Systematic Review of the Effect of Home Modification and Fall Prevention Programs on Falls and the Performance of Community-Dwelling Older Adults

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KEY WORDS

- accident prevention
- accidental falls
- · activities of daily living
- · community health services
- environment design
- treatment outcome

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Marian Arbesman, PhD, OTR/L, is Consultant, AOTA Evidence-Based Practice Project; President, ArbesIdeas, Inc.; and Adjunct Assistant Professor, Department of Rehabilitation Science, University at Buffalo, State University of New York, Williamsville. This systematic review explored the impact of fall prevention programs and home modifications on falls and the performance of community-dwelling older adults. It was conducted as part of the American Occupational Therapy Association's Evidence-Based Practice Project. Thirty-three articles were analyzed and synthesized. The strongest results were found for multifactorial programs that included home evaluations and home modifications, physical activity or exercise, education, vision and medication checks, or assistive technology to prevent falls. Positive outcomes included a decreased rate of functional decline, a decrease in fear of falling, and an increase in physical factors such as balance and strength. The strength of the evidence for physical activity and home modification programs provided individually was moderate. Implications for practice, education, and research are also discussed.

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This systematic review was part of a larger project that reviewed research studies examining the effect of occupation- and activity-based interventions designed to promote and support productive aging. The objective of this systematic review was to synthesize existing literature to answer the following focused question: "What is the evidence for the effect of home modification and fall prevention programs on the performance of community-dwelling older adults?" We reviewed the effect of home modification as both a separate intervention and a component of several fall prevention programs. Fall prevention programs that studied the effects of physical activity interventions on strength, endurance, or balance, such as exercise-based or tai chi intervention programs, were also included in this review.

Background and Statement of the Problem

Falls are a major public health concern and contribute significantly to mortality and morbidity in the older adult population. In many studies, *falls* are defined as unintentionally coming to rest on the ground, floor, or other lower level (Buchner et al., 1993). Falls are the leading cause of injury and deaths in people over age 65 (Centers for Disease Control and Prevention [CDC], 2011). One in 3 adults age 65 and older fall each year (Hausdorff, Rios, & Edelber, 2001; Hornbrook et al., 1994), and in 2009, 2.2 million nonfatal fall injuries were treated in emergency departments (CDC, 2011). The risk of a serious injury after a fall increases with age, and in 2009, the rate of fall injuries for adults age 85 and older was reported to be almost 4 times that for adults between ages 65 and 74 (CDC, 2011). In 2000, direct medical costs of falls were estimated to total more than \$19 billion, and almost \$200

million of that total was related to fatal fall injuries (Stevens, Corso, Finkelstein, & Miller, 2006).

After an injurious fall, an older adult may experience difficulties in activities of daily living (ADLs) and instrumental activities of daily living (IADLs) and have an increased risk of early death (Alexander, Rivara, & Wolf, 1992; Sterling, O'Connor, & Bonadies, 2001). Falls also affect performance in other areas of occupation (AOTA, 2008). Tinetti and Williams (1998) reported that older adults falling twice or more in a 3-yr period were less involved in social and leisure activities. In addition, even after a fall without injury, older adults may develop a fear of falling that leads to a decrease in activity level with a decrease in overall strength and endurance (Kressig et al., 2001; Tennstedt et al., 1998). This fear of falling is also reported to increase future risk of falling (Vellas, Wayne, Romero, Baumgartner, & Garry, 1997).

Health care practitioners of all types work with this population in an attempt to decrease falls and risk of falls through such interventions as medication management, vision screening, exercise or physical activity programs, home modifications, and education. Occupational therapy practitioners play a key role in supporting older adults who wish to remain safely in their homes and connected to their communities. Many occupational therapy practitioners provide services through home evaluations before discharge from a rehabilitation facility, through occupational therapy home health services, or by providing aging-in-place services through consultation or entrepreneurial opportunities.

Regardless of service pathway, occupational therapy practitioners provide interventions for community-dwelling older adults that include home evaluations with recommendations for home hazard reduction, home modifications, education on use of assistive technology and modified techniques, and training in fall prevention strategies related to physical activities to improve strength and balance. According to Steultjens et al. (2004, p. 459), occupational therapy brings a "client-centered, problem solving attitude" to the process of supporting communitydwelling older adults' independence and safety. Reviewing the most recent evidence for various fall prevention and home modification strategies can provide guidance for occupational therapy practice decisions and can have implications for education and research.

Method

The articles included in this review were the result of database searches for articles published from 1990 to November 2008. Selected articles published in 2009–2011 were recommended by experts in the field and in-

cluded in the review. In addition, bibliographies of selected articles were reviewed for potentially relevant articles. Search terms for the review were determined by a team of experts for the overall project and included *ADLs, adaptive equipment, aging in place, assistive technology, environmental barriers, environmental modification, fall prevention, falls, fear of falling, home assessment, home modification, home safety, independent living, IADLs, occupational performance, personal care, self-care skills, selfhelp devices,* and *universal design.* Articles selected for the review included studies in which the focus was on older adults living in the community. In addition, the interventions studied were within the scope of practice of occupational therapy and included a fall prevention or home modification intervention.

After AOTA Project Consultant Marian Arbesman initially identified articles, lead author Carla A. Chase and two graduate students in occupational therapy involved in the project, Kathryn Mann and Sarah Wasek, individually reviewed each article to determine whether it fit the inclusion criteria. Discrepancies were resolved through discussion until group consensus about article eligibility was achieved. Studies were then further analyzed, categorized, and summarized according to established protocols. Detailed information about the methodology and a complete list of search terms for the entire project dedicated to productive aging can be found in "Methodology for the Systematic Reviews on Occupation- and Activity-Based Intervention Related to Productive Aging" in this issue (Arbesman & Lieberman, 2012).

Results

Of the 33 studies included in this review (see Supplemental Table 1, available online at http://ajot.aotapress. net; navigate to this article, and click on "supplemental materials"), 31 were randomized controlled trials (RCTs; Level I studies) and 2 were Level II studies. Not all studies included occupational therapy services specifically; rather, they involved interventions within occupational therapy's scope of practice. The results presented here are divided into themes on the basis of the intervention studied and include multifactorial studies, studies of physical activity alone, and studies assessing the effectiveness of home assessment and home modifications.

Multifactorial Interventions

Multifactorial approaches to fall prevention combine multiple interventions in one package. The types of interventions included may vary but often incorporate several of the following approaches: home modifications, education

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on health and safety, medication management, vision management, gait and balance training, and exercise. The disciplines providing these services may also vary but often include occupational therapy, internal medicine, physical therapy, nursing, and social services.

The evidence that multifactorial approaches reduce falls and difficulties with ADLs and IADLs in older adults is strong. Ten Level I RCTs explored multifactorial approaches (Clemson et al., 2004; Close et al., 1999; Davison, Bond, Dawson, Steen, & Kenny, 2005; Day et al., 2002; Gitlin et al., 2006; Hogan et al., 2001; Hornbrook et al., 1994; Logan et al., 2010; Nikolaus & Bach, 2003; Shumway-Cook et al., 2007). Clemson et al. (2004) reported a 31% reduction in falls at 14-mo followup for the Stepping On program, which included occupational therapy and incorporated environmental and home safety, balance, strength, vision screening, and medication management. Davison et al. (2005) reported 36% fewer falls after an intervention that combined occupational therapy, physical therapy, and medical management for older adults presenting to an emergency department after a fall. In addition, participants had a shorter duration of hospital admissions during follow-up and better falls efficacy than those in the control group. Groups did not differ, however, on the number of participants falling and the number of hospital admissions.

Nikolaus and Bach (2003) reported 31% fewer falls in the year after an intervention that included a diagnostic home visit and home intervention assessing the home for environmental hazards and providing advice for hazard reduction. In addition, training in the use of technical and mobility aids was provided, and a second home visit took place 3 mo later. Occupational therapy, physical therapy, nursing, and social work provided the intervention. Nikolaus and Bach reported that the intervention was most effective in a subgroup that had fallen 2 or more times before study recruitment. The results indicated that the rate of falls and proportion of frequent fallers was significantly reduced in this subgroup.

Close et al. (1999) found that an occupational therapy home assessment and a medical visit with referrals as appropriate led to a reduction in falls and fall risk, a decrease in the chance of hospital admission, and a slower decline in ADL function at 1-yr follow-up. All participants were recruited to the study after presenting to the emergency department after a fall. Participants in the intervention group were provided with minor equipment and referred to social services for additional adaptations. All participants in the Logan et al. (2010) study were recruited after calling an ambulance after a fall. The multifactorial intervention incorporated strength and balance exercises, home assessment of hazards, and review of medications and blood pressure as provided by occupational therapy, physical therapy, and nursing. Referrals were made to other agencies as needed. The results indicated fewer calls for an ambulance, fewer falls, better performance in ADLs and IADLs, and a significant decrease in fear of falling at follow-up.

Gitlin et al. (2006) evaluated the effectiveness of an individualized program to reduce difficulties in ADLs and IADLs, improve self-efficacy, and reduce fear of falling in community-dwelling older adults >70 yr old with difficulty in one or more ADLs. Five sessions provided by an occupational therapist examined environmental hazards and incorporated problem solving to identify behavioral and environmental contributors to performance difficulties. A single visit by a physical therapist focused on balance and muscle strengthening and fall recovery techniques. Results of the study indicated that participants in the intervention group had less difficulty with ADLs and IADLs, improved self-efficacy, and decreased fear of falling compared with control participants. In addition, those in the intervention group had fewer home hazards and more use of adaptive strategies, with significant improvements persisting at 1-yr follow-up.

Day et al. (2002) studied falls among older adults living at home with good to excellent self-reported health. Using an intervention that incorporated group-based exercise, home hazard management, and vision in various combinations, they reported that exercise alone provided the strongest evidence for a single intervention. The addition of home hazard management, vision management, or both further reduced falls. Shumway-Cook et al. (2007) provided group exercise, fall prevention education, and falls risk assessment to older sedentary adults. Although the intervention group had a 25% decrease in falls at follow-up compared with the control group, the results were not significant. Hogan et al. (2001) found no difference in falls and emergency department visits between groups for an intervention providing an individualized treatment plan plus exercise for older adults who fell within 3 mo before study recruitment. They reported, however, that participants who had reported two or more falls during the prerecruitment period had a significantly longer time between falls and fewer falls.

Physical Activity Interventions

Studies of physical activity interventions in the systematic review included group and individual sessions that incorporated balance retraining, walking, general exercise in sitting and standing, lower-extremity strengthening, use of a workstation format, or tai chi. Mixed but overall positive results were found in studies that measured the impact of physical activity programs on the performance of communitydwelling older adults. Seven RCTs reported a significant decrease in falls and fall risk after physical activity, regardless of the type of exercise incorporated into each study (Buchner et al., 1997; Faber, Bosscher, Chin, Paw, & van Wieringen, 2006; Gardner, 1998; Lord, Ward, Williams, & Strudwick, 1995; Means, Rodell, & O'Sullivan, 2005; Skelton, Dinan, Campbell, & Rutherford, 2005; Voukelatos, Cumming, Lord, & Rissel, 2007). Exercise programs in these studies included functional walking, tai chi, balance, flexibility, lower-limb strengthening, and gait training. Voukelatos et al. (2007) also reported a reduction in fear of falling in a study of tai chi with community-dwelling older adults.

Lin, Wolf, Hwang, Gong, and Chen (2007) examined the effects of several fall prevention programs; the group participating in an exercise program showed improved functional reach and balance scores and a decreased fear of falling compared with either an education group or a home safety assessment and modification group. In a Level I RCT of Finnish older adults living in the community, Luukinen et al. (2007) found no significant difference between control and intervention groups in fall rates after exercise; however, results indicated a significant decrease in the decline of balance skills over a 6-mo period. In another Level I RCT, Lord et al., 2005) compared an extensive intervention combining exercise with strategies for maximizing vision and sensation with a minimal intervention providing brief advice and with a no-intervention control. Although researchers found no difference in fall rates, the participants receiving the most extensive intervention had a decrease in some physiological risk factors related to falls such as knee flexion and sit-to-stand time but no improvement in balance.

Nitz and Choy (2004), in a Level I RCT, compared a fall prevention pamphlet control group with a group participating in a series of workstations of balance activities in addition to receiving a pamphlet. Participants in the workstation group showed improvement in functional motor ability, lateral reach, and functional step compared with control participants, but no difference in falls was found between groups at follow-up. In Hauer et al. (2001), older adults in a geriatric rehabilitation unit were randomized to either an exercise program emphasizing strength, balance, and functional performance or a placebo control group before discharge to the community. Both groups received physical therapy twice a week that did not emphasize strength and balance. The results indicated that those in the exercise intervention group had improved strength, functional motor performance, and balance and reduced fear of falling compared with the control group. No differences were found between groups for falls.

In several Level I RCTs included in the systematic review, results varied with age, fall history, and participant's activity level. For those over age 80, strengthening, balance retraining that progressed in difficulty, and a walking plan led to fewer falls and fewer injuries when falls did occur (Campbell et al., 1997; Robertson, Devlin, Gardner, & Campbell, 2001). Campbell et al. (1997), however, found no difference in ADL performance at follow-up. Means et al. (2005) reported that participants in an exercise intervention group with a history of multiple falls had fewer falls in follow-up than did the control group with a similar fall history. Morgan, Virnig, Duque, Abdel-Moty, and DeVito (2004) reported that falls among higher functioning older adults increased after an exercise program, whereas lower functioning adults had a decrease in the risk of falls.

Home Assessment and Home Modifications

The home assessment and home modification interventions in this section of the systematic review included hazard identification, structural changes to the inside and outside of the home, and provision of assistive technology and assistive devices. A Level II prospective cohort study (Liu & Lapane, 2009) surveyed older adults at baseline and during a 2-yr follow-up period as part of the second Longitudinal Study of Aging. Liu and Lapane (2009) found that those having residential modification at baseline (e.g., railings, bathroom modifications) were less likely to experience a decline in physical functioning. In a Level I RCT, Cumming et al. (1999) compared occupational therapy home visits for home modifications for older adults before hospital discharge with a nointervention control group. The occupational therapist facilitated the implementation of the home modifications. Although both groups showed no difference in falls at follow-up, a significant difference was found between groups at follow-up for participants reporting one or more falls in the year before recruitment.

In a Level II nonrandomized controlled trial in Sweden (Petersson, Kottorp, Bergström, & Lilja, 2009), occupational therapists provided assessments for home modifications for older adults with disabilities reporting difficulty in at least one of these areas: getting in and out of the home, mobility indoors, or self-care in the bathroom. The local government provided grants to install the home modifications. Participants in the intervention group reported significantly less difficulty in everyday tasks at follow-up than the comparison group.

In a Level I RCT, Campbell et al. (2005) studied targeted falls prevention provided to older adults ≥75 yr old with severe visual impairment. Home safety assessment and modification provided by an occupational therapist was compared with vitamin D supplementation and a home exercise program provided by a physical therapist, a combination of both interventions, or a social visit. Although the home safety group had significantly fewer falls than the exercise group, strict adherence to exercise was also associated with fewer falls. Neither group reported reduced injuries as a result of the falls. In a Level I RCT by Mann, Ottenbacher, Fraas, Tomita, and Granger (1999), an occupational therapist provided a functional assessment, environmental interventions, and assistive technology to frail older adults living alone. Although both intervention and control groups had a functional decline at 18-mo follow-up, the control group declined significantly more than the control group. Tomita, Mann, Stanton, Tomita, and Sundar (2007; Level I RCT) evaluated the effectiveness of commercially available smart home technology to operate lights, appliances, door, and windows for frail older adults living alone. Although no difference was found in IADL performance between groups at follow-up, those in the intervention group reported a high degree of satisfaction with the technology. Stevens, Holman, Bennett, and de Klerk (2001; Level I RCT) reported no differences between groups when a home modification assessment and information on hazard reduction was provided to healthy older adults by a research nurse.

A Level I RCT (Pighills, Torgerson, Sheldon, Drummond, & Bland, 2011) compared the effectiveness of a home modification assessment by an occupational therapist with that of a nonprofessional assessor. The study also included a no-treatment control group. Both the occupational therapists and the nonprofessional assessors received training in home modification assessment. Outside agencies provided the home modifications for the older adults. Although Pighills et al. (2011) found no effect on fear of falling, those in the occupational therapy assessment group had fewer falls than did those in the control group. No difference was found when comparing falls for the trained assessor and control groups, and no difference was found in ADLs at follow-up between either occupational therapy or assessor groups versus the control group.

Discussion

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The role of occupational therapy practitioners in fall prevention and in providing support for older adults

striving to remain in their home and actively participate in their community as they age includes facilitation of exercise through individual and group sessions, education about strategies to remain safe and independent, and recommendations for assistive technology and home modifications. This review provided strong evidence that when used in combination, these interventions play a role in successfully reducing the number of falls, limiting fear of falling, and preserving independence in communitydwelling older adults. When physical activity and home modifications are provided individually, the evidence that these interventions reduce falls and maintain and promote ADL and IADL performance is moderate. The evidence also indicates that the subgroup of frequent fallers show the greatest benefits from individual and multifactorial interventions (Cumming et al., 1999; Hogan et al., 2001; Nikolaus & Bach, 2003). In addition, participants with better adherence to a physical activity program had a lower rate of falls at follow-up than those who did not have good adherence to the program (Campbell et al., 2005).

Fall prevention and home modification interventions are crucial for the reduction of morbidity and mortality related to falls. Occupational therapy practitioners are experts in this area because they provide client-centered and occupation-based interventions with older adults. In addition, occupational therapy practitioners recognize that the physical and psychological benefits of maintaining independence need to be weighed against potential physical damage if an injury occurs as a result of a fall (Arbesman, Campbell, & Rhynders, 2001). Pighills et al. (2011) emphasized the value of occupational therapy with community-dwelling older adults, and they reported that adherence to recommendations was significantly higher in the occupational therapy group than in the nonprofessional assessor group.

The systematic review presented here has several strengths. The methodology included a large time frame (since 1990) and incorporated several bibliographic databases, thus ensuring that relevant literature was captured. In addition, a wide range of interventions was studied in the articles included in the review. Of the 33 articles included in the review, 31, or 94%, were Level I RCTs, and 100% were Level II or Level I. Although studies at all levels may have limitations, those at Level I are less vulnerable to bias and more generalizable. In addition, the outcomes are more likely to be attributed to the intervention being studied.

Some of the articles included in this systematic review, however, had limitations. Several studies were not blinded, had high dropout rates, and had small sample sizes. Many of the studies used self-report, and the methods for recording falls and injuries varied among the studies. Selfreported function may have involved participants responding to general ADL and IADL status questions with a broad sweeping report rather than considering each task separately, which would provide a more detailed account of their abilities and challenges. Interventions included in studies may not have been clearly described, and the definition of home modifications and equipment may have varied among studies. The studies were conducted in several countries, and whether differences in health care systems had an impact on the design and implementation of the interventions is unknown. In addition, determining the contribution of individual components of multifactorial interventions is difficult, and it was also not always clear whether home modifications were completed on the basis of the recommendations provided or whether modifications were made appropriately.

Implications for Research and Education

The information provided in this systematic review provides occupational therapy educators with evidence on fall prevention and home modification that can be integrated into program curricula and student research activities. The results have the following implications for future research:

- Specifying a population that would specifically benefit from a given type of intervention may be important; for example, one study found that people over age 80 and those considered frail responded particularly well to fall reduction interventions (Robertson et al., 2001).
- Although the amount of research in the area of fall prevention through various physical activity or exercise programs is fairly large and growing, more research is needed that explores the impact of home modifications on fall prevention and performance in all areas of occupation.
- Home modification studies have often missed the opportunity to measure outcomes related to maintained or increased ability to complete ADLs or IADLs and to analyze performance in a variety of environments and contexts. Using standardized outcome measures for functional status and safety in the home such as the Canadian Occupational Performance Measure (Law et al., 1994), the In-Home Occupational Therapy Evaluation (Stark, Somerville, & Morris, 2010), and the Safety Assessment of Function and the Environment for Rehabilitation (Chiu, Oliver, Marshall, & Letts, 2002) can provide a more consistent way to examine change by assessing the wide range of environment

ments in which older adults participate, including the home and community.

Implications for Occupational Therapy Practice

The results of this systematic review contribute to evidencebased practice for occupational therapy practitioners working with older adults in community-based settings and reinforce the importance of the role of occupational therapy in the home and community. The findings have the following implications for occupational therapy practice:

- In general, a client-centered intervention plan that includes a mix of exercise, education, home modifications, and assistive technology is supported by the best evidence for fall prevention and occupational performance in community-dwelling older adults.
- Regardless of the setting in which one practices, occupational therapy practitioners can incorporate fall prevention and home modification strategies throughout the occupational therapy process, from evaluation to intervention planning and implementation and outcome review.
- The evidence discussed here reinforces the role of occupational therapists on the home and community team and the importance of client-centered care with a mix of interventions to provide the best fit. ▲

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