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PERSPECTIVES

Falls in Older People: Risk Factors, Assessment and Intervention

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Abstract

Preventing falls and fall-related injuries in older people continues to challenge health professionals worldwide. While most falls do not have a significant impact on older people, falls remain the most common cause of injury-related hospitalization and death in this age group. Risk factors for falls are manifold and a range of screening and assessment tools exist to identify and delineate risk in older people. There are now a number of studies demonstrating that it is possible to reduce falls and potentially injuries from falls, including fractures. Targeted exercise is effective as a single intervention in community-dwelling older populations but is ineffective as a single intervention in hospitals and residential aged care facilities. A number of other single approaches to prevention including medication review and cataract extraction have been shown to be effective in community-dwelling populations. Multifactorial approaches appear to be more effective in hospitals and in people living in residential aged care facilities. This *Perspective* looks at the epidemiology and risk factors for falls as well as objective assessment of falls risk. Interventions are discussed for community and hospital settings, as well as for residential aged care facilities. *IBMS BoneKEy*. 2009 October;6(10):368-384.

Introduction

"*The liability of old people to tumble...is such a commonplace of experience that it has been tacitly accepted as an inevitable aspect of ageing and thereby deprived of the exercise of curiosity*." —J.H. Sheldon, *BMJ*, 1960

The prevention of falls in older people continues to be an area of global health interest with data highlighting the increasing costs both to individuals and health care systems alike. Over the years a substantial body of literature has emerged that has led to a better understanding of the contributing factors to the risk of falling as well as evidence that falls can be prevented using population-specific interventions.

A third of the population aged 65+ fall each year (1;2), rising to 50% in those aged 85+ (3). Of those who fall, 50% do so repeatedly (4). Women fall more often than men and are more likely to sustain a significant injury (2). Falls occur more frequently in residential aged care facilities (RACFs) with reported incidence rates of 1.5-1.7 falls/bed/year (5;6). The majority of published epidemiological data refer to Caucasian populations. However, there is some evidence to suggest that falls rates vary across populations, with lower reported rates in Asian, Hispanic and Black populations (7;8). Further work is required to understand the reason for this apparent racial/cultural disparity.

Consequences of Falls

The majority of falls that occur in older people do not come to the attention of a health care professional and only a small percentage of falls actually cause harm. That said, falls are the leading cause of injury-related hospitalization in older people with a fall being the cause of presentation to the emergency department in up to 14% of people aged 65+ and up to 4% of hospital admissions (9;10).

Some might suggest that fracture prevention is the most important target in terms of falls prevention and that a fall itself is not an important clinical endpoint (11). However, the data tell us differently and show that a significant number of hospitalizations and bed days occupied occur in people who fall but have not sustained a serious injury (fracture or head injury). Data from the Australian Institute of Health and Welfare (12) show that in 2005-6, 37% of fall injury-related hospitalizations were not associated with a fracture and that this percentage increased with advanced age. The data also show that increasing age is associated with an increasing number of bed days occupied as a result of a fall.

Definitions and Ascertainment of Data

Accurate epidemiological data are dependent on clear characterization of outcome measures. A number of definitions of a fall and fall-related injury have emerged over the years and this is compounded by a number of different methods of reporting falls data – falls rates, number of falls, time to first fall, recurrent falls, recurrent fallers, injurious falls, etc. As a consequence, it is difficult to compare outcomes in studies published across the world. This difficulty has been addressed to some degree by a recent consensus publication where a number of experts in the area have agreed upon a taxonomy framework that includes a definition of a fall and fall-related injury (13).

A fall is defined as “an unexpected event in which the participants come to rest on the ground, floor, or lower level.’’ A lay description has been suggested for use both in the research and clinical setting: “In the past month, have you had any falls including a slip or trip in which you lost your balance and landed on the floor or ground or lower level?”

For research purposes, the recommended approach to falls data collection is prospective daily recording using a falls diary with a minimum of monthly reporting. Outcomes reported should include falls, number of fallers/nonfallers/frequent fallers, fall rate per person year, and time to first fall (as a safety measure).

Risk Factors for Falls

Over 400 risk factors for falls have been reported in the scientific literature with a number of different risk factors often present in any one individual. The acronym DAME remains one of the simplest ways of categorizing falls risk factors:

D = drugs and alcohol
A = age-related physiological changes
M = medical problems
E = environment

Drugs and alcohol

Medications have been implicated as an iatrogenic cause of falls in older people. The pharmacokinetic and pharmacodynamic properties of drugs are often affected by aging and this alteration in ability to handle drugs can predispose older people to side effects not seen in younger people. Centrally acting medications have been consistently reported in the literature as increasing falls risk with sedative hypnotics, benzodiazepines, antipsychotics and antidepressants being the most commonly reported classes of drug (14-19;20).

The evidence for other drug classes is less consistent but the use of multiple medications (usually defined as 4+ regularly prescribed medications) has been shown to be a risk factor for falls (15;21-24). Use of multiple medications may of course be a proxy measure for poor health and one study showed that after adjusting for underlying chronic disease, the number of prescribed medications was no longer an independent predictor of falls (25).

Age-related physiological changes

Maintenance of upright posture is a complex, dynamic process that involves the integration of sensory and neuromuscular systems (Fig. 1). Accurate information about an individual's position in space is acquired through visual, vestibular and sensory inputs. The information is channeled centrally to the brain where it is rapidly and accurately processed leading to an effective effector response sent via the spinal cord and allowing the individual to adjust his or

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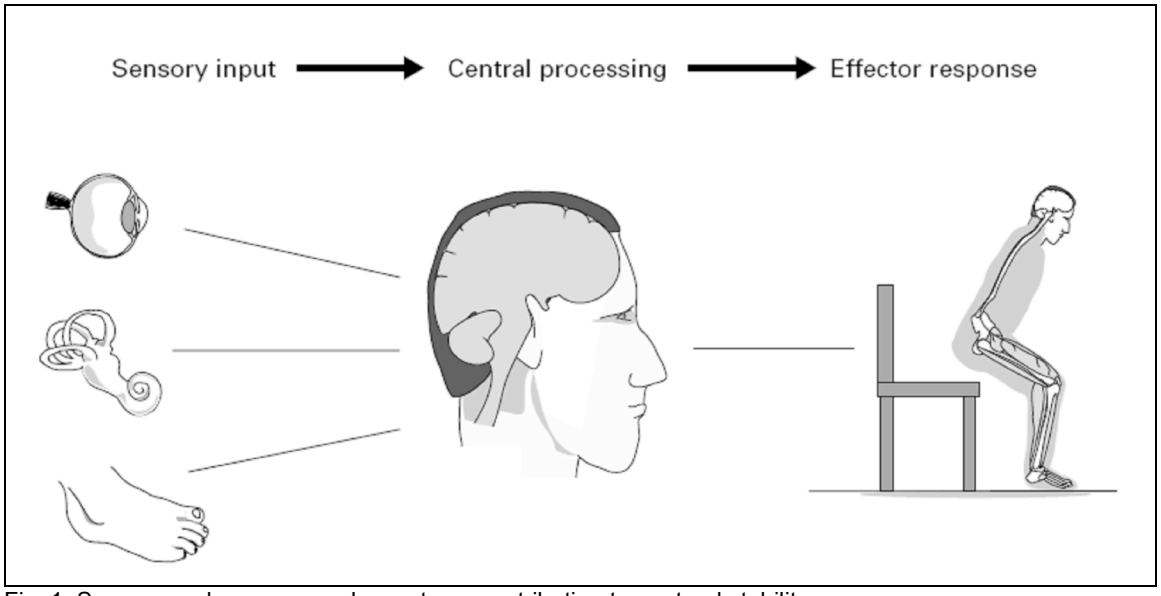

Fig. 1. Sensory and neuromuscular systems contributing to postural stability.

her positon in space and maintain an upright posture. Advanced age is associated with a number of physiological changes including reduced visual acuity, changes in temporo-spatial gait patterns, decreased reaction time, muscle strength and balance (26); all increase an older individual's risk of falling. These changes are frequently compounded by pathological changes associated with disease processes that further increase an individual's risk of falls.

Medical problems

Older people frequently have a number of disease processes that can impact directly on their ability to maintain an upright posture and to respond to sudden perturbations. Any disease that alters the accuracy of sensory input to the brain (*e.g.*, cataracts, peripheral neuropathy), the ability of the brain to process information accurately (*e.g.*, stroke, dementia) or to produce an effective effector response (*e.g.*, stroke, diabetes, osteoporosis) may increase an individual's risk of falling. Table 1 highlights a number of disease processes with the ability to increase an individual's risk of falling. The most commonly reported diseases associated with falls are stroke (15;27-30), dementia (31-33), depression (27;34-37) and Parkinson's disease (15;35;38;39).

Environment

Numerous studies have looked at environmental risk factors for falls. Not surprisingly, risk factors put forward include slippery or wet floors, poorly lit rooms, obstructed walkways, etc. However, prospective studies specifically looking at home hazards in relation to falls have consistently failed to demonstrate a clear association between the environment and falls (15;27;34;40;41). Environmental hazards when considered in isolation are unlikely to predict falls and the more important issue to consider is the older individual's ability to interact safely with his or her environment.

Identification of People at Risk of Falls

Falls risk assessment is particularly important in older people with osteoporosis, as over 60% of older people with femoral neck osteoporosis have fall-related risk factors (42), and 90% of hip fractures result from a fall (43). People at risk of falls can be identified on the basis of age, place of presentation, usual place of residence, number of diseases and prescribed medications. Inquiring about a history of falls in the previous year is a simple way of identifying an at-risk population. Older people living in RACFs or presenting to the emergency department are well-

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Table 1. Diseases that can affect postural stability.

Diseases affecting sensory input	***Vision***	Age-related refractive error Senile macular degeneration Glaucoma Cataracts Stroke causing visual field defect
	Proprioception	Diabetes Vitamin B_{12} deficiency Syphilis (rare) Degenerative joint disease, especially of neck and knees
	Vestibular	Age-related middle and inner ear changes Chronic ear infections Perforated ear drum Labyrinthitis Meniere's disease
Diseases affecting central processing	***Cerebrum***	Cerebrovascular disease (stroke) Dementia Brain tumor (benign and malignant)
	Cerebellum	Cerebrovascular disease (stroke) Long-term alcohol misuse Idiopathic cerebellar degeneration
	Basal ganglia	Cerebrovascular disease (stroke) Parkinson's disease
	Brain stem	Cerebrovascular disease (stroke) Atherosclerosis Postural hypotension
Diseases affecting effector response	***Spinal cord and nerves***	Any condition causing narrowing of the spinal cord Motor neuron disease Multiple sclerosis Foot drop (common peroneal nerve)
	Muscles	Cerebrovascular disease (stroke) Motor neuron disease Muscular dystrophy Multiple sclerosis Polymyalgia rheumatica Polymyositis Hypothyroidism Vitamin D deficiency Diabetes Muscle disuse following fracture, injury or prolonged immobility
	Joints	Osteoarthritis Rheumatoid arthritis
	Other	Foot deformities Poor-fitting shoes Peripheral vascular disease Urinary incontinence

documented high-risk populations (6;9). The predictive validity of published falls risk assessment screens has been examined in recent reviews (44;45). Oliver *et al*. (45) found that of 45 screens designed for use in hospitals, only six underwent prospective validation, and only two were validated in two or more cohorts. It has been suggested that many of the tools lack either sensitivity or specificity and classify too few or too many people as fallers.

Assessment of Risk of Falls

A detailed history of the events surrounding a fall is essential and corroborative information should be sought in those with limited recollection of the incident.

Points to consider in the history include:

(i) Does the individual have amnesia for the event?

Reason – possible syncope, cardiac or neurological problem.

(ii) Where and at what time did the fall happen?

Reason – postural hypotension in proximity to change in posture, falls occurring in relation to medication ingestion, postprandial hypotension, mechanical falls at night with poor lighting, etc.

(iii) What was the individual doing at the time of the fall – getting up from chair/bed, turning head, reaching up or bending down?

Reason – certain conditions are related to specific actions such as postural hypotension on standing or carotid sinus syndrome related to turning of the head.

(iv) Was the fall preceded by any dizziness or palpitations?

Reason – possible neurocardiogenic syncope, cardiac arrhythmia, vestibular problem.

(v) What injuries were sustained as a result of the fall?

Reason – low trauma fractures should trigger an assessment of bone health.

Assessment of postural stability is a key area in the management of an older person at risk of falling. The AGS/BGS/AAOS Guideline (46) recommends the Timed Up and Go Test (TUGT) as one of a number of simple screening tools available to identify people who warrant more detailed assessment of gait and balance. It measures the time taken for a person to rise from a chair, walk three meters at normal pace and with his or her usual assistive device, turn, return to the chair and sit down. A time of 15 or more seconds to complete the test indicates impaired functioning (47-49). Perell *et al*. (44) have examined the predictive validity of functional mobility assessment tools for predicting falls. They concluded that, in addition to the TUGT, the Tinetti performance-oriented mobility assessment (50), the Berg balance scale (51), the modified gait abnormality rating scale (52), and the elderly fall screening test (53) were useful tests.

A recently developed comprehensive assessment tool (the physiological profile assessment, PPA) takes a physiological approach to evaluating falls risk (54). It involves assessment of sensorimotor factors that contribute to postural stability, including vision (contrast sensitivity), peripheral sensation (proprioception), strength (knee extension), reaction time (hand) and postural sway (on a firm surface and foam rubber mat) (Fig. 2). In a series of large prospective studies, this combination of tests has been shown to be able to discriminate between fallers and non-fallers with an accuracy of 75%, with a similar sensitivity and specificity (55-57). A web-based software program assesses an individual's performance in relation to a normative database, which enables the calculation of an overall falls risk score – a single index score derived from a discriminant functional analysis of previous large-scale prospective studies. The program also generates a profile of individual test performances (using z-scores) to identify physiological strengths and weaknesses, and allows for tailored

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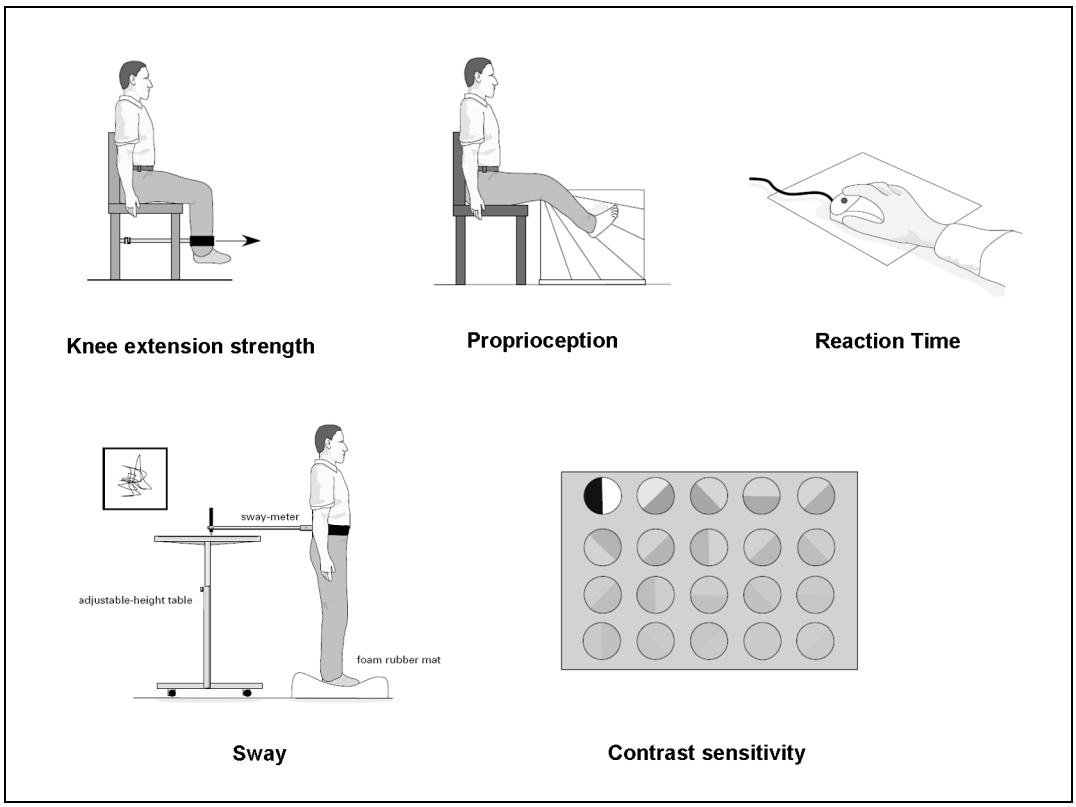

Fig. 2. Measures contributing to the physiological profile assessment.

intervention based on the deficits identified (Fig. 3).

Interventions to Prevent Falls

Given the multiplicity of risk factors for falls, it is perhaps not surprising that the intervention literature contains a large number of different approaches to prevention with different interventions targeting different populations. This provides a challenging environment when attempting to decide what population(s) may benefit from which approach to intervention. Once again, a useful taxonomy for interventions has been put forward by the Prevention of Falls Network Europe Group and is in the process of being adopted by the Cochrane groups charged with providing reviews in this area.

Interventions are now grouped into three broad categories: Single interventions, multiple interventions and multifactorial interventions:

Single interventions: one intervention for all participants, *e.g.*, exercise.

Multiple interventions: more than one intervention and all participants receive the same interventions.

Multifactorial interventions: more than one intervention is available but interventions offered to individuals are based on a risk assessment so that participants will receive different combinations of interventions based on identified risk.

Community-Dwelling Populations

Exercise

Targeted exercise has been one of the most frequently tested interventions to prevent falls both as a single intervention and as a component of multiple and multifactorial interventions. Exercise means many things to many people and there are many reasons to exercise. However, not all exercise is effective in preventing falls. A recently published systematic review and meta-analysis of exercise as a single approach to intervention looked at a number of aspects of exercise to determine the most effective

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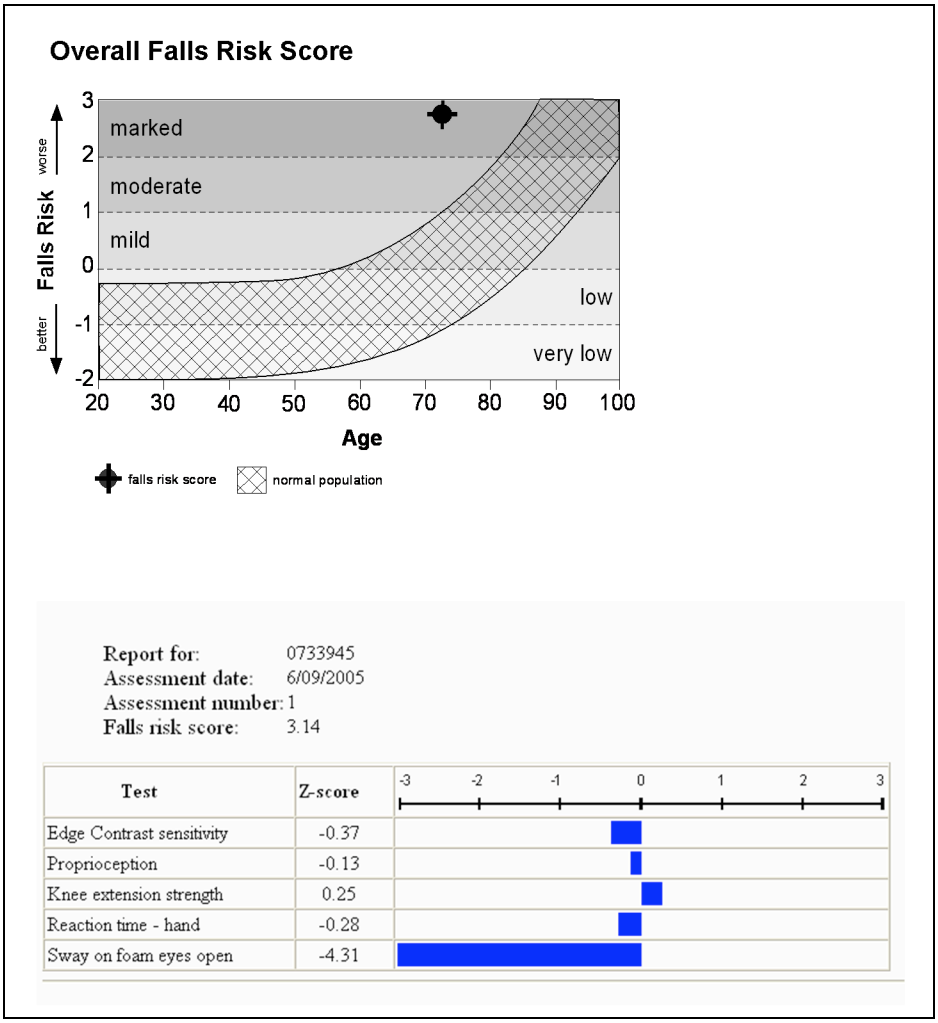

Fig. 3. Overall falls risk score and analysis of performance on each physiological measure for a 75-year-old woman with a history of multiple falls.

components of exercise in falls prevention (58). The pooled results of 44 trials and 9,603 participants demonstrated an overall 17% reduction in risk of falls (RR, 0.87, 95% CI: 0.75-0.91). The greatest effects of exercise on falls were obtained from programs that challenged balance (movement of center of mass, reduced the base of support and the need for upper limb support), included a higher total dose of exercise (equivalent to > 2 hours per week), and did not include a walking program (RR, 0.58, 95% CI: 0.48–0.69). The review also demonstrated potential harm if exercise is low-dose, doesn't challenge balance and focuses on walking (RR, 1.2, 95% CI: 1.00-1.44).

Other single interventions

Home safety assessment and environmental modification undertaken by an occupational therapist have been shown to be effective in preventing falls. Successful studies using this approach have targeted high risk populations, including those being discharged from the hospital with a history of falls (59), older people under the care of a geriatrician (60) and those with severe visual impairment (61). Interventions to address visual problems have also been tried with varying degrees of success. There is evidence to support expedited cataract extraction in visually impaired older people (62) as well as recently reported results of the benefits for older people of using a single lens rather than multifocal or bifocal spectacles while outdoors (unpublished

data). However, another study showed an increase in falls and potential harm from falls by providing older people with a visual assessment and tailored visual intervention (usually new glasses) (63). Formal medication review (64) and controlled withdrawal of centrally-acting medications (65) have both been shown to be effective intervention strategies as has detailed cardiovascular assessment of older people presenting to the emergency department with an unexplained fall or collapse (66). Specific netting with wire coils applied over footwear has also been shown to prevent falls when walking outdoors in winter conditions (67).

Multiple and multifactorial interventions

A number of multiple and multifaceted interventions have been shown to prevent falls in older people (9;68-74). Interventions in this area have varied greatly, targeting different populations with different levels of risk and different combinations of medical, nursing and allied health directed and/or delivered interventions. As with all multiple interventions it is difficult to be certain as to which component(s) of the intervention are effective. The simplistic view is often that the individual components are additive and that if we could determine the most effective components of the intervention, the rest could be discarded, making the intervention potentially more cost-effective. In reality there is likely to be an interaction between the different components of an intervention and it is certainly possible that the order in which components of an intervention are applied may affect the outcome. Promoting exercise, including outdoor mobility in people on centrally acting medications or with visual impairment, without addressing the medication or visual problem may potentially increase an individual's risk of falling. More work is required in this area.

Hospitals

Safety and the specific objective of preventing harm is a key area of activity in hospitals worldwide. A fall is one of the top reported adverse events occurring in patients while in the hospital. As a result, many hospitals, health services and health departments have generated policies and clinical guidelines targeting this area. Unfortunately, the number of policies and clinical guidelines greatly exceeds the evidence base to support in-patient falls prevention at a hospital level. While absence of evidence does not equate to evidence of absence, caution is required when extrapolating approaches taken in published trials to the wider hospital population. There is also a pre-occupation with the need to have a risk assessment tool that accurately identifies those at risk of falling in the hospital. Tools exist and have undergone validation in some patient populations, but they are far from perfect and should only be used alongside the application of good clinical acumen (75;76). Some might argue that the risk assessment tool has become a means to an end and the failure to clearly link assessment to person- and ward-specific interventions is likely to result in a failure to impact the rate of falls.

Three multifactorial randomized controlled trials have shown benefit and all have focused on patients in the aged care (geriatric medicine) and rehabilitation settings (77-79). In one study undertaken in the sub-acute setting, the benefit of the intervention was not achieved until 45+ days into the intervention period (77). The suggestion is that these people were potentially benefiting from the additional exercise. This would therefore have limited applicability in acute settings where lengths of stay are considerably shorter. The other two successful trials focused on a more acute setting, one study looking at patients in geriatric medicine wards (78) and another specifically targeting hip fracture patients and looking at a new model of service delivery (79). Successful studies in hospitals have involved different professions working together.

The largest reported study of patients in the hospital looked at a multifactorial intervention in 3,999 patients in both the aged care acute and rehabilitation settings. Fifty hours of additional combined physiotherapy and nursing input was provided weekly to each intervention site for three months. The intervention included assessment of risk of falls, staff and patient

education, medication review, assessment and modification of the ward environment and an exercise program. The intervention was not effective (RR, 0.96, 95% CI: 0.72-1.28). With a reported median length of stay of 7 days, the authors suggest that patients may not be in the hospital long enough to benefit from components of the intervention, *e.g.*, exercise, but also that a 3-month intervention period may not be long enough to produce sustainable change in the clinical setting.

Personal experience and practice in this area fosters the belief that in-patient falls can be reduced across a hospital but that the reduction is achieved over a period of months and years and therefore does not lend itself to a formal randomized controlled clinical trial. Practices that have been in place for generations (*e.g.*, use of night sedation) as well as staff attitudes and behaviors take time to change. Figures 4, 5, and 6 show the results of a hospital-wide approach to falls prevention that has taken almost three years to achieve a statistically significant change in falls rates although changes in prescribing practice were achieved much earlier. The work involves all medical and surgical wards in a hospital with a monthly meeting of the senior ward staff and continued formal and informal education of junior medical staff and allied heath professionals.

Residential Aged Care Facilities

The terminology used to define what constitutes an RACF varies across the world but essentially describes a supported environment where older people with functional deficits (physical and/or cognitive) reside with a view to being assisted with activities of daily living. Over twenty randomized controlled trials have specifically targeted older people living in RACFs with evidence to support single, multiple and multifactorial approaches to prevention.

Single interventions

A number of studies have looked at exercise as a possible strategy for prevention in RACFs. However, unlike the community setting, there is no convincing evidence that exercise as a single approach is effective in RACFs. Zermansky *et al*. (80) demonstrated the benefits of medication review in older people that included targeted reduction in centrally-acting drugs and commencing calcium and vitamin D. While the primary outcome of the study was number of changes to medication, the team was able to show a statistically significant reduction in falls rates (RR 0.59, 95% CI: 0.49-0.7). There is also evidence to support supplementation with vitamin D as a single intervention to prevent falls in RACFs (81-83).

Multiple interventions

A single study targeting incontinent nursing home dwellers showed the benefits of weekday regular toileting with promotion of fluid intake and exercise with each bathroom visit (84). The intervention group improved from a functional perspective including measures of continence but also had fewer falls when compared to the control group.

Multifactorial interventions

There have been a number of studies in this area and there is reasonably good evidence to suggest that a multifactorial approach to preventing falls in RACFs is the most effective approach. Successful trials in this area have focused on exercise (85-88) in combination with environmental modifications (85;86;88) and/or medication review (85-88). When data from the three trials reporting hip fracture are pooled there is a significant reduction in incidence of hip fracture – RR, 0.48 (0.24-0.98). Nurse-initiated studies do not appear to be successful (89;90) and there is a suggestion that low intensity nurse-initiated and nurse-dependent models may increase falls, possibly by taking staff away from their normal duties (89).

Hip protectors (Fig. 7) do not prevent falls but do warrant mention as a potential approach to injury prevention in RACFs. The Cochrane review on hip protectors as a single intervention suggests a “marginally statistically significant reduction in hip fracture incidence” (RR, 0.77, 95% CI: 0.62-0.97) (91). It should be noted that two of the

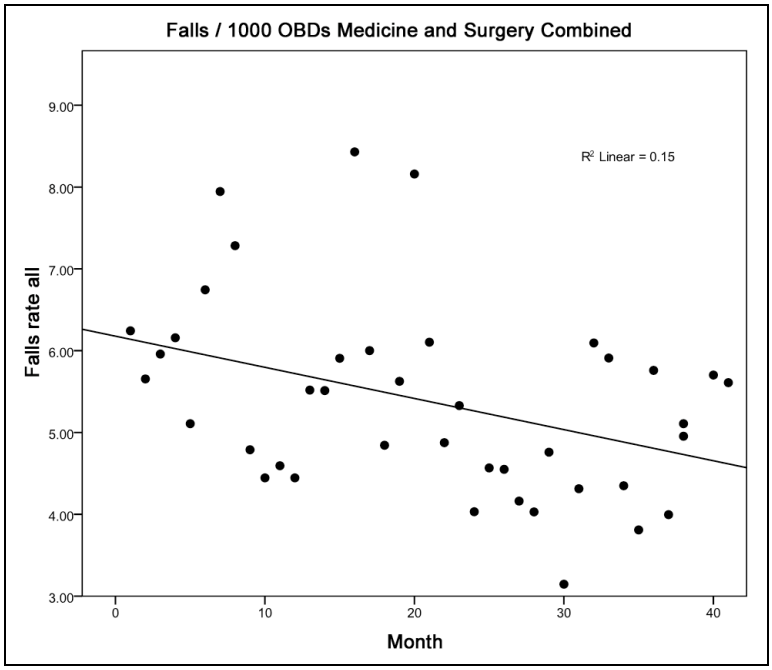

Fig. 4. Falls rates over time.

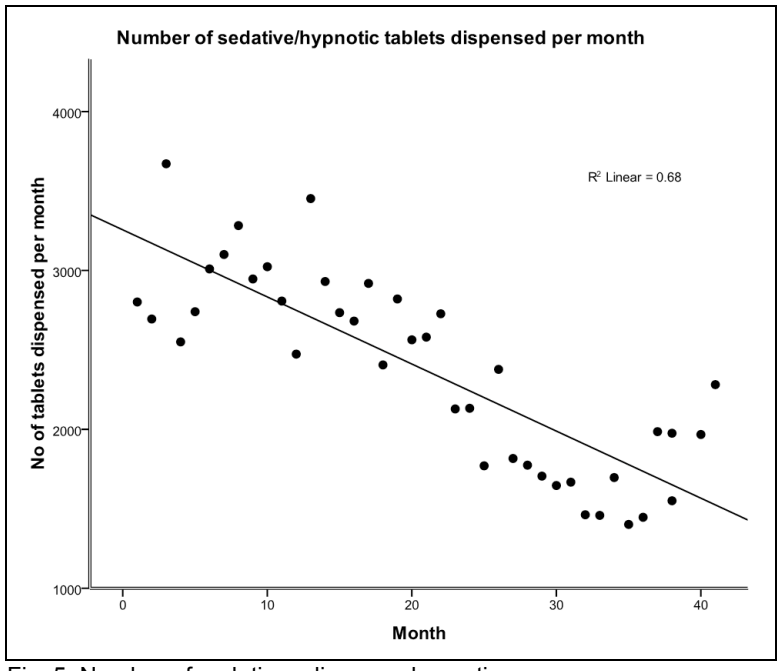

Fig. 5. Number of sedatives dispensed over time.

effective multifactorial studies contributing to the pooled data supporting hip fracture reduction included the use of hip protectors as one of the possible interventions (85;87). Jensen *et al*. (92), who included hip protectors in their multifactorial RCT, undertook a subgroup analysis and showed that the intervention was more successful in preventing falls in cognitively better individuals (MMSE > 10) (92). However they also reported that fracture reduction was greater in the cognitively poorer group, suggesting that hip protectors may well have an important impact on this group. However, compliance remains a challenge in the

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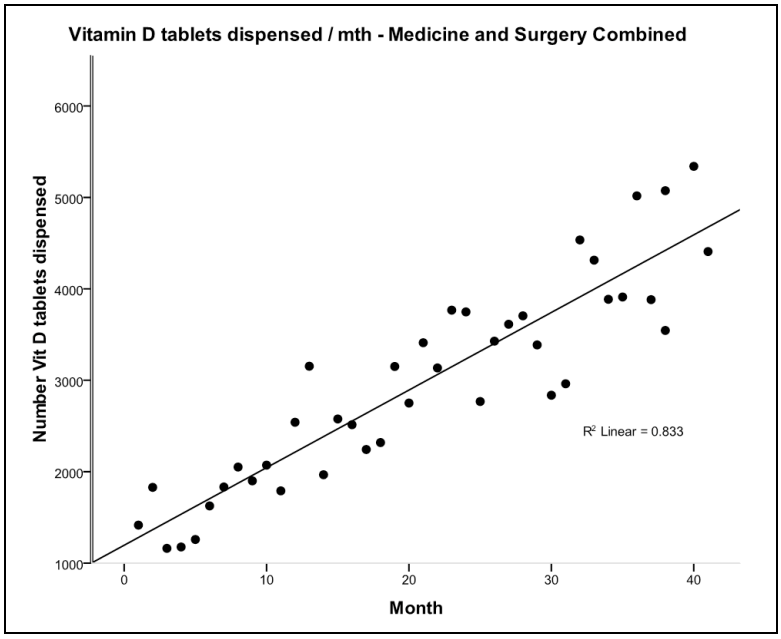

Fig. 6. Number of vitamin D tablets dispensed over time.

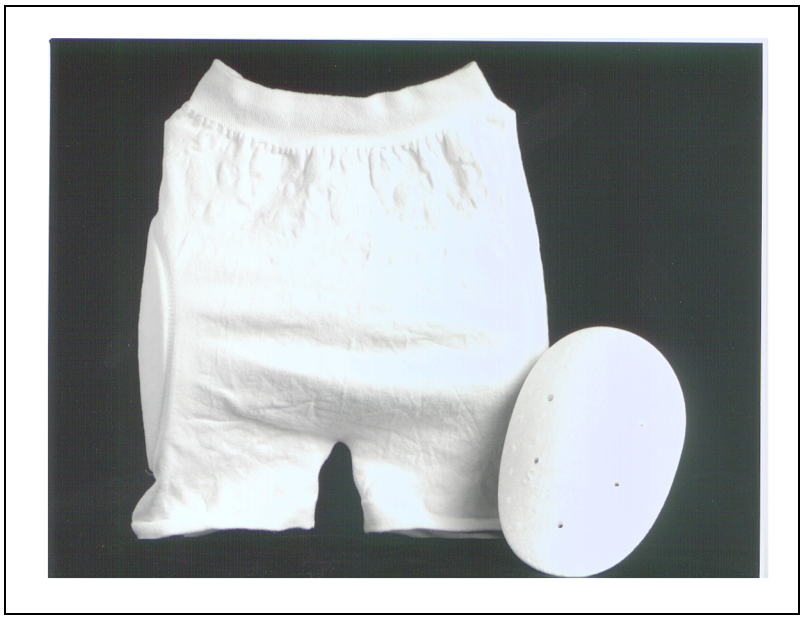

Fig. 7. Hip protectors.

application of hip protectors as an intervention.

Conclusions

A substantial body of evidence now exists to assist in the identification of individuals at risk of falls and fractures. This is now supported by intervention strategies shown to reduce risk of falls and in some cases injuries from falls. However the evidence from clinical trial data that falls prevention can lead to fracture prevention is limited. Falls prevention trials have largely been of an order of magnitude smaller than that of pharmacological trials looking at fracture prevention through treatment of osteoporosis.

Cost-effectiveness data have been poorly reported in clinical trials of falls prevention and one might reasonably argue that not all falls are equal. This raises the question as to what falls we should be aiming to prevent. A fall in a 90-year-old frail older person may well have a more significant impact on function and use of health care than a fall in a 65-year-old healthy woman. Should we be targeting resources to high-risk populations where a fall is likely to impact everyday function or should we be taking a population health-based approach to prevention? No studies have shown that it is possible to prevent falls in community-dwelling cognitively impaired older people and more work is required in this area.

Overall, clinical trials have looked largely at falls and osteoporosis in isolation while clinically most people believe that fracture prevention has to involve a combination of falls prevention and improved management of bone health. Again, more work is needed in this area both in the research arena and in the development of clinical service models that deal with older people. In the interim there is more than enough evidence available to provide practicing health care professionals with strategies to prevent falls in older people.

Conflict of Interest: The author reports that she has indirectly benefitted financially from the production of the physiological profile assessment mentioned in this review.

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