al., 2008). As many as 32% of those who fall require assistance with activities of daily living for up to six months after their fall (Schiller et al., 2007). In a study of community-dwelling older adults, Tinetti and Williams (1997) documented that injurious falls were associated with nursing home placement. Many older adults (23% – 43%) experience fear of falling, which in turn leads to activity restriction and additional fear of embarrassment and losing independence (Lach, 2005; Yardley and Smith, 2002). Dollars spent on direct medical costs of falls in the United States for persons aged 65 and older in 2005 totalled \$19.4 billion and are expected to reach \$43.8 billion by 2020 (CDC, 2011; Stevens et al., 2006).

Public health initiatives, such as those from the WHO (2007) and Healthy People 2020 (U.S. Department of Health and Human Services [USDHHS], 2011), promote regular physical activity across older adult populations. Nonetheless, survey data reveal that 56% of persons over the age of 74 are sedentary and only 12% engage in muscle-strengthening activities (CDC/NCHS, 2009). Over the last decade, there has been marked progress in research identifying correlates of and mechanisms for physical activity initiation and maintenance across populations. Review articles have been published focusing on the efficacy of physical activity interventions (Conn et al., 2003; Conn et al., 2002; King et al., 1998; van der Bij, et al., 2002), including programmes designed to reduce falls (Gillespie et al., 2009; Sherrington et al., 2008b). However, few have addressed the public health impact and translation of these programmes into real world settings. Despite support for physical activity intervention efficacy, the extent to which these interventions might be effectively adopted, implemented, and maintained remains unclear. Specific to older adults, the challenge remains to synthesize findings in a way that fosters the translation of this body of research into practice (Glasgow, et al., 2004; Glasgow and Emmons, 2007; Green and Glasgow, 2006; Whittemore, 2009).

One approach to appraising the translation potential of fall-preventive physical activity interventions is through the reach, efficacy/effectiveness, adoption, implementation, and maintenance (RE-AIM) framework (Glasgow and Emmons, 2007). The RE-AIM framework has been used to design and assess health behaviour interventions, and to evaluate translation potential through literature review (Akers et al., 2010; Antikainen and Ellis, 2011; RE-AIM, 2011; White, et al., 2009). Reach refers to participation rates of target audiences and the representativeness of participating individuals. Efficacy and effectiveness refers to the measurement and analysis of (i) health and behaviour outcomes that facilitate the explanation of change, clarify anticipated results, and identify unanticipated consequences; and (ii) global outcomes, such as quality of life and cost effectiveness. Adoption refers to the participation rate and representativeness of interventionists and delivery settings. Implementation refers to intervention fidelity, or the extent to which interventions are delivered as intended. Maintenance refers to the extent to which (i) the effects of an intervention are maintained among individuals over time; and (ii) an intervention becomes institutionalized or part of an organizational routine. Expanding literature review methods to include the RE-AIM framework, which emphasizes external validity (Glasgow et al., 2004), will clarify the translation potential of fall-preventive physical activity interventions.

THE REVIEW

Aim

The aim of this literature review was to appraise the external validity of physical activity interventions designed to reduce falls among community-dwelling older adults.

Design

A quantitative systematic review with narrative synthesis was performed. Methods relevant to the aim of this paper (e.g., problem identification, literature search, data extraction management and analysis) outlined by Whitemore (2005) and the preferred reporting items for systematic reviews (Liberati et al., 2009), were used in review processes. The RE-AIM framework guided the identification, appraisal, and synthesis of indicators representing each of its dimensions (RE-AIM, 2011). The presentation of results is based on the RE-AIM framework, whose goal is to encourage researchers, clinicians, and policy makers to think critically about intervention elements that improve sustainability, adoption, and implementation (Green and Glasgow, 2006).

Search Methods

Systematic computer searches were conducted in 2010 using PsycINFO, PubMed, CINAHL, and the Cochrane Review databases (2000–2010). Search terms included: falls; accidental falls, fall prevention, nursing, physical activity intervention, exercise intervention, physical activity. Reference lists from relevant studies and resources were also reviewed to identify studies not found via computer search. Research reports were considered for the review that: (i) described intervention and intervention implementation studies, which included fall-preventive physical activity; (ii) included community-dwelling adults over the age of 60; (iii) examined intervention effects on physical activity behaviours, balance and strength, or fall occurrence; (iv) used quasi-experimental or randomized controlled trial methods; and (v) were published in the English language (see Figure 1). Studies were excluded that targeted persons in the hospital or in long term care settings.

Search Outcome

The search yielded 407 titles and abstracts. Seventy-two articles of relevance were read by both authors. Forty-six studies met inclusion criteria and were analysed for this review. Table 1 lists studies chosen for this review and key intervention characteristics.

Quality Appraisal

Using criteria indicators of each RE-AIM dimensions (Table 2), both authors independently appraised each of the 46 studies included in this review. Authors re-examined articles in which their analyses were discordant, discussing differences until consensus was reached. Findings were integrated into the results section of this paper.

Data Abstraction

Data from eligible studies was abstracted to facilitate this review. Data coding was based on RE-AIM dimension indicators and intervention characteristics. Data was stored in an electronic spread sheet to facilitate descriptive analyses and data synthesis.

Data Synthesis

After quality appraisal and data abstraction, textual descriptions of each study were composed (see supporting information Table S1 in the online version of the article in Wiley Online Library). The RE-AIM dimension indicators (Table 2) and intervention characteristics (see supporting information Table S2 in the online version of the article in Wiley Online Library) were quantitatively summarized. A narrative synthesis of study results was organized by dimensions in the RE-AIM framework (Noyes et al., 2008; Popay et al., 2006; RE-AIM, 2011).

RESULTS

The selected studies were published between 2000 and 2010. Eighty-two percent tested interventions in controlled laboratory settings, while the remaining 18% were tested in community-based settings. Experimental design was used in 76% of the studies and quasi-experimental design in the remaining 24%.

Reach and Representativeness

The median sample size of studies reviewed was 198, ranging from 15 to 1200. Participants were described in the majority of studies; however documentation of race and ethnicity, socioeconomic characteristics, and fall risk factors was variable. Of the studies that described participant ethnicity or race, the proportion of African American study participants was less than 20% (Binder et al., 2002; Healy et al., 2008). Native Americans comprised approximately 10.5% in another study (Healy et al., 2008). The average age of participants ranged from 68 to 88 years (median 76 years); 51% to 95% were female across studies that included both genders. Six studies included only females and two included only males. Studies reporting education levels described most participants had a high school or college education. However, Healy (2008) and Lin and colleagues (2006) reported that 50.5% and 90% of their respective participants had 12 years of education. Forty-two percent of studies recruited individuals with fall risk, specifying inclusion factors such as a history of falls, frailty, fear, sedentary lifestyle, and imbalance. The remaining 58% of studies either did not target individuals with fall risk or targeted those with other risks, such as osteoporosis. Participation rates, defined as the number of persons initiating an intervention divided by the number of eligible participants identified (RE-AIM, 2011), were described by 43% of the studies reviewed and averaged 57%.

Efficacy and Effectiveness

Health outcomes were reported in all studies in terms of fall occurrence and/or fall risk. Fall occurrence (e.g., incidence rates, incidence risk ratios, mean differences) was identified as a primary or secondary outcome in 70% of the studies reviewed; 59% of these reported statistically significant intervention effects. The remaining 41% of reports measuring fall occurrence reported statistically insignificant intervention effects or statistically significant effects in both experimental and control groups.

Eighty-seven percent of studies reviewed also reported health outcomes in terms of fall risk (e.g., physical function, balance, strength) using more than 30 measures. Seventy-five percent of these studies described statistically significant improvements in at least one fall risk measure. Others describe statistically insignificant intervention effects on fall risk or statistically significant effects in both experimental and control groups. For example, Steadman and colleagues (2003) found that fall risk significantly decreased among intervention and control group participants. Helbostad and colleagues (2004) found equivalent results between groups that received traditional physiotherapy and physiotherapy plus instruction on home exercises. However, the sample size in their study ($n = 77$) may not have been large enough to detect important group differences. Two studies (Fukukawa et al., 2008, Greaney et al., 2008) reported no statistically significant change in fall risk among intervention participants for reasons that may relate to intervention dosing. Latham et al. (2003) reported no statistically significant intervention effects on fall occurrence or risk, to which they attributed promoting only quadriceps exercises.

In addition to health outcomes, behavioural outcomes were measured and reported in 24% of the studies reviewed. Two studies validated self-reported physical activity behaviour with objective measures via pedometers (Shigematsu et al., 2008) and accelerometers (Dubbert et al., 2002). Subjective measures included the Physical Activity Scale for the Elderly (Barnett et al., 2003; Clemson et al., 2003; Hauer, et al., 2001; Liu-Ambrose et al., 2005; Logghe et al., 2009), a walking diary or activity calendar (Dubbert et al., 2002; Hakim et al., 2008), a Likert scale eliciting exercise frequency (Shigematsu et al., 2008), the Yale Physical Activity Scale (Greaney et al., 2008; Rubenstein et al., 2000), Physician-based Assessment and Counselling on Exercise (Healy et al., 2008), and the Community Healthy Activities Model Program for Seniors (LaForest et al., 2009). Results were not consistent within or across studies. Barnett and colleagues (2003) found that intervention participants experienced decreased falls and risk without changes in self-reported physical activity behaviours. Hauer and colleagues (2001) found that self-reported physical activity behaviour and fall risk improved significantly, but fall occurrence did not. In a study comparing resistance training to agility and flexibility training, fall risk decreased most significantly among resistance and agility groups, but self-reported physical activity behaviour was similar across all groups (Liu-Ambrose et al., 2005).

Psychosocial outcomes included depression, fear of falling, motivation, and social support. The Geriatric Depression Scale was used to measure depression in four studies; two of which reported statistically significant improvements in scores post-intervention (Inokuchi et al., 2007; Lin et al., 2007) while the remaining two reported no improvements (Alpert et al., 2009, Vogler et al., 2009). Fear of falling was measured using the Balance Self-Confidence scale (Robitaille et al., 2005), Falls Self-Efficacy Scale (Clemson et al., 2003, Fukukawa et al., 2008; Greaney et al., 2008; Healy et al., 2008; Logghe et al., 2009; Nitz and Choy, 2004), the Modified Falls Efficacy Scale (Clemson et al., 2003; Day et al., 2002; Latham et al., 2003; Vogler et al., 2009) the Mobility Efficacy Scale (Clemson et al., 2003) the Survey of Activities and Fear of Falling in the Elderly Scale (Li et al., 2005) a 10 cm visual analog scale (Lin et al., 2006; Lin et al., 2007; Weerdesteyn et al., 2009) the Falls Control and Falls Management scales (Healy et al., 2009), and the Activities Specific

Balance Scale (Haines et al., 2009; Hakim et al., 2008). Of the studies measuring fear of falling, 46% reported improvements post-intervention. One study measured motivation using the exercise stages of change tool, which showed increased readiness post-intervention (Dubbert et al., 2002). Among the four studies measuring social support, two reported improvements via the Perceived Social Support of Exercise Scale, (Dubbert et al., 2002) and an investigator developed one item scale (Healy et al., 2008); and two reported no effects via an investigator developed five item scale (Fukukawa et al., 2008) and the Falls Handicap Inventory (Steadman et al., 2003).

Global outcomes, such as cost effectiveness and quality of life were reported infrequently. Robertson and colleagues (2001) described cost savings in a nurse-delivered exercise prescription intervention for persons over 80. Quality of life was measured via the brief version of the World Health Organization's Quality of Life, the SF-36, the European Quality of Life Scale, and the Aging Frailty Scale (Ashburn et al., 2007; Carter et al., 2002; Steadman et al., 2003; Haines et al., 2009). Intervention effects on quality of life ranged from positive among intervention participants (Ashburn et al., 2007) to positive among all study participants (Steadman et al., 2003) to having no effect (Carter et al., 2007; Haines et al., 2009).

Although many studies controlled for baseline demographic and risk variables, only six identified potential modifying variables (Binder et al., 2002; Healy et al., 2008; Means and O'Sullivan, 2005; Rubenstein et al., 2000; Robitallie et al., 2005). The majority of these reports did not describe moderator analyses or interpretations. One study reported an interaction between baseline social support and self-efficacy; those with lower baseline social support had higher self-efficacy post-intervention (Fukukawa et al., 2008).

Four of the studies reviewed referenced a theoretical framework. Hakim and colleagues (2008) designed and tested a fall risk reduction programme operationalizing social cognitive theory constructs of behavioural capability, expectations, expectancies, components of observational learning, and self-efficacy. Although there were significant changes in fall risk and knowledge, measures and outcomes representing all theoretical constructs were not described (Hakim et al., 2008). Greaney and colleagues (2008) evaluated an intervention tailored to stage of change, consistent with the transtheoretical model. Intervention effects were seen when *maintenance* group participants were removed from analyses (Greaney et al., 2008). Healy and colleagues (2008) examined the efficacy of coaches in assisting persons to decrease their fear of falling and falls operationalizing cognitive behavioural constructs of self-efficacy, goal setting, and knowledge. Although self-reported physical activity and social activity did not improve significantly over time, measures of fall risk and fear of falling did improve significantly across data collection time points (Healy et al., 2008). Clemson and colleagues (2003) examined the effectiveness of an educational programme operationalizing the concepts of self-efficacy and decision making. Control group confidence and physical activity behaviours decreased over time compared to the intervention group, but differences were not statistically significant (Clemson et al., 2003).

Adoption

Many studies identified study setting and the level of interventionist expertise. Countries represented were Australia, Canada, China, Germany, Japan, New Zealand, The Netherlands, Taiwan, the United Kingdom, and the United States. Two studies (DiBrezza et al., 2005; Lin et al., 2006) were conducted in rural locations. Group-based interventions were conducted in senior community centres, community centres, retirement communities, indoor health facilities, rehabilitation facilities, and clinic settings. Multiple sites were also used in some studies. For example, orthopaedic surgeons promoted two simple daily exercises among clients in more than 60 clinics (Kita et al., 2007). Another study examined

the effects of Tai Chi in several rural Taiwan villages (Lin et al., 2006). Eighty-three percent of studies described interventionist characteristics and expertise, indicating that volunteers, nurses, occupational therapists, physicians, physical therapists, physical therapy aides, exercise instructors, and Tai Chi instructors all delivered interventions. The majority of studies did not describe inclusion/exclusion criteria used to select settings or interventionists, or details enough to calculate adoption rates.

Implementation

Interventions occurred in sessions lasting from 15 to 120 minutes at intervals ranging from 1 to 45 days. Intervention doses ranged from 1 to 315 contacts (face to face or telephone sessions) with a median dose of approximately 15.5 contacts. Intervention implementation costs, identified in three studies, ranged from \$14.87 per participant (Hakim et al., 2003) to \$80.00 per person (Carter et al., 2007) to \$NZ487 per person. Longer interventions reported higher implementation costs, but additional details were not available across studies.

In addition to RE-AIM literature review criteria, details about intervention critical content were also explored to foster understanding of each intervention's essential ingredients (Sidani and Braden, 1998). Behavioural, affective, and cognitive critical content included: (i) providing education about falls and safety; (ii) encouraging social support; (iii) enhancing motivation for physical activity; (iv) individualizing physical activities; (v) reducing fear or optimizing efficacy; (vi) promoting self-regulation; and (vii) providing resources for physical activity at home. Many studies identified more than one critical input, but did not provide descriptions of their linkages to the problem being studied, causal mechanisms or mediating variables, or outcomes, making it difficult to evaluate which critical content fostered intervention effects. For example, of the 11 (24%) interventions that encouraged social support, 4 reported measures and analyses of perceived social support whereas 9 reported improvements in the occurrence or risk of falls post-intervention. Of the six (14%) studies that enhanced motivation for physical activity, one reported measures and analysis of motivation, whereas all six reported improvements in one or more health or behavioural outcomes. Behavioural, affective, and cognitive critical content was delivered through group meetings, phone calls, home visits, and written materials, but specific details about the critical content was limited.

Physical activity critical content in most studies included instructions for progressively intensified leg strengthening and balance activities and exercises. Tai Chi was also used (Hakim et al., 2008; Lin et al., 2006; Li et al., 2005; Logghe et al., 2009; Voukelatos et al., 2007; Woo et al., 2007) and associated with decreased fall risk (Li et al., 2005; Lin et al., 2006; Voukelatos et al., 2007) and fall occurrence (Li et al., 2005; Voukelatos et al., 2007). Non-traditional strength and balance activities such as square stepping, jazz dancing, and walking were also associated with decreased fall risk (Alpert et al., 2009; Dubbert et al., 2002; Shigematsu et al., 2008). Aids such as ankle weights, resistance bands, and exercise balls were used in 24% of studies reviewed.

At least one component of intervention fidelity was described in 5 (11%) of the studies reviewed. Four studies described interventionist training that included two to five days of instruction and access to well-developed manuals and experts (Healy et al., 2008; LaForest, 2009; Robertson et al., 2001; Robitaille et al., 2005). An additional 24 studies (53%) indicated that interventionists were trained, but did not describe training methods or targeted competencies. Healy and colleagues (2008) integrated fidelity monitoring measures based on the five component model developed by the behavioural change consortium (Bellg et al., 2004). Haines and colleagues (2009) had participants share their intervention experiences with non-interventionist interviewers. Steadman and colleagues (2003) evaluated intervention delivery via an independent observer.

Intervention attendance, via self-report or interventionist records, was reported in 21 studies (46%). Average attendance ranged from 18% to 100%. Rationale for participant non-attendance, when reported, was varied. One report described that participants did not attend all sessions due to a loss of interest, inconvenient timing, or becoming ill (Voukelatos et al., 2007).

Intervention completion was described via attrition rates in 98% of studies reviewed, ranging from 1% to 60%. Several reports grouped attrition rationale into broad categories such as illness, lack of transportation or motivation, relocation to a nursing home, death, inconvenient schedules, and intervention non-adherence. Comparisons of participants who withdrew from studies to those who completed studies, described in 42% of studies, produced varied results. Several studies reported statistically insignificant group differences in demographic characteristics, fall history, or physical function (Hakim et al., 2003; Healy et al., 2008; Li et al., 2005; Nitz and Choy, 2004); others reported statistically significant group differences. Compared to participants who completed interventions, participants who did not complete interventions were more often men (Morgan et al., 2004), widowed, divorced, or single (Lin et al., 2007), older (Fukukawa et al., 2008), taking more medications (Morgan et al., 2004) weaker, less active or physically functional (Day et al., 2002; Means and O'Sullivan, 2005; Morgan et al., 2004), or with lower maximal oxygen consumption rates (Day, 2002).

Maintenance

Follow up time ranged from immediately post-study to 24 months, with a median of 6 months. Few studies reported details about the maintenance of individual health-related behaviour post-intervention. Five studies whose follow up time was at least six months reported that 31 – 72% of participants continued physical activities as recommended. At least 12 (26%) of the interventions reviewed have been sustained (Barnett et al., 2003; Campbell et al., 2005; Clemson et al., 2004; Healy, 2008; LaForest et al., 2009; Li et al., 2005; Lord et al., 2003; Robertson et al., 2001; Rubenstein et al., 2000; Skelton et al., 2005; Voukelatos et al., 2007; Weerdesteyn et al., 2009). For example, “Stepping On” (Clemson, 2004) is being implemented and evaluated in Wisconsin communities (WDHS, 2011; CDC, 2008). “A Matter of Balance” is being evaluated in at least 10 states (CDC, 2008; Healy, 2008). The “Nijmegen Falls Prevention Program” has been disseminated to many physiotherapists in The Netherlands (Weerdesteyn et al., 2009). The CDC compendium of effective fall interventions details seven of the interventions described in studies reviewed (Stevens, 2010).

DISCUSSION

The RE-AIM framework and methods used in this review provided guidance for systematically appraising the external validity of selected studies. The strength of this approach was the a priori acknowledgement that interventions requiring health-related behavioural change are complex and involve multi-level, interactive, social-ecological determinants, which provides a foundation for understanding intervention translation potential in real world settings (Green and Glasgow, 2006; Kessler and Glasgow, 2011). The primary limitation of this review was the emphasis on internal validity in study reports appraised. However, this is not surprising given that efficacy and internal validity are of central importance in randomized controlled trials (RCT). Similar limitations have been found in other reviews using the RE-AIM framework (Antikainen and Ellis, 2011; Glasgow et al., 2004; White et al., 2009). Although the Consolidated Standards of Reporting Trials includes extensions for non-pharmacological intervention studies (Boutron et al., 2008) and pragmatic studies (Zwarenstein et al., 2008), most research reports in this review were designed and reported as classic RCT. In summary, the RE-AIM framework and methods

used in this review begin to clarify the translation potential of fall-preventive physical activity interventions. Implications of review findings linked to each RE-AIM dimension provide a basis for improving future translational research in this field.

Similar to other RE-AIM reviews (Antikainen and Ellis, 2011; Glasgow et al., 2004; White et al., 2009), this review found the majority of studies reported on reach, however few reported on representativeness. There were limited sub-cultural, ethnic, educational, and income differences reported in studies reviewed. Given that falls are a globally significant public health problem, effective interventions to promote physical activity and decrease falls in these populations is important from a public health perspective. To reduce health disparities and provide a basis for the development of relevant interventions, research recruitment and reporting efforts must better address the needs of diverse older persons in their community contexts. Successful intervention design for translation requires an integrative understanding of the unique cultural and contextual perspectives, characteristics, and resources of the target population, as well as the theoretically relevant determinants of behaviour that can be transformed into culturally sensitive behaviour change strategies (Fleury and Lee, 2006).

Indicators of RE-AIM efficacy and effectiveness were comprehensively reported, providing evidence that physical activities improve health outcomes. However, the proportion of studies measuring behavioural outcomes in this review was small (24%) compared to a RE-AIM review of theory based physical activity interventions (100%) (Antikainen and Ellis, 2011). This discrepancy may reflect an emphasis on dose response goals more than behavioural goals in this field of research. While knowledge of which physical activities work safely at which doses is essential, especially in light of existing sociocultural forces negating physical activity among older adults (Brawley et al., 2003), it does not address decisional processes and actions related to the adoption, initiation, and maintenance of these activities into everyday life. Prescribed recommendations for fall-preventive physical activities appear simple, but interacting complexities emerge when used in real world settings (van Stralen et al., 2009). For example, when considering prescribed activities, older adults are often faced with unique and variable barriers to being active and complex behavioural change processes required for maintaining (or regaining) independence (Brawley et al., 2003). Considering the complexity of behaviour change and the high rates of physical inactivity in older adult populations (CDC/NCHS, 2009), integrating behavioural elements into intervention design and evaluation will foster research translation. To this end, continued development of reliable, valid, and feasible measures of physical activity behaviour is needed (Satariano and McAuley, 2003).

A minority of interventions reviewed identified mediating variables or based their interventions on theories of behavioural change. In addition to understanding which physical activities are associated with fall reduction, questions remain about which additional intervention elements are necessary to influence motivation for physical activity initiation and maintenance (van Stralen et al., 2009; Pawson et al., 2005; Sidani and Braden, 1998). Clear links between outcomes and mediating variables that reflect treatment response to a well specified problem of interest will better explain intervention causal mechanisms, and thus generate additional knowledge to guide practice (Whittemore and Grey, 2002). Development, testing, and translation of these linkages can be facilitated through use of theory to guide intervention design, implementation, and evaluation (Lipsey and Cordray, 2000; Sidani and Braden, 1998).

Interventionists described in this review had varied backgrounds, demonstrating the potential for interdisciplinary collaboration in this field. Effectiveness studies included in this review carried out interventions in multiple community and clinic settings suggesting

that physical activity interventions may be adopted in homes, community-based settings, and settings outside highly controlled environments. In addition to identifying interventionist background and intervention setting, reporting how they were chosen (inclusion/exclusion criteria), adoption rates, and organizational spread will provide meaningful information about intervention applicability in different settings by different interventionists (Green and Glasgow, 2006; Glasgow et al., 2004).

The intensity, frequency, and duration of interventions tested were reported across studies reviewed. However, few reports provided specific descriptions of behavioural, affective and cognitive critical content used; and few described if interventions were implemented consistently or as intended. These findings are similar to previous reviews using the RE-AIM framework (Antikainen and Ellis, 2011; Glasgow et al., 2004; White et al., 2009). Based on information provided, it would be difficult to replicate interventions in practice settings. Additional attention to implementation components such as detailed descriptions of critical content will improve the ability to reproduce and apply interventions across clinical settings. Attention to fidelity will also foster the implementation, evaluation, and adaptation of these interventions in practice (Bellg et al., 2004).

Measures of intervention attendance, completion, and attrition, reported by the majority of studies reviewed, are essential for evaluating programme implementation, maintenance, and feasibility in the targeted population. Few studies described details about intervention acceptability. Researchers report that older persons are motivated by easily accessible small classes composed of similarly aged people, emphasizing mobility and balance, and led by instructors capable of providing guidance for individualized progression (Hutton et al., 2009). Older persons also have preferences for programmes that respect individual goals, promote social interaction, and focus on life enhancing aspects of fall preventive behaviours, while avoiding negative messages (Bunn et al., 2008; McInnes and Askie, 2004). Descriptions of intervention acceptability from participant perspectives may improve understanding of the extent to which interventions are feasible, suitable, satisfying, and attractive (Bowen et al., 2009).

CONCLUSION

Physical activity interventions that reduce the risk and occurrence of falls among community dwelling older adults have been identified as critically important for achieving global health objectives and for reducing health care costs. Nurses can encourage physical activity that reduces fall risk among their individual clients and within their organizations and communities. To foster translation into practice, programmatic intervention research is needed which reflects the complexity of human responses to fall risk, the complexity of diverse practice settings, and the relational elements in health promotion interventions (Whittemore and Grey, 2002). Based on the findings in this review, future researchers are encouraged to focus on issues of external validity as outlined by the RE-AIM framework, including research that: (i) targets diverse populations; (ii) incorporates and tests theories of behavioural change in real world settings; (iii) operationalizes and reports intervention critical content that enables replication and translation; (iv) explores innovative measures for physical activity behaviours and fall risk; and (v) evaluates the feasibility and acceptability of fall prevention interventions. Strong partnerships among researchers, clinicians, and community members will help interventions become more realistic and relevant (Baumbusch et al., 2008; Garnham et al., 2009; Hanson et al., 2006).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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SUMMARY

What is Known about the Topic

- Injurious falls are a global public health concern.
- Regular engagement in physical activities that build leg strength and balance reduces the risk of falls and their occurrence.
- Translation of research evidence into practice is slow as evidenced by the continuation of high physical inactivity rates and high fall rates.

What This Paper Adds

- Physical activity interventions designed to reduce falls, led by nurses and other interventionists in varied settings and social contexts, efficaciously reduce fall occurrence and fall risk.
- Use of fall-preventive physical activity interventions in nursing may increase when dose response effects of physical activity on fall occurrence are integrated and tested with elements reflecting the change required for adoption and maintenance of physical activity behaviours.
- The external validity of fall preventive physical activity interventions in diverse cultures and contexts, over time, has yet to be demonstrated.

Implications for Practice and Policy

- The translation of fall-preventive physical activity intervention research into practice may be fostered by thinking critically about intervention elements that improve sustainability, adoption, and implementation.
- The reach, efficacy/effectiveness, adoption, implementation, maintenance framework guides clinicians, policy makers, and researchers to integrate and appraise the external validity of research studies, providing a basis for understanding translation potential into real world settings.

Figure 1.
Search results

Table 1

Studies reviewed: Key intervention characteristics

Author	Number	Intervention Delivery	Length (weeks)	Attendance Attrition	Long-term Follow-up ^d
Alpert et al. (2009)	68	Group	15	Attendance 100% Attrition 13%	
Ashburn et al. (2007)	142	Individual in home by PT	6	Attendance: 95% Attrition 8%	✓
Barnett et al. (2003)	163	Group in community by exercise instructor	52	Attendance 62% Attrition 8%	
Binder et al. (2002)	115	Group in exercise facility by PT tech	36	Attendance 100% Attrition 23%	
Bunout et al. (2005)	298	Group	52	Attendance 52% Attrition 19%	✓
Campbell et al. (2005)	391	Individual at home by PT	26	Attendance NA Attrition 21%	✓
Carter et al. (2002)	93	Group in community centres by instructors	20	Attendance 89% Attrition 14%	
Clenson et al. (2004)	310	Group in community by OT	7	Attendance NA Attrition 9%	✓
Day et al. (2002)	272	Group	15	80% attended > 50% Attrition 11%	✓
DiBrezzo et al. (2005)	16	Group in senior centres by instructors	10	Attendance 77% Attrition 16%	
Dubbert et al. (2002)	212	Individual in clinic and phone by RN	8	Attendance NA Attrition 15%	✓
Fukukawa et al. (2008)	29	Group in community centre	8	Adherence: NA Attrition 11%	
Greaney et al. (2008)	966	Individual over the phone by counsellors	52	Attendance: NA Attrition 20%	✓
Haines et al. (2009)	53	Individual via DVD/in person at home by PT	2	Attendance: NA Attrition 34%	✓
Hakim et al. (2003)	80	Group in community centre	12	Attendance NA Attrition 34%	
Hauer et al. (2001)	57	Group in rehabilitation by recreation specialist	12	Attendance 85% Attrition 21%	✓
Healy et al. (2008)	335	Group in community by volunteers	8	Attendance: 89% Attrition: 25%	✓
Helbostad et al. (2004)	77	Group and individual by PT	12	Attendance: > 80% Attrition: 31%	✓

Author	Number	Intervention Delivery	Length (weeks)	Attendance	Attrition	Long-term Follow-up ^d
Inokuchi et al. (2007)	268	Group in day centres by RN	17	Attendance 91% Attrition 11%		
Iwamoto et al. (2009)	68	Group in clinic or hospital	20	Attendance 100% Attrition 1%		
Kita et al. (2007)	683	Individual in clinic by MD	32	Attendance NA Attrition 19%		✓
La Forest et al. (2009)	200	Group in community by EI	12	Attendance 78% Attrition 8%		✓
Latham et al. (2003)	486	Individual in homes & phone by PT	10	Attendance 82% Attrition 9%		✓
Li et al. (2005)	256	Group by Tai Chi instructor	2	Attendance: 78% Attrition 32.5%		✓
Lin et al. (2006)	1200	Group in community by Tai Chi experts	52	Attendance 49% Attrition 24.5%		✓
Lin et al. (2007)	150	Individual in home by PT	16	Attendance: NA Attrition 16%		
Liu-Ambrose et al. (2004)	104	Group activity by EI	25	Attendance 78–85% Attrition 6 %		✓
Logghe et al. (2009)	269	Group by Tai Chi Chuan instructors	13	Attendance: 47% Attrition 11%	80%	✓
Lord et al. (2003)	551	Group in community by EI	52	Attendance 42.3% Attrition 9%		✓
Luukinen et al. (2007)	486	Individual & group (home & rehab) by PT /OT		Attendance: NA Attrition 13%		
Means et al. (2005)	210	Group by PT	6	Attendance NA Attrition 30%		✓
Morgan et al. (2004)	219	Group by PT and assistant	8	Attendance 70% Attrition 31.4%		✓
Nitz & Choy (2004)	73	Group in clinic by PT and student	10	Attendance: NA Attrition 39%		
Robertson et al. (2001)	240	Individual in homes by RN	24	Attendance NA Attrition 12%		✓
Robitaille et al. (2005)	200	Group in community by fitness pro	12	Attendance 78% Attrition 18%		
Rubenstein et al. (2000)	59	Group in clinic by PT students	12	Attendance: 84% Attrition 12%		
Sherrington et al. (2008a)	173	Group in rehabilitation by PT	5	Attendance: NA Attrition 8%		
Shigematsu et al. (2008)	68	Group in health centre by EI	12	Attendance: 84–91% Attrition 5%		

Author	Number	Intervention Delivery	Length (weeks)	Attendance Attrition	Long-term Follow-up ^a
Skelton et al. (2005)	100	Group by EI	36	Attendance NA Attrition 30%	
Steadman et al. (2003)	198	Group in hospital setting by PT	6	Attendance NA Attrition 33%	✓
Suzuki et al. (2004)	52	Group in community centres	26	Attendance 75.3% Attrition 15%	✓
Vogler et al. (2009)	180	Individual in home by PT	12	Attendance 70% Attrition 6%	
Voukelatos et al. (2007)	702	Group in community by Tai Chi instructors	16	Attendance: 71% Attrition 3%	
Weerdesteyn et al. (2006)	113	Group	5	Attendance 87% Attrition 11%	✓
Weerdesteyn et al. (2009)	88	Group in rehabilitation by PT	5	Attendance: NA Attrition: NA	✓
Woo et al. (2007)	180	Group in community centres	52	Attendance 76.3–81% Attrition 2%	

^a = Follow up of 6 months or longer

EI=Exercise Instructor

MD= Medical Doctor

NA= Data not available

PT= Physical therapist or Physiotherapist

RN= Registered Nurse

Table 2

RE-AIM framework dimensions and indicators

RE-AIM Dimension Indicators by RE-AIM dimension	Percentage of studies that reported on each RE-AIM indicator
Reach	
Sample size	100 %
Participant characteristics	100 %
Description of the target population	98 %
Selection criteria	95 %
Participation rate	43 %
Characteristics of non-participants	2 %
Cost of recruitment	2 %
Efficacy/effectiveness	
Behavioural outcome	24 %
Primary outcome measures	100 %
Primary outcome results	100 %
Quality of life measures	22 %
Cost effectiveness	4 %
Critical inputs guided by theory	9 %
Adverse outcomes	39 %
Adoption	
Intervention setting and location	72 %
Description of staff who delivered the intervention	82 %
Method to identify target delivery agent	0%
Level of expertise of delivery agent	67 %
Inclusion/Exclusion of settings or interventionists	6 %
Cost of adoption.	2 %
Implementation	
Intervention type and delivery	100 %
Critical input identification	100 %
Number of contacts	100 %
Timing of contacts	95 %
Duration of contacts	76 %
Intervention fidelity	11 %
Participant attendance	69 %
Completion rates	98 %
Attrition analysis	42 %
Implementation cost.	9 %
Maintenance	
Follow up of at least 6 months	57 %
Individual behaviour was described 6 months after the intervention	11 %

RE-AIM Dimension Indicators by RE-AIM dimension	Percentage of studies that reported on each RE-AIM indicator
Information on continued delivery	8 %