Falls Risk Factors: Assessment and Management To Prevent Falls and Fractures*

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RÉSUMÉ

Les chutes et les fractures pathologiques sont des défis communs, dangereux et importants de la santé publique. Ils sont mieux compris comme des syndromes gériatriques étroitement liés à la fragilité et d'autres problèmes de la santé liés à l'âge. Ils sont associés à de nombreux facteurs de risque, dans tous les domaines de la santé – physiques, psychologiques, sociaux et environnementaux. Au niveau de la population, le défi consiste à améliorer la santé et le bien-être de toutes les personnes âgées à réduire l'incidence des chutes. Au niveau clinique, le défi consiste à évaluer les facteurs de risque individuels et d'appliquer des interventions multifactorielles factuelles sur mesure. » La composante plus puissante est l'entraînement physique de l'équilibre et de la résistance.

ABSTRACT

Falls and fragility fractures are common, dangerous, and important public health challenges. They are best understood as geriatric syndromes with close relation to frailty and other aging-related health problems. They are associated with many risk factors, in all health domains – physical, psychological, social, and environmental. At a population level, the challenge is to improve the health and well-being of all older people to reduce the incidence of falls. At a clinical level, the challenge is to assess the individual risk factors and apply evidence-based individually tailored, multifactorial interventions. The most powerful component is strength-and-balance exercise training.

* Sincere thanks to my patients and to my many research and clinical collaborators over the 28 years during which I have been privileged to work with frail older people in the England National Health Service.

Manuscript received: / manuscrit reçu : 26/02/10

Manuscript accepted: / manuscrit accepté : 20/10/10

Mots clés : chutes, fractures pathologiques, facteurs de risque, fragilité, syndrome gériatrique, prévention

Keywords: falls, fragility fractures, risk factors, frailty, geriatric syndrome, prevention

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Introduction

A fairly broad definition of a fall is that adopted in England by the National Institute for Clinical Excellence [NICE] (2004), and subsequently in the updated AGS/BGS Clinical Practice Guideline in 2009 (American Geriatrics Society and British Geriatrics Society [AGS/BGS], 2009): "an event whereby an individual comes to rest on the ground or another lower level with or without a loss of consciousness." Slightly more restrictive wording was proposed as part of a shared taxonomy for falls research by Profane (Prevention of Falls Network Europe, www.profane.eu.org) (Lamb, Jorstad-Stein, Hauer, & Becker, 2005): "an unexpected event in which the participants come to rest on the ground, floor, or lower level." Even more restrictive is the definition proposed by Tinetti and Williams (1997): "a fall is a sudden unintentional change in position causing an individual to land at a lower level, on an object, the floor, or the ground, other than as a consequence of sudden onset of paralysis, epileptic seizure, or overwhelming external force."

doi:10.1017/S0714980810000747

Most researchers reporting epidemiological data or clinical interventions have not defined a fall, and since it is not possible without detailed assessment to distinguish the several exceptions in the definition set forth by Tinetti and Williams (1997), their definition is not suitable for most purposes.

In a clinical context with an individual patient, assessment involves an attempt to place the event in the spectrum with syncope (a transient loss of consciousness) at one end and loss of balance due to postural instability at the other. Sometimes this is clear-cut, sometimes not. Neither of the aforementioned definitions, by AGS/BGS and Lamb et al., attempt to exclude syncope in their wording for the good reason that an overlap exists in the phenomenology, experience, and pathophysiology of these events. This point is addressed further, below.

However defined or identified in various epidemiological studies, similar rates of about one third of persons over age 65 falling each year, and rising with age to over 50 per cent of those aged 80-plus, have been reported from England, Australia, and North America (Fleming, Matthews, & Brayne, 2008; Masud & Morris, 2001; Lord, Sambrook, Gilbert, Kelly, Nguyen, Webster et al., 1994; Rubenstein, 2006). These falls are a major cause of disability and the leading cause of injury-related death in people over 75 years (Scuffham & Chaplin, 2002).

Understanding falls as a geriatric syndrome

For an individual older person, a fall may be a trivial or profound – even fatal – event. Accordingly, an individual fall may itself merit attention for its physical or psychological impact, as explored further in Nyman. It is also likely a symptom rather than a diagnosis, and what it may signify in terms of contributory factors covers a broad range of physical, cognitive, behavioral, and environmental domains. The term "geriatric syndrome" describes clinical conditions in older persons that do not fit into "disease categories" but which are highly prevalent, multifactorial, associated with multiple co-morbidities and poor outcomes, such as increased disabilities and decreased quality of life (Inouye, Studenski, Tinetti, & Kuchel, 2007). Falls meet all of these criteria and have significant association with the presence of frailty (Nowak & Hubbard, 2009). In common with other geriatric and frailty syndromes, falls are more common in older women than in men, and are associated with higher risk of injury (Campbell, Spears, & Borrie, 1990; Kannus, Parkkari, Koskinen, Niemi, Palvanen, Järvinen et al., 1999; Stevens & Sogolow, 2005; Peel, Kassulke, & McClure, 2002).

In this article, therefore, the intention is to situate an understanding of falls and their prevention within the broader scope of clinical gerontology and geriatric medical practice, areas which have evolved away from the traditional medical notions of pathology, disease, and cure.

Risk factors, causes, and context

In keeping with this notion of falling as a geriatric syndrome, it follows that risk factors for falling, identified by case-control comparative studies or by prospective cohort studies indicate a broad range of significant associations that are not indicative of a specific disease process. Because of the myriad designs of such studies, any summative list of risk factors will cover a mix of domains, including demographic characteristics, diseases, impairments in physiological or cognitive domains, functional capacity, and social and physical environmental factors. This mix can be seen from the following list drawn from a review of 16 studies (Rubenstein, 2006) and listed in order of magnitude of association: (a) lower limb weakness (includes proximal and distal muscle groups); (b) balance deficit (particularly dynamic balance); (c) gait abnormalities; (d) visual impairment (includes acuity and contrast sensitivity); (e) mobility limitation (includes self-perceived difficulty); (f) cognitive impairment; (g) impaired functional status; (h) postural (orthostatic) hypotension; and (i) fear of falling (particularly with self-imposed activity limitation).

A similar multiple-domain approach is seen in a falls risk assessment tool designed for use in primary-care populations in England. Individuals who meet three or more of the following criteria are deemed to be at sufficient risk to merit intervention (Nandy, Parsons, Cryer, Underwood, Rashbrook, Carter et al., 2004): (a) fall in the previous year (self-reported); (b) taking four or more medications per day; (c) history of stroke or Parkinson's disease; (d) self-reported problems with balance; and (e) unable to get out of chair at knee height, without using arms.

Both this and the previous list focus on the "intrinsic" factors that can be ascribed to an individual at rest. But falls occur when an individual with a specific mosaic of such characteristics behaves (usually moving but can be standing) in a specific context such that their postural stability is overcome. The risk of falling has been shown to increase as the number of these risk factors increases (Tinetti, Speechley, & Ginter, 1988). Any context can be described in terms of the "falls hazards" they contain, and indeed validated assessment tools have been developed for clinical practice (Clemson, 1997). The point is that the magnitudes of association of falling with any intrinsic or environmental factor are not fixed but are mutually interdependent and contingent on additional factors influencing

https://doi.org/10.1017/S0714980810000747 Published online by Cambridge University Press

performance of the specific activity in question. These factors are more difficult to identify but include speed, technique, fluidity of intent and execution, attention, and so on. In terms of prediction, therefore, risk factors will behave differently depending upon the population in question, the activity, the place, and the time. For example, a "loose rug" may become hazardous only to the person with poor vision or muscle weakness combined with poor judgment. Likewise, most patients survive "culprit medications" successfully until compromised by other factors including acute illness.

Because of the interrelationship of these factors, ascribing a cause for falls is problematic. When assessing a patient who has fallen, there are occasions when the explanation is overwhelmingly attributable to a single or few factors, but for any individual these might vary from event to event over time. For some populations, in which the distribution of risk factors is fairly homogeneous and the environmental challenges are shared, the profile of attributable risk may be reasonably consistent. Any falls prevention strategy has to consider these factors when a medical practitioner is deciding the balance between individual (clinical) and population (public health) approaches and between assessment-based targeted interventions and predefined packages, such as exercise programs.

Dizziness, unsteadiness, and syncope

A patient commonly reports dizziness when describing a fall or, indeed, a fear of falling. Dizziness is unpleasant for the patient but has unclear implications for the clinician. Does she mean vertigo, unsteadiness, faintness, weakness, or even syncope? An attempt to disentangle the patient's message is worth the effort as it may lead to recognition of a specific and treatable condition such as orthostatic hypotension, a cardiac dysrhythmia, or benign paroxysmal positional vertigo (BPPV), a not uncommon condition in older adults for which effective treatment exists (Bhattacharyya, Baugh, Orvidas, Barra, Bronston, Cass et al., 2008). Diagnosis of syncope can also be problematic as patients may not recall the loss of consciousness, even when observed in a clinical testing situation of tilt testing (Brignole, 2006; Parry, Steen, Baptist, & Kenny, 2005). A further reason for the diagnostic difficulty, however, is that many older people, particularly those presenting to emergency departments, may experience a range of symptoms –including postural instability, dizziness, falls, and syncope (Shaw & Kenny, 1997) – because these phenomena share pathophysiological mechanisms. This is shown in Figure 1. Once recognized, however, syncope management can be effective (The Task Force for the Diagnosis and Management of Syncope of the European Society of Cardiology [ESC], 2009).

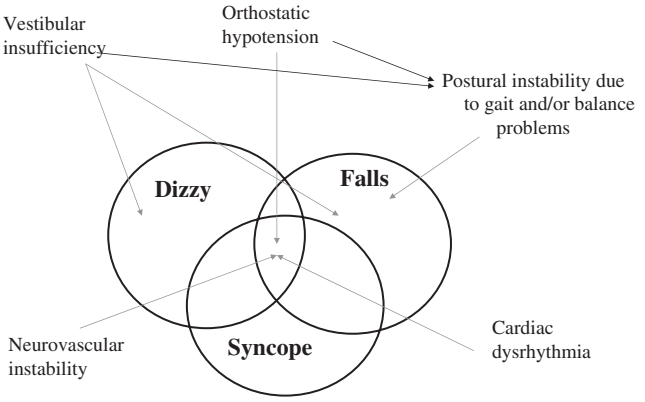

Figure 1: Overlapping syndromes, each with multiple and shared causes.

Orthostatic hypotension (OH) can cause syncope and co-exist with other causes of syncope due to various manifestations of neurovascular instability such as carotid sinus syndrome. It may also contribute to non-syncopal falls through its negative effect on postural stability or attentiveness in suitably compromised individuals. It is detected by measuring supine blood pressure (BP) after a minimum of 10 minutes lying down, relaxed, followed by measurements after 1 and 3 minutes standing, with support if necessary. OH is defined as ≥ 20-mm Hg systolic and/or ≥ 10-mm Hg diastolic drop of BP; the definition also holds if the systolic BP falls below 100 mm Hg. It is most likely to be present on rising initially in the morning so it may be missed when a patient is assessed in an office setting. A similar drop in BP may occur post-prandially, especially after a full carbohydrate meal.

In older patients, there may be several contributory factors to OH including deconditioning and volume depletion, particularly during acute illness, as well as the direct impact of medications. OH is one of the many reasons why falls may be the presenting feature of acute illness or why they occur during recovery from a period of illness during which the patient lost mobility. Autonomic failure associated with diabetes mellitus or neurodegenerative conditions in which the protein α-synuclein precipitates in neuronal cytoplasm (the synucleinopathies) may be a contributory or less commonly a sole evident factor. Clinical management is tailored to address these various factors as far as possible, but in addition there is evidence for a generic approach to OH associated with autonomic failure (Freeman, 2008).

The key role of gait and dynamic postural instability

Gait or balance deficits emerged as the most consistent independent predictors from a systematic review of

https://doi.org/10.1017/S0714980810000747 Published online by Cambridge University Press

18 prospective cohort studies of clinical-level falls risk factors (Ganz, Bao, Shekelle, & Rubenstein, 2007).

Numerous studies have demonstrated an association between falls and gait pattern or speed, and several assessment procedures that incorporate both gait and balance have been shown to be predictive of subsequent falls. Measurements of physiological domains, such as strength and proprioception that contribute to gait and balance, are also predictive of falling, but better predictors are the functional tests that incorporate integrative processes or a composite test of impairments such as the physiological profile assessment (Lord, Menz, & Tiedemann, 2003). A systematic review of falls risk assessment tools – including 27 that involved measures of physical activity related to gait, strength, or balance – concluded that although several had moderate to good validity and reliability, few had been validated in remote samples or in more than one setting, so no single tool could be recommended as suitable for falls prediction in all settings or subpopulations of older people (Scott, Votova, Scanlan, & Close, 2007).

One test used commonly in clinical practice is the timed up-and-go test in which the person is observed and timed rising from a chair of standard height, without pushing up with their arms, walking to a point 3 metres away, turning, and returning to sit in the chair. The tool was originally validated on 60 day-hospital patients, where it was found that a poor performance was significantly correlated with slow gait speed, balance, and functional ability (Podsiadlo & Richardson, 1991). Subsequent studies have derived various cut-points for identifying likely fallers (Shumway-Cook, Brauer, & Woollacott, 2000), but this will vary according to the other characteristics of the sample studied and the suitable cut-point will depend on the balance to be struck between sensitivity (not missing a potential faller) and specificity (not being over-inclusive): increased sensitivity will be at the expense of reduced specificity. Older people who begin to experience mobility difficulties and modify or reduce their usual activities are at greater subsequent risk of falls, particularly if fear of falling results in significant activity limitation (Friedman, Munoz, West, Rubin, & Fried, 2002).

Cognition, gait, incontinence, and falls

There is a well-established association between cognitive impairment and falls, the rate being several-fold higher in various cohorts studied (Shaw, 2002). The presence of cognitive impairment impacts the prediction of falling based on functional mobility assessment (Rockwood, Awalt, Carver, & Macknight, 2000). Several domains of cognition are involved in gait and the performance of functional mobility tasks, including visual and spatial perception, judgment, attention, sensorimotor integration, and memory. Executive function has come under increasing scrutiny as a key factor as observational studies have shown that falls often occur because of difficulty walking while performing another task, in both older frail and young healthy populations (Templer & Connell, 1994; Barra, Bray, Sahni, Golding, & Gresty, 2006). Falls occurring in the context of multitasking illustrate the central feature of frailty, a condition or syndrome which results from a multisystem reduction in reserve capacity to the extent that a number of physiological systems are close to, or past, the threshold of symptomatic failure (Campbell & Buckner, 1997).

Executive function is impaired in many recognized neurodegenerative conditions, such as Parkinson's disease, but also as part of the more common diffuse white matter disease with which changes in gait and cognition (Alexander & Hausdorff, 2008), mood (Baldwin, Jeffries, Jackson, Sutcliffe, Thacker, Scott et al., 2005), and urinary control (Sakakibara, Hattori, Uchiyama, & Yamanishi, 1999) are also associated and underlying vascular disease implicated pathophysiologically (Alexopoulos, Meyers, Young, Campbell, Silbersweig, & Chalson, 1997). Thus the clinical picture is of an older person with higher-level gait disorder – a slower, smaller, and somewhat asymmetrical step pattern, with an inconsistent trajectory – faced with the challenge of urinary urge and frequency with the resultant need to move fast to avoid incontinence. Add to this the likely nocturia, fatigue from broken nights and impaired judgement and the increased rate of falls is easy to understand. Consequently, the epidemiological links between these geriatric syndromes (Tinetti, Inouye, Gill, & Doucette, 1995) may reflect shared associations with underlying age-associated impairments. An integrated approach to their management may be beneficial (Morris & Wagg, 2007; Martin, 2009).

The contribution of other medical co-morbidities and their treatments

It is well established that falls are more common in older people with one or more co-morbidities as long as their severity does not preclude any independent mobility at all. Medication use, both polypharmacy and specific drugs affecting blood pressure or central nervous system (CNS) function, has also been shown to be a consistent risk factor in cross-sectional and prospective risk factor studies (Hartikainen, Lonnroos, & Louhivuori, 2007). Medication review with withdrawal of "culprit medications" is a consistent message in clinical practice guidelines for falls prevention (National Institute for Clinical Excellence [NICE], 2004; AGS/BGS, 2009).

Recent studies have attempted to differentiate the impact of the chronic medical conditions from the treatments given as part of their management. In a study of over 4,000 community-dwelling women in England (mean age: 69 years), the prevalence of having fallen in the past year increased with the increasing number of chronic diseases whereas no independent association with falling was observed for the number of drugs used (Lawlor, Patel, & Ebrahim, 2003). Circulatory disease, chronic obstructive pulmonary disease, depression, and arthritis all contributed to an increased falls risk, which when adjusted for drugs was cumulative from about a 50 per cent increase with one chronic condition to an almost fourfold increase with five or more conditions. Only hypnotics/anxiolytics and antidepressants were independently associated with an increased odds of falling, each class being associated with a 50 per cent increase of odds of falling. The fully adjusted, population-attributable risk of falling associated with having at least one chronic disease was 32 per cent but was less than 5 per cent for each class of drugs: this is an important factor in considering the focus of a population falls prevention strategy.

Among a similar number of Chinese men and women in Hong Kong (mean age: 72 years), 19 per cent of whom reported one or more falls in the previous year, the medications associated with falls after adjustment for age and sex were aspirin, diabetic drugs, nitrates, NSAIDs, and paracetamol (Lee, Twok, Leung, & Woo, 2006). Medical conditions significantly associated with falls were stroke, diabetes, eye diseases (cataract and/or glaucoma), ischaemic heart disease and congestive heart failure, lower-body musculoskeletal problems, and self-rated health. In multivariate analyses, only antidiabetic agents and nitrates, however, remained significantly associated with falls, increasing the odds by about 50 per cent. The study authors concluded that the association between many medications and falls was mediated through the underlying medical conditions and neuromuscular impairment.

Which medications matter: When, how, and what to do

A recent systematic review (Hartikainen et al., 2007) of 28 observational studies and one randomized clinical trial (RCT) concluded that the main group of drugs associated with an increased risk of falling was psychotropics: benzodiazepines, antidepressants, and antipsychotics. Anti-epileptics and drugs that lower blood pressure were weakly associated with falls. A later large study from the ABC cohort of over 3,000 participants showed the odds for recurrent falls risk was less than 2 and that there was a dose-response relationship between total CNS medication dose and recurrent falls: those taking higher doses had a nearly threefold increased risk of recurrent falls (Hanlon, Boudreau, Roumani, Newman, Ruby, Wright et al., 2009).

The clinical implications of the mixed message about co-morbidities, drugs, and falls are as follows: (a) the presence of chronic conditions increases the likelihood of falls; (b) this relationship may be partly explained by impairments of gait and balance; and (c) drug treatment of these chronic conditions with drugs has the potential to alleviate future falls risk (e.g., by enhancing physical activity) but may also contribute directly to falls risk, particularly CNS medication at high doses or in combinations.

Reducing or withdrawing CNS medication was shown to reduce falls by 66 per cent over 10 months in an RCT conducted through family medical practitioners (Campbell, Robertson, Gardner, Norton, & Buchner, 1999). There are few other RCTs of medication modification as a sole intervention, but this has been a component of most effective fall-reducing multicomponent interventions for community-dwelling people (AGS/BGS, 2009) and home care residents (Ray, Taylor, Meador, Thapa, Brown, Kajihara et al., 1997; Oliver, Connelly, Victor, Shaw, Whitehead, Genc et al., 2007). In their seminal RCT (Tinetti, Baker, McAvay, Claus, Garrett, Gottschalk et al., 1994) , the authors conducted a medication review linked to modification which was one of three interventions applied to all participants and which together resulted in a 23 per cent falls reduction at 12 months follow-up. An RCT of a pharmacist-directed review of 661 residents in 65 care homes in England generated a significant increase in drug changes per patient (3.1 versus 2.4 for controls), and they had significantly fewer falls (0.8 and 1.3 falls per patient respectively) (Zermansky, Alldred, Petty, Raynor, Freemantle, Eastaugh et al., 2006).

Osteoporosis, falls, and fractures

Osteoporosis is the most common bone disease in both sexes. Its major impact is fractures occurring with low impact trauma, such as falling from standing height. These are fragility fractures. The epidemiology shows a typical pattern over time from Colles fractures, peaking in the first decade or so after menopause, through to (often asymptomatic) vertebral collapse to hip fractures, the average age for which is now over 80 years in England (Royal College of Physicians of London, 2007). Pubic rami and subcapital fractures of the humerus are also common from age 70 onwards. While osteoporosis is several-fold more prevalent in women, more than half the men aged 50 and over with a hip fracture have osteoporosis. The incidence of any limb fracture (per 1,000 personyears) in European

https://doi.org/10.1017/S0714980810000747 Published online by Cambridge University Press

women aged 50 and over is 19 and 7.3 for men, with distal forearm fracture rates of 7.3 and 1.7, hip fracture rates of 1.3 and 0.8, and vertebral fracture rates of 10.7 and 5.7 for women and men respectively (Ismail, Pye, Cockerill, Lunt, Silman, Reeve et al., 2002). Lifetime fracture prevalence exceeds 40 per cent in women over the age of 75 years. White people are affected more than other ethnic groups across all ages and both genders (Donaldson, Reckless, Scholes, Mindell, & Shelton, 2008). Hip fractures result in a death rate of about 10 per cent within a month(the National Hip Fracture Database National Report 2010, http://www.nhfd.co.uk/,accessed 06.01.2011) , and the excess mortality is 20 per cent at one year. The average age of hip fracture patients is increasing, and the associated frailty may explain why the one-year case fatality rate appears to be increasing (Vestergaard, Rejnmark, & Mosekilde, 2007).

Osteoporosis is defined according to bone mineral density (BMD), dual X-Ray absorptiometry (DEXA) scanning being the gold standard for measuring this in research and clinical practice. The World Health Organization (WHO) defines osteoporosis as a BMD more than 2.5 standard deviations (SDs) below the average for a young, healthy adult: (T-score = ≤ 2.5). Osteopenia is a BMD between –1.0 and –2.5 SDs. BMD is a better predictor of fractures than blood pressure is of stroke, with a relative risk of hip fracture of 2.6 for each 1-SD decrease in bone mineral density at the hip (Marshall, Johnell, & Wedel, 1996), but many, perhaps most, individuals with fragility fractures do not have a BMD which qualifies as osteoporosis (Stone, Seeley, Lui, Cauley, Ensrud, Browner et al., 2003). It is for this reason that focusing solely on the identification of osteoporosis, such as with population screening, would be a poor population strategy for preventing fragility fractures. We need an emphasis on falls prevention if we wish to prevent fractures (Järvinen, Sievänen, Khan, Heinonen, & Kannus, 2008).

Osteoporosis is usually primary, related to a range of factors affecting bone metabolism. These may be non-modifiable, such as (a) gender, (b) age, (c) a family history of fragility fractures, (d) early menopause, and (e) Caucasian ethnicity. Modifiable factors include (a) physical activity levels, (b) body weight, (c) smoking, (d) alcohol intake, and (e) low calcium or vitamin D intake (Melin, Wilske, Ringertz, & Sääf, 1999). Secondary osteoporosis is associated with chronic inflammatory conditions, notably (a) inflammatory bowel disease, (b) rheumatoid arthritis and chronic liver disease, (c) poor nutrition associated with celiac disease or anorexia nervosa, and (d) metabolic disturbances which directly affect bone metabolism such as male hypogonadism, hyperparathyroidism, renal disease, and glucocorticoid excess, which is generally iatrogenic.

In patients replete with vitamin D and calcium by either dietary modification or medication, bisphosponates significantly reduce the risk of hip, wrist, and vertebral fractures in post-menopausal women with osteoporosis or those with a previous vertebral compression fracture (Wells, Cranney, Peterson, Boucher, Shea, Robinson et al., 2008a, 2008b). So, in contrast to a population strategy, treatment to increase BMD is an effective strategy to reduce fractures in selected patients, particularly those who have presented with a first fragility fracture. Clinical decisions can be supported by estimation of the 10-year prospective fracture risk using the WHO Fracture Risk Assessment Tool (http://www.shef.ac.uk/FRAX/).

Why do patients with Parkinson's disease fall, and can we prevent it?

Falls incidence rates in Parkinson's disease (PD) are high, up to 68 per cent, and often multiple, with previous falls, disease duration, bradykinesia, and dementia being independent predictors of falling (Wood, Bilclough, Bowrin, & Walker, 2002). Other studies have highlighted less condition-specific features such as reduced muscle power and slower gait (Allen, Sherrington, Canning, & Fung, 2010), fear of falling (Mak & Pang, 2009), and attentional deficits (Allcock, Rowan, Steen, Wesnes, Kenny, & Burn, 2009). Of interest in view of the clinical observation of apparent impulsiveness of PD patients who fall, was the recent finding that there may be a deficit of postural awareness as well as stability (Kamata, Matsuo, Yoneda, Shinohara, Knoue, & Abe, 2007). Both osteoporosis and fragility fractures are more common in PD (Genever, Downes, & Medcalf, 2005).

An RCT that tested an 8-week program of strength-and-balance exercise and avoidance strategy in patients with PD for a mean of 8 years (UPDRS motor score 19), with recurrent falls rates over 50 per cent, showed suggestive but inconclusive benefits (Ashburn, Fazakarley, Ballinger, Pickering, McLellan, & Fitton, 2007). The pattern of falling among participants was highly variable but the moderate (Hoehn and Yahr 2 and 3) sub-group benefited, while those with more severe disease did not. An as-yet-unreported RCT of 10 weeks (2 per week) group exercise program showed only a transient reduction in falls despite enduring improvements in balance (Goodwin, V., unpublished PhD, Peninsula School of Medicine, Exeter, England: conference presentation, British Geriatrics Society, April 2010). A systematic review of eight trials including 203 participants doing treadmill exercise showed improved gait speed, stride length, and

walking distance (Mehrholz, Friis, Kugler, Twork, Storch, & Pohl, 2010), but there was no overall evidence for falls reduction. This suggests that the diffuse factors involved may require a more complex approach than strength and balance training. Further trials are in progress.

Which interventions to reduce falls? And for whom should they be targeted?

The evidence for falls reduction interventions suitable for community-dwelling older people has been summarized in a recent Cochrane review (Gillespie, Gillespie, Robertson, Lamb, Cumming, & Rowe, 2003). The conclusions are similar to those incorporated in the recent update of the AGS/BGS clinical guidelines (AGS/BGS, 2009). Since the seminal trial of Tinetti et al. (1994), approaches evaluated in RCTs have differed in several respects: (a) targeted on fallers who present for help versus those found by systematic case-finding; (b) high-risk population versus others; (c) health care based versus population based; and (d) provision of direct intervention versus referral to relevant other professionals. Furthermore, some have included exercise training as a common core, while others have used individually directed physiotherapy as deemed necessary. Some interventions have focused on a single risk factor; others, multiple risk factors. Both strategies have resulted in positive and negative trial effects. Targeting multiple risk factors appears to be more effective if they are provided by the assessment team rather than via referral (Gates, Fisher, Cooke, Carter, & Lamb, 2008). The reduction in fall risk may be associated with the number of risk factors improved or eliminated (Tinetti, McAvay, & Claus, 1996).

The AGS/BGS guidelines summarized the evidence-based multifactorial intervention as consisting of the following: (a) an exercise program incorporating balance, gait, and strength training (flexibility and endurance training should also be offered, but not as sole components of the program); (b) adaptation or modification of the home environment; (c) withdrawal or minimization of psychoactive medications; (d) withdrawal or minimization of other medications; (e) management of postural (orthostatic hypotension); and (f) management of foot problems and footwear.

The importance of balance and strength training of sufficient intensity and duration has been confirmed by a recent systematic review (Sherrington, Whitney, Lord, Herbert, Cumming, & Close, 2008). This confirmation is important because, at least in England, where falls services are widespread if not yet comprehensive, the exercise component falls short of the evidence standards in most cases (Royal College of Physicians Clinical Effectiveness and Evaluation Unit, 2007).

Since falls are common – most do no immediate harm and health services are unaware of them – it may be neither feasible nor clinically necessary to mount a secondary prevention response in each case. Clearly, those individuals with significant injury such as fragility fractures are at higher risk of persisting disability and are more likely to present to health services. Prevention of subsequent fractures requires a strategy to respond to the first incidence of fracture, as these patients are at higher subsequent risk: a 50-year-old woman faces a 17 per cent lifetime chance of a hip fracture (Kanis, Johnell, De Laet, Jonsson, Oden, & Ogelsby, 2002), and nearly half of these will have had a previous less serious fragility fracture, thereby providing an opportunity for action (Edwards et al., 2007). A focus on the 16 per cent of post-menopausal women can be done through targeted fracture liaison services in acute and primary care settings. In Canada, this type of program has been shown to be cost-effective within one year of implementation (Sander, Elliot-Gibson, Beaton, Bogoch, & Maetzel, 2008).

Patients presenting to emergency services without fragility fractures include many whose fall has been precipitated by an acute medical problem, such as an infection, which has usually dominated the medical response. But combining this with an assessment of falls risk and implementing an intervention accordingly has been shown not only to reduce future falls rates but also to influence positively future dependency and health resource use in England (Close, Ellis, Hooper, Glucksman, Jackson, & Swift, 1999; Davison, Bond, Dawson, Steen, & Kenny, 2005). In this setting, a history of previous falls, falling indoors, and being unable to rise from the floor were predictive of future falls (Close et al., 2003).

A similar intervention approach applied after hospital discharge targeting frail older people admitted with mobility decline was effective in Germany (Nikolaus & Bach, 2003). A systematic review of home assessment interventions concluded that comprehensive well-focused programs incorporating an "environmental-fit perspective" can be successful in reducing falls (even without other interventions) when targeted at a high-risk group (Clemson, Mackenzie, Ballinger, Close, & Cumming, 2008).

There is also evidence for including the correcting of vision impairment as part of multifactorial falls prevention (Day, Fildes, Gordon, Fitzharris, Flamer, & Lord, 2002) but not for improving vision without attending to other risk factors.

The place of calcium and vitamin D supplementation in reducing falls and fractures has been unclear due to inconsistent trial results, perhaps associated with differences in the vitamin D status of the trial participants

https://doi.org/10.1017/S0714980810000747 Published online by Cambridge University Press

and the trial preparations used. A recent meta-analysis concluded that supplementation for people aged 50 and older conferred a reduced risk of any fracture of 12 per cent (risk ratio 0.88, 95% CI 0.83 to 0.95), the greatest effect being with a daily dose of 1200 mg of calcium and 800 international units (IUs) of vitamin D (Tang, Eslick, Nowson, Smith, & Bensoussan, 2007).

Prevention of injury

Head injury and fragility fractures are the major physical injuries to result in mortality or permanent disability. Hip protectors, consisting of plastic shields or foam pads fitted in pockets within specially designed underwear, have been developed to reduce hip fracture risk from a sideways fall. Early studies were encouraging, indicating a halving of the fracture risk for people in nursing homes. Later experience has not confirmed this advantage. Uptake and adherence is low among high-risk groups; what's more, even additional risk has been suggested in wearers with urinary urgency or frequency combined with manual dexterity and balance problems. This combination is not unusual. Accordingly, a recent Cochrane review with meta-analysis of 16 studies involving a total of over 16,000 older people living in nursing care facilities or older adults living at home showed no benefit from hip protectors for the majority of older people living in their own homes. They may reduce risk in nursing home populations, but the effect is small. Better design and user selection may yet show that this approach can help, but at present there is no case for widespread adoption (Gillespie, Gillespie, & Parker, 2010).

How should community health resources be best directed to reduce falls and injuries?

In summary, the evidence of benefit resulting from multifactorial interventions is strongest for those individuals presenting to acute care and receiving directly provided services, but the key components have not been consistent. Similar risk profiles and amenability to benefit from interventions may be found in other groups, such as those falling at home and being helped to get up and remain at home by emergency practitioners or community services. But local factors affecting the deployment of health services and the health-related behaviors of older people will influence whether these findings do indeed translate to other settings. Several RCTs elsewhere have not demonstrated benefit from similar intervention approaches applied to older fallers identified by prospective case finding in primary care rather than by emergency presentation (Gillespie, Gillespie, Robertson, Lamb, Cumming, & Rowe, 2003). One European trial applied a comprehensive intervention but it lacked an exercise training component (van Haastregt, Diederiks, van Rossum, de Witte, Voorhoeve, & Crebolder, 2000).

Only one study, in North America, has demonstrated a reduction in falls through incorporation of effective clinical practice by non-falls experts in a population-wide approach (Tinetti, Baker, King, Gottschalk, Murphy, Acampora et al., 2008). It has been suggested that assessment-based individualized multifactorial interventions are an over-complication for most older patients, who would gain most by direct application of the exercise training program (Campbell & Robertson, 2007). Further research is needed to clarify how best to identify those who do need more detailed assessments: this would include the need to identify and manage syncope (Parry, Frearson, Steen, Newton, Tryambake, & Kenny, 2008) along with other causes of unexplained recurrent falls such as vestibular impairments.

There is also the need to address the impact of fear of falling. This may be an early indication of balance problems (Martin, Hart, Spector, Doyle, & Harari, 2005) or it may have psychological roots, and is important not only because of its impact on quality of life and dependency but because it is also a risk factor for future falls (Friedman et al., 2002).

Many governments have now determined policies or national clinical guidance for falls and fracture prevention. The wisdom of linking falls and fragility fracture management is strongly supported by the evidence although there is no direct research evidence for this in practice.

In England, NICE (2004) guidance recommends that a multifactorial falls risk assessment linked to interventions should be performed for older people who (a) have had recurrent falls, (b) present to medical attention because of a fall, and (c) demonstrate abnormalities of gait and balance.

This has now been supplemented by further advice to commissioners of local health and social care, emphasizing the importance of key groups for targeting (such as those with fragility fractures) but also making a case for a broader population strategy that focuses on prevention and early recognition of frailty so as to apply interventions which have the potential not only to reduce falls and injuries but also to address the other geriatrics syndromes and associated dependency (Martin, 2009).

The relevant public health approach may therefore depend upon the degree of risk. For many individuals, the risk is low and the preventive approach is not falls-specific. Furthermore, falls reduction itself seems less of a motivator for older people than the more "positive" message of preserving mobility (Help the

https://doi.org/10.1017/S0714980810000747 Published online by Cambridge University Press

Aged, 2005). Taking regular physical exercise, maintaining social contacts, eating healthily, and having regular eye checks and medication reviews are all likely to contribute to reducing falls risk. For older individuals or those with emerging frailty, strength-and-balance exercise training becomes increasingly important.

References

Alexander, N.B., & Hausdorff, J.M. (2008). Guest editorial: Linking thinking, walking, and falling. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *63*(12), 1325–1328.

Alexopoulos, G.S., Meyers, B.S., Young, R.C., Campbell, S., Silbersweig, D., & Charlson, M. (1997). 'Vascular depression' hypothesis. *Archives of General Psychiatry*, *54*(10), 915–922.

Allcock, L.M., Rowan, E.N., Steen, I.N., Wesnes, K., Kenny, R.A., & Burn, D.J. (2009). Impaired attention predicts falling in Parkinson's disease. *Parkinsonism & Related Disorders*, *15*(2), 110–115.

Allen, N.E., Sherrington, C., Canning, C.G., & Fung, V.S. (2010). Reduced muscle power is associated with slower walking velocity and falls in people with Parkinson's disease. *Parkinsonism & Related Disorders*, *16*(4), 261–264.

American Geriatrics Society and British Geriatrics Society (AGS/BGS). (2009). *Clinical Practice Guideline: Prevention of Falls in Older Persons*. Retrieved February 20, 2010, from http://www.americangeriatrics.org/education/prevention_of_falls.shtml

Ashburn, A., Fazakarley, L., Ballinger, C., Pickering, R., McLellan, L.D., & Fitton, C. (2007). A randomised controlled trial of a home-based among people with Parkinson's disease exercise programme to reduce the risk of falling. *Journal of Neurology, Neurosurgery, and Psychiatry*, *78*(7), 678–684.

Baldwin, R., Jeffries, S., Jackson, A., Sutcliffe, C., Thacker, N., Scott, M., et al. (2005). Neurological findings in late-onset depressive disorder: Comparison of individuals with and without depression. *The British Journal of Psychiatry*, *186*, 308–313.

Barra, J., Bray, A., Sahni, V., Golding, J.F., & Gresty, M.A. (2006). Increasing cognitive load with increasing balance challenge: Recipe for catastrophe. *Experimental Brain Research*, *174*, 734–745.

Bhattacharyya, N., Baugh, R.F., Orvidas, L., Barrs, D., Bronston, L.J., Cass, S., et al. (2008). Clinical practice guideline: Benign paroxysmal positional vertigo. *Otolaryngology and Head and Neck Surgery*, *139*(5 Suppl. 4), S47–S81.

Brignole, M. (2006). Distinguishing syncopal from non-syncopal causes of fall in older people. *Age and Ageing*, *35*(Suppl. 2), ii46–ii50.

Campbell, A.J., & Buckner, D.M. (1997). Unstable disability and the fluctuations of frailty. *Age and Ageing*, *26*(4), 315–318.

Campbell, A.J., & Robertson, M.C. (2007). Rethinking individual and community fall prevention strategies: A meta-regression comparing single and multifactorial interventions. *Age and Ageing*, *36*, 656–662.

Campbell, A.J., Robertson, M.C., Gardner, M.M., Norton, R.N., & Buchner, D.M. (1999). Psychotropic medication withdrawal and a home-based exercise program to prevent falls: A randomized, controlled trial. *Journal of the American Geriatrics Society*, *47*, 850–853.

Campbell, A.J., Spears, G.F.S., & Borrie, M.J. (1990). Examination by logistic regression modeling of the variables which increase the relative risk of elderly women falling compared to elderly men. *Journal of Clinical Epidemiology*, *43*, 1415–1420.

Clemson, L. (1997). *Home fall hazards: A guide to identifying fall hazards in the homes of elderly people and an accompaniment to the assessment tool, the Westmead Home Safety Assessment (WeHSA)*. West Brunswick, Victoria: Co-ordinates Publications.

Clemson, L., Mackenzie, L., Ballinger, C., Close, J.C., & Cumming, R.G. (2008). Environmental interventions to prevent falls in community-dwelling older people: A meta-analysis of randomized trials. *Journal of Aging and Health*, *20*(8), 954–971.

Close, J., Ellis, M., Hooper, R., Glucksman, E., Jackson, S., & Swift, C. (1999). Prevention of falls in the elderly trial (PROFET): A randomised controlled trial. *Lancet*, *353*, 93–97.

Close, J.C.T., Hooper, R., Glucksman, E., Jackson, S.H.D., & Swift, C.G. (2003). Predictors of falls in a high risk population: Results from the prevention of falls in the elderly trial (PROFET). *Emergency Medicine Journal*, *20*, 421–425.

Davison, J., Bond, J., Dawson, P., Steen, I.N., & Kenny, R.A. (2005). Patients with recurrent falls attending Accident & Emergency benefit from multifactorial intervention – a randomised controlled trial. *Age and Ageing*, *34*, 162–168.

Day, L., Fildes, B., Gordon, I., Fitzharris, M., Flamer, H., & Lord, S. (2002). Randomised factorial trial of falls prevention among older people living in their own homes. *BMJ*, *325*(7356), 128–134.

Donaldson, L.J., Reckless, I.P., Scholes, S., Mindell, J.S., & Shelton, N.J. (2008). The Epidemiology of Fractures in England. *Journal of Epidemiology and Community Health*, *62*(2), 174–180.

Edwards, B.J., Bunta, A.D., Simonelli, C., Bolander, M., & Fitzpatrick, L.A. (2007). Prior fractures are common in patients with subsequent hip fractures. *Clinical Orthopaedics and Related Research*, *461*, 226–230.

Fleming, J., Matthews, F.E., & Brayne, C.; Cambridge City over-75s Cohort (CC75C) study collaboration. (2008). Falls in advanced old age: Recalled falls and prospective

follow-up of over-90-year-olds in the Cambridge City over-75s Cohort study. *BMC Geriatrics*, *8*, 6.

Freeman, R. (2008). Neurogenic Orthostatic Hypotension. *The New England Journal of Medicine*, *358*, 615–624.

Friedman, S.M., Munoz, B., West, S.K., Rubin, G.S., & Fried, L.P. (2002). Falls and fear of falling: Which comes first? A longitudinal prediction model suggests strategies for primary and secondary prevention. *Journal of the American Geriatrics Society*, *50*, 1329–1335.

Ganz, D.A., Bao, Y., Shekelle, P.G., & Rubenstein, L.Z. (2007). Will my patient fall? *JAMA*, *297*, 77–86.

Gates, S., Fisher, J.D., Cooke, M.W., Carter, Y.H., & Lamb, S.E. (2008). Multifactorial assessment and targeted intervention for preventing falls and injuries among older people in community and emergency care settings: Systematic review and meta-analysis. *BMJ*, *336*(7636), 130–133.

Genever, R.W., Downes, T.W., & Medcalf, P. (2005). Fracture rates in Parkinson's disease compared with age- and gender-matched controls: A retrospective cohort study. *Age and Ageing*, *34*, 21–24.

Gillespie, L.D., Gillespie, W.J., & Parker, M.J. (2010). Hip protectors for preventing hip fractures in older people. *Cochrane Database of Systematic Reviews*, (10). Art. No.: CD001255. doi:10.1002/14651858.CD001244.pub4.

Gillespie, L.D., Gillespie, W.J., Robertson, M.C., Lamb, S.E., Cumming, R.G., & Rowe, B.H. (2003). Interventions for preventing falls in elderly people. *Cochrane Database of Systematic Reviews*, (4). Art. No.: CD000340. doi:10.1002/14651858.CD000340.

Gillespie, L.D., Robertson, M.C., Gillespie, W.J., Lamb, S.E., Gates, S., Cumming, R.G., & Rowe, B.H. (2009). Interventions for preventing falls in older people living in the community. *Cochrane Database of Systematic Reviews*, (2), Art. No.: CD007146. doi:10.1002/14651858.CD007146.pub2.

Hanlon, J.T., Boudreau, R.M., Roumani, Y.F., Newman, A.B., Ruby, C.M., Wright, R.M., et al. (2009). Number and dosage of central nervous system medications on recurrent falls in community elders: The Health, Aging and Body Composition study. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *64*(4), 492–498. Published Online First: Feb 4, 2009.

Hartikainen, S.A., Lonnroos, E., & Louhivuori, K. (2007). Medication as a risk factor for falls: Critical systematic review. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *62A*, MS1172–M1181.

Help the Aged. (2005). *Don't Mention the F- Word*. Retrieved, from http://www.helptheaged.org.uk

Inouye, S.K., Studenski, S., Tinetti, M.E., & Kuchel, G.A. (2007). Geriatric syndromes: Clinical, research, and policy implications of a core geriatric concept. *Journal of the American Geriatrics Society*, *55*, 780–791.

Ismail, A.A., Pye, S.R., Cockerill, W.C., Lunt, M., Silman, A.J., Reeve, J., et al. (2002). Incidence of limb fracture across Europe: Results from the European Prospective Osteoporosis Study (EPOS). *Osteoporosis International*, *13*(7), 565–571.

Järvinen, T.L., Sievänen, H., Khan, K.M., Heinonen, A., & Kannus, P. (2008). Shifting the focus in fracture prevention from osteoporosis to falls. *BMJ*, *336*, 124–126.

Kamata, N., Matsuo, Y., Yoneda, T., Shinohara, H., Inoue, S., & Abe, K. (2007). Overestimation of stability limits leads to a high frequency of falls in patients with Parkinson's disease. *Clinical Rehabilitation*, *21*(4), 357–361.

Kanis, J.A., Johnell, O., De Laet, C., Jonsson, B., Oden, A., & Ogelsby, A.K. (2002). International variations in hip fracture probabilities: Implications for risk assessment. *Journal of Bone and Mineral Research*, *17*, 1237–1244.

Kannus, P., Parkkari, J., Koskinen, S., Niemi, S., Palvanen, M., Järvinen, M., et al. (1999). Fall-induced injuries and deaths among older adults. *JAMA*, *281*, 1895–1899.

Lamb, S.E., Jorstad-Stein, E.C., Hauer, K., & Becker, C.; on behalf of the Prevention of Falls Network Europe and Outcomes Consensus Group. (2005). Development of a common outcome data set for fall injury prevention trials: The Prevention of Falls Network Europe Consensus. *Journal of the American Geriatrics Society*, *53*, 1618–1622.

Lawlor, D., Patel, R., & Ebrahim, S. (2003). Association between falls in elderly women and chronic diseases and drug use: Cross sectional study. *BMJ*, *327*, 712–717.

Lee, J.S.W., Twok, T., Leung, P.C., & Woo, J. (2006). Medical illnesses are more important than medications as risk factors of falls in older community dwellers? A cross-sectional study. *Age and Ageing*, *35*, 246–251.

Lord, S.R., Menz, H.B., & Tiedemann, A. (2003). A physiological profile approach to falls risk assessment and prevention. *Physical Therapy*, *83*(3), 237–252.

Lord, S.R., Sambrook, P.N., Gilbert, C., Kelly, P.J., Nguyen, T., Webster, I.W., et al. (1994). Postural stability, falls and fractures in the elderly: Results from the Dubbo Osteoporosis Epidemiology Study. *The Medical Journal of Australia*, *160*(11), 684–685, 688–691.

Mak, M.K., & Pang, M.Y. (2009). Fear of falling is independently associated with recurrent falls in patients with Parkinson's disease: A 1-year prospective study. *Journal of Neurology*, *256*(10), 1689–1695. Published Online First: May 28, 2009.

Marshall, D., Johnell, O., & Wedel, H. (1996). Meta-analysis of how well measures of bone mineral predict fractures. *British Medical Journal*, *312*, 1254–1259.

Martin, F.C. (2009). Next steps for falls and fracture reduction. *Age and Ageing*, *38*, 640–643.

Martin, F.C., Hart, D.J., Spector, T.D., Doyle, D., & Harari, D. (2005). Fear of falling limiting activity in young-old women is associated with reduced functional mobility rather than psychological factors. *Age and Ageing*, *34*(3), 281–287.

Masud, T., & Morris, R.O. (2001). Epidemiology of Falls. *Age and Ageing*, *30*(Suppl. 4), 3–7.

Mehrholz, J., Friis, R., Kugler, J., Twork, S., Storch, A., & Pohl, M. (2010). Treadmill training for patients with Parkinson's disease. *Cochrane Database of Systematic Reviews*. (1), CD007830.

Melin, A.L., Wilske, J., Ringertz, H., & Sääf, M. (1999). Vitamin D status, parathyroid function and femoral bone density in an elderly Swedish population living at home. *Aging (Milan, Italy)*, *11*(3), 200–207.

Morris, V., & Wagg, A. (2007). Lower urinary tract symptoms, incontinence and falls in elderly people: Time for an intervention study. *International Journal of Clinical Practice*, *61*(2), 320–323.

Nandy, S., Parsons, S., Cryer, C., Underwood, M., Rashbrook, E., Carter, Y., et al. (2004). Development and preliminary examination of the predictive validity of the Falls Risk Assessment Tool (FRAT) for use in primary care. *Journal of Public Health (Oxford, England)*, *26*(2), 138–143.

National Institute for Clinical Excellence (NICE). (2004). *Clinical practice guideline for the assessment and prevention of falls in older people. Royal College of Nursing*. London: National Institute for Clinical Excellence.

Nikolaus, T., & Bach, M. (2003). Preventing falls in community-dwelling frail older people using a home intervention team (HIT): Results from the randomized Falls-HIT trial. *Journal of the American Geriatrics Society*, *51*(3), 300–305.

Nowak, A., & Hubbard, R. (2009). Falls and frailty: Lessons from complex systems. *Journal of the Royal Society of Medicine*, *102*, 98–102.

Nyman, S.R. (2011). Psychosocial issues in engaging older people with physical activity interventions for the prevention of falls. *Canadian Journal on Aging*, *30*(1), 45–55.

Oliver, D., Connelly, J.B., Victor, C.R., Shaw, F.E., Whitehead, A., Genc, Y., et al. (2007). The prevention of falls and fractures in hospitals and care homes. Systematic review and meta-analyses of clinical studies of prevention strategies, with an exploration of cognitive impairment as an effect modifier. *BMJ*, *334*(7584), 82.

Parry, S.W., Frearson, R., Steen, N., Newton, J., Tryambake, P., & Kenny, R.A. (2008). Evidence-based algorithms and the management of falls and syncope presenting to acute medical services. *Clinical Medicine*, *8*(2), 157–162.

Parry, S.W., Steen, I.N., Baptist, M., & Kenny, R.A. (2005). Amnesia for loss of consciousness in carotid sinus syndrome: Implications for presentation with falls. *Journal of the American College of Cardiology*, *45*, 1840–1843.

Peel, N.M., Kassulke, D.J., & McClure, R.J. (2002). Population based study of hospitalized fall related injuries in older people. *Injury Prevention*, *8*, 280–283.

Podsiadlo, D., & Richardson, S. (1991). The timed 'up and go' a test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society*, *39*, 142–148.

Ray, W.A., Taylor, J.A., Meador, K.G., Thapa, P.B., Brown, A.K., Kajihara, H.K., et al. (1997). A randomized trial of a consultation service to reduce falls in nursing homes. *JAMA*, *278*, 557–562.

Rockwood, K., Awalt, E., Carver, D., & Macknight, C. (2000). Feasibility and measurement properties of the functional reach and the timed up and go tests in the Canadian Study of Health and Aging. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *5*, M70–M73.

Royal College of Physicians Clinical Effectiveness and Evaluation Unit. (2007). *National Clinical Audit of Falls and Bone Health in Older People, 2007*. Retrieved from: http://www.rcplondon.ac.uk/clinical-standards/ceeu/Current-work/Pages/Falls-and-Bone-Health-in-Older-People.aspx

Royal College of Physicians of London, Clinical Effectiveness and Evaluation Unit. (2007). *National Clinical Audit of Falls and Bone Health in Older People*. (National Report, 2007). Retrieved from http://www.rcplondon.ac.uk/clinical-standards/ceeu/Current-work/Pages/Falls-and-Bone-Health-in-Older-People.aspx#national

Rubenstein, L.Z. (2006). Falls in older people: Epidemiology, risk factors and strategies for prevention. *Age and Ageing*, *35*(Suppl. 2), ii37–ii41.

Sakakibara, R., Hattori, T., Uchiyama, T., & Yamanishi, T. (1999). Urinary function in elderly people with and without leukoariosis: Relation to cognitive and gait function. *Journal of Neurology, Neurosurgery, and Psychiatry*, *67*, 658–660.

Sander, B., Elliot-Gibson, V., Beaton, D.E., Bogoch, E.R., & Maetzel, A. (2008). A coordinator program in post-fracture osteoporosis management improves outcomes and saves costs. *The Journal of Bone and Joint Surgery. American Volume*, *90*, 1197–1205. PubMed PMID: 18519311.

Scott, V., Votova, K., Scanlan, A., & Close, J. (2007). Multifactorial and functional mobility assessment tools for fall risk among older adults in community, home-support, long-term and acute care settings. *Age and Ageing*, *36*(2), 130–139.

Scuffham, P., & Chaplin, P. (2002). *The incidence and costs of accidental falls in the UK*. (Final Report). New York: York Health Economic Form Consortium, The University of York.

Shaw, F.E. (2002). Falls in cognitive impairment and dementia. *Clinics in Geriatric Medicine*, *18*, 159–173.

Shaw, F.E., & Kenny, R.A. (1997). The overlap between syncope and falls in the elderly. *Postgraduate Medical Journal*, *73*(864), 635–639.

Sherrington, C., Whitney, J.C., Lord, S.R., Herbert, R.D., Cumming, R.G., & Close, J.C. (2008). Effective exercise for the prevention of falls: A systematic review and meta-analysis. *Journal of the American Geriatrics Society*, *56*, 2234–2243.

Shumway-Cook, A., Brauer, S., & Woollacott, M. (2000). Predicting the probability of falls in community-dwelling older adults using the timed up and go test. *Physical Therapy*, *80*, 896–903.

Stevens, J.A., & Sogolow, E.D. (2005). Gender differences for non-fatal unintentional fall related injuries among older adults. *Injury Prevention*, *11*, 115–119.

Stone, K.L., Seeley, D.G., Lui, L.Y., Cauley, J.A., Ensrud, K., Browner, W.S., et al. (2003). BMD at multiple sites and risk of fracture of multiple types: Long-term results from the study of osteoporotic fractures. *Journal of Bone and Mineral Research*, *18*, 1947–1954.

Tang, B.M.P., Eslick, G.D., Nowson, C., Smith, C., & Bensoussan, A. (2007). Use of calcium or calcium in combination with vitamin D supplementation to prevent fractures and bone loss in people aged 50 years and older: A meta-analysis. *The Lancet*, *370*(9588), 657–666.

Templer, J., & Connell, B.R. (1994). Geriatrics: Environmental and behavioural factors in falls among the elderly. *Rehabilitation*, *30*, 92–93.

The Task Force for the Diagnosis and Management of Syncope of the European Society of Cardiology (ESC). (2009). Guidelines for the diagnosis and management of syncope (version 2009). *European Heart Journal*, *30*(21), 2631–2671. doi:10.1093/eurheartj/ehp298.

Tinetti, M.E., Baker, D.I., King, M., Gottschalk, M., Murphy, T.E., Acampora, D., et al. (2008). Effect of dissemination of evidence in reducing injuries from falls. *The New England Journal of Medicine*, *359*, 252–261.

Tinetti, M.E., Baker, D.I., McAvay, G., Claus, E.B., Garrett, P., Gottschalk, M., et al. (1994). A multifactorial intervention to reduce the risk of falling among elderly people living in the community. *The New England Journal of Medicine*, *331*, 821–827.

Tinetti, M.E., Inouye, S.K., Gill, T.M., & Doucette, J.T. (1995). Shared risk factors for falls, incontinence, and functional dependence. Unifying the approach to geriatric syndromes. *JAMA*, *273*, 1348–1353.

Tinetti, M.E., McAvay, G., & Claus, E. (1996). Does multiple risk factor reduction explain the reduction of fall rate in the Yale FICSIT trial. *American Journal of Epidemiology*, *144*, 389–399.

Tinetti, M.E., Speechley, M., & Ginter, S.F. (1988). Risk factors for falls among elderly persons living in the community. *The New England Journal of Medicine*, *319*, 1701–1707.

Tinetti, M.E., & Williams, C.S. (1997). Falls, injuries due to falls, and the risk of admission to a nursing home. *The New England Journal of Medicine*, *337*(18), 1279–1284.

van Haastregt, J.C., Diederiks, J.P., van Rossum, E., de Witte, L.P., Voorhoeve, P.M., & Crebolder, J.M. (2000). Effects of a programme of multifactorial home visits on falls and mobility impairments in elderly people at risk: Randomized controlled trial. *British Medical Journal*, *321*, 994–998.

Vestergaard, P., Rejnmark, L., & Mosekilde, L. (2007). Has mortality after a hip fracture increased? *Journal of the American Geriatrics Society*, *55*(11), 1720–1726. Published Online First: Oct 3, 2007.

Wells, G., Cranney, A., Peterson, J., Boucher, M., Shea, B., Robinson, V., et al. (2008a). Alendronate for the primary and secondary prevention of osteoporotic fractures in postmenopausal women. *Cochrane Database of Systematic Reviews*, (1). Art. No.: CD001155. doi:10.1002/14651858.CD001155.pub2.

Wells, G., Cranney, A., Peterson, J., Boucher, M., Shea, B., Robinson, V., et al. (2008b). Risedronate for the primary and secondary prevention of osteoporotic fractures in postmenopausal women. *Cochrane Database of Systematic Reviews*, (1). Art. No.: CD004523. doi:10.1002/14651858.CD004523.pub3.

Wood, B.H., Bilclough, J.A., Bowrin, A., & Walker, R.W. (2002). Incidence and prediction of falls in Parkinson's disease: A prospective multidisciplinary study. *Journal of Neurology, Neurosurgery, and Psychiatry*, *72*, 721–725.

Zermansky, A.G., Alldred, D.P., Petty, D.G., Raynor, D.K., Freemantle, N., Eastaugh, J., et al. (2006). Clinical medication review by a pharmacist of elderly people living in care homes—randomised controlled trial. *Age and Ageing*, *35*, 586–591.