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Exercise for falls management: Rationale for an exercise programme aimed at reducing postural instability

Dawn A. Skelton and Susie M. Dinan

It is evident in the scientific and health promotion literature that interest in methods of reducing the risk factors associated with falls, in falls themselves, and in fall-induced injuries is increasing. However, the scientific evidence supporting the role exercise has to play in the management of elderly people who fall is inconsistent and, therefore, confusing. There have been calls for further research evidence, models of practice, guidelines on prevention, and treatment initiatives. Strategically, current guidelines are helpful but more detail is needed in order to assist practitioners to design effective exercise programmes for this vulnerable group. This paper provides a rationale for a specific, tailored, progressive programme of exercise. The programme not only incorporates all the basic fitness components seen in any well-run seniors' exercise class, but also includes specific falls management strategies, such as bone loading, gait, dynamic posture, balance, reaction and co-ordination training, together with adapted Tai Chi and functional floor activities to improve coping skills and confidence. This Falls Management Exercise Programme (FaME) is being evaluated in a controlled trial, funded by Research into Ageing and conducted at Imperial College School of Medicine, London, UK.

INTRODUCTION

To date, there are no national guidelines giving detailed, specific advice on exercises for falls prevention and exercise protocols in old age. Two systematic reviews of randomised, controlled, intervention trials (Sowden et al., 1996; Gillespie et al., 1997) concluded that exercise reduces the risk of falling as part of multifactorial intervention. Since then, however, Campbell et al. (1997) have shown how falls can be reduced by an individual programme of strength and balance exercises, which they list. Possibly the only detailed, published account of an exercise intervention programme is given by Koch et al. (1994), who describe the assessment and intervention protocol they developed for a multifactorial home-based intervention programme (Tinetti et al., 1994). Neither of the systematic reviews made recommendations for exercise that were sufficiently

Dawn Skelton, Exercise Physiologist, Cellular and Integrative Biology, Division of Biomedical Sciences, Imperial College School of Medicine at St Mary's, Norfolk Place, London W2 1PG, UK.
e.mail: d.skelton@ic.ac.uk
Susie Dinan, Senior Clinical Exercise Practitioner, Royal Free Hospital, Pond Street, London NW3 2QG, UK.

(Reprint requests to DS)

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specific to be implemented by practitioners. Guidelines commissioned by the Health Promotion Division of the Department of Health in the UK are valuable for developing multifactorial interventions for falls prevention but give no specific advice on exercise other than that it should involve muscle strengthening and balance work, especially Tai Chi (Feder, Cryer, & Donovan, 1998). Guidelines have been produced for physiotherapists and occupational therapists working with older people who have fallen (Simpson, Harrington, & Marsh, 1998; Simpson, Marsh, & Harrington, 1998). The recommendations include balance training, strengthening the muscles around the hip, knee and ankle, increasing flexibility (range of motion) of the trunk and lower limb, teaching how to rise from the floor, and the provision of mobility aides and appliances if necessary. These guidelines are positive and helpful. However, they do not give specific advice about the selection and combination of exercises, or about intensity, duration, frequency, baseline measures, or increments of progression. A welcome forthcoming document from the Health Education Authority, however, will provide a framework for practice in the use of physical activity and the management of fractures and falling (Health Education Authority Older People's Programme, 1999).

This paper aims to integrate evidence and practice in order to provide practitioners with a framework for selecting specific, tailored, progressive exercises that can be adapted to suit older people with a wide range of physical abilities. The framework is organised around a 4-point plan to improve *balance*, *functional capacity*, *bone and muscle mass*, and *confidence*. This programme, in addition to including the basic fitness components seen in any carefully constructed seniors' class, also incorporates specific falls management activities. These include sustained three-dimensional Tai Chi-based movement patterns, targeted strengthening and stretching exercises, dynamic postural and gait training, and functional floor and standing activities to improve postural skill and confidence. The programming design utilises a combination of supervised and home-based sessions and telephone support.

Before designing a falls management exercise programme, it is important to identify the physical deficits contributing to a higher risk of falls or fall-induced injuries that can be ameliorated by exercise training. It is also necessary to differentiate between risk factors for falling and outcomes or consequences of falling. For example, depression is a risk factor for falls, as well as an outcome of falls (Thapa et al., 1994; Rizzo et al., 1998). Over 400 risk factors have been identified (see Sowden et al., 1996 and Piotrowski Brown in this issue). Some of them, such as inappropriately prescribed drugs, vitamin D deficiency, environmental hazards, and type of footwear worn, cannot be influenced directly by exercise. However, most intrinsic physical risk factors, such as low muscle strength, poor balance, and gait deficiencies are amenable to change with exercise. Cwikel and Fried (1992) formulated a conceptual model that considers both the risk factors for falls and the agents involved in falls. They proposed "a complete fall prevention strategy" comprising primary (pre-fall stage), secondary (at the time of the fall), or tertiary (post-fall stage) prevention.

Physical fitness is especially important in old age. Without it, everyday tasks and unforeseen demands such as slopes, uneven ground, trips, and even everyday tasks such as getting up from the toilet may place insurmountable demands on the ageing body (Fentem, Bassey, & Turnbull, 1988, Skelton and McLaughlin, 1997). Although several muscle groups in the lower limb may well be weaker amongst fallers (Whipple, Wolfson, & Amerman, 1987; Lord, McLean & Strathers, 1992), few studies have examined muscle groups other than the quadriceps, ankle dorsiflexors, and plantarflexors. Moreover, the hip flexors and ankle invertors and evertors appear to be neglected. Apart from Whipple et al. (1987) no researcher seems to have measured isokinetic strength, which is probably important in preventing falls. Similarly, muscle power (strength × speed of contraction) is rarely assessed. Lower limb muscle power, however, is likely to be very important in correcting a displacement or movement error (Bassey et al., 1992). To prevent a trip an individual must have sufficient lower limb muscle power to get a stabilising leg (or enough upper body power to get a stabilising arm) out fast enough to prevent the fall or reduce the severity of the effects of the fall (see Maki in this issue). Also,

muscle power is strongly related to ability to perform everyday tasks (Skelton, Greig, Davies, & Young, 1994). Among elderly women who had surgery to repair a hip fracture, muscle power was 70% less in the uninjured leg, than their healthy counterparts (Levy, Young, Skelton, & Yeo, 1994). In addition to size, number, and type of muscle fibres, muscle power at any age is related to the length of the muscle (Harridge & Young, 1998). Adaptive shortening due to immobility also reduces muscle power. Reduced sensory input exacerbates the inefficiency of musculoskeletal systems in correcting a displacement or movement error and stabilising posture. Age-related changes in connective tissue results in further reduction of flexibility, loss of tensile strength in the ligaments, and greater rigidity in the muscles and peripheral support structures of the joints of the lower limb.

Poor balance is prevalent amongst fallers (O'Brien, Culham, & Pickles, 1997) and many of the risk factors for postural instability are largely due to inactivity and ageing muscles (Lord, Clark, & Webster, 1991). Balance is a complex automatic integration of several body systems. With age and inactivity these unconscious processes may not integrate as well or as quickly, so in order to maintain their balance and avoid falling older people may have to give a greater proportion of their attention to keeping upright with concomitant fatiguing effort. The "stops walking when talking" phenomenon reflects this difficulty (Lundin-Olsson, Nyberg, & Gustafson, 1997).

Body sway is commonly regarded as an indicator of postural stability. We all sway slightly during quiet standing, but in older adults, particularly in women, sway is more evident, especially during single leg standing (Nasher, 1993). On a firm surface, Lord, Clark, and Webster (1991) found that increased body sway was related to poor tactile sensitivity and poor joint position sense. On a compliant surface (which reduced peripheral sensation), increased body sway was related to poor visual acuity, reduced vibration sense, decreased ankle dorsiflexion strength, and poor joint position sense. When subjects had their eyes closed, sway was more related to quadriceps and ankle dorsiflexion strength and increased reaction time. Vestibular impairment was not associated with increased sway.

Changes in gait pattern may also be associated with balance (Nasher, 1993). Older people tend to step with a wider base, spending increased time in the double leg support phase of walking and minimising the time spent on one leg. There is, therefore, a decrease in stride length and trunk rotation, with the result that a more unbalanced or even shuffling gait may develop. When required to increase walking speed, older people tend to increase their cadence rather than their stride length; younger people do the reverse (Greig et al., 1993). Older people with diseases such as peripheral neuropathy, arthritis, and osteoporosis are likely to adapt their gait even more to relieve stress and pain.

Fear of falling can also cause older people to limit their movement (Tinetti, Speechley, & Ginter, 1988), not just in terms of habitual activity but also in their normal body movements (Murphy & Isaacs, 1982). Reluctance to move can lead to poor co-operation with rehabilitative methods Murphy & Isaacs, 1982) and avoidance of a particular activity that led to a fall (Tideiksaar, 1989). The trunk becomes more rigid so that rotational movement of the pelvis is reduced which can lead to pain and discomfort that limits further movement (Patla, 1994). Movement errors or novel movements are known to facilitate the acquisition of motor skills so conversely, fallers may inadvertently cause a loss of postural skills by constraining their own movements (Nasher, 1993).

Other age-related changes that may affect postural stability include the reduction of reflex speeds and poor co-ordination, and vestibular dysfunction (often medication related) may mean there is overlap between the timing of reflexes and the voluntary responses to correct the loss of balance. In our experience, these negative changes in response and loss of flexibility and strength in the muscles and joints of the lower limb, seem to result in people relying more on the larger muscles of the upper leg and trunk. Balance detection and correction is also influenced by reduced sensitivity of skin receptors (oedema, arthritis, and medications) (Patla, 1994).

Functional difficulties are common amongst fallers (Wolinsky, Johnson, & Fitzgerald, 1992), for example, their ability to get up off the floor after a

fall (Tinetti, Lui, & Claus, 1993). A falls exercise management programme should retrain or maintain the ability to get up from the floor to avoid a "long lie" after a non-injurious fall, and include practice at other coping skills such as summoning help and keeping warm while on the floor (Simpson, Harrington, & Marsh, 1998; Simpson, Marsh, & Harrington, 1998).

There is considerable interest in exercise as an intervention to reduce osteoporosis (Rutherford, 1997). It appears that regular physical activity is the most important preventative measure against hip fractures, with the risk among those who take regular activity being halved (Law, Wald, & Meade, 1991). Therefore it is important to consider the inclusion of bone-loading exercises in the design of a falls management strategy.

Exercise should be considered not only as a means of reducing falls but also of reducing fear of falls and depression, both of which are common amongst fallers (Tinetti et al., 1994).

RATIONALE FOR THE FALLS MANAGEMENT EXERCISE PROGRAMME (FaME)

Development of the FaME Programme

The FaME programme has been designed to take account of both positive and negative outcomes relating to falls, within the scientific literature. A progressive tailored programme had to be evolved that would be sufficiently specific, functional, and of ample intensity, frequency, and duration to be effective in reducing risk factors, actual risk, and the fear of falls. Also it had to encompass the wide range of baseline fitness and mobility levels seen amongst the subjects at the start of the programme. Injury prevention was a priority. The programme is arranged in three phases, utilising a combination of home-based and supervised sessions. It also aims to reflect the current evidence on overcoming barriers to exercise and ways of improving long-term adherence in older people (Finch, 1997).

Summarising the exercise evidence

Several trials may have used exercise of insufficient duration, intensity (overload), or frequency to effect change to the person's gait or movement patterns (Means, Rodell, O'Sullivan and Cranford, 1996; Mulrow et al., 1994). Other trials have used a general exercise class aimed at seniors, which may not have been sufficiently specific to be effective (Lord, Ward, Williams, & Strudwick, 1995, Reinsch, MacRae, Lachenbruch, & Tobis, 1992). Trials that have been unsuccessful in showing a risk reduction with exercise have often relied on the individual's recollection of falling rather than collecting falls data prospectively. Also, in some trials the criteria for what constitutes a fall is not clearly defined. In these circumstances, the answer to "How many falls did you have in the last year?" can give inaccurate data. Finally, many trials failed to target their subjects and included non-fallers in the study (Reinsch et al., 1992; McMurdo, Mole, & Paterson, 1997, Means et al., 1996). As exercise must be specific to the task, if the subjects did not fall before the trial then a change in fall status is difficult to gauge. For effective falls management, the exercise must be set at sufficient intensity, duration, and frequency and work with a targeted population group. It also needs to be specific.

Specificity

Specificity of training is important not only to athletes but also to older people. It is possible to improve quadriceps strength in women aged over 75 years by nearly 30% in just 12 weeks (Skelton, Young, Greig, & Malbut, 1995) without seeing major improvements in functional ability. But when exercise mimics functional moves, consistent improvements are seen in most of the functional tasks assessed before and after training (Skelton & McLaughlin, 1996). One long-term (10 year) follow-up of regular walkers also showed the importance of specificity, for although the health of the walkers was better than those who were sedentary, there was no significant reduction in the number of falls they had compared to the group who stopped regular walking (Pereira et al., 1998).

Another 1 year study showed no difference in muscle strength, body sway, or fracture rate following an unvarying non-progressive bone-loading home-based exercise programme, designed to improve strength, faulty posture, and co-ordination (Kerschan et al., 1998). Some previous exercise trials have not found a significant decrease in risk of falls, even when there has been improvements in some of the measured risk factors such as strength (Hornbrook et al., 1994, Buchner et al., 1997), or postural hypotension (Millar & McMurdo, 1999).

The need for specificity was seen in a large series of randomised, controlled trials called the FICSIT programme (see Piotrowski Brown in this issue, Province et al., 1995). Seven USA sites addressed the effects of interventions on the rate of falls. Each site used different combinations of intervention, some used exercise, others made modifications to other risk factors (i.e. environment, medications), some did both. Tinetti and colleagues (1994) used a range of interventions including falls assessment, medication review, exercise, and assessment of risks in the home, to reduce several risk factors for falling and succeeded in reducing both the fear of falling and actual falls by 30%. When all the FICSIT site interventions were pooled the exercise groups had an estimated 10% lower risk of falling than the control groups. When allocated into categories of exercise intervention (balance, strength, endurance), the four sites that looked at balance training found a 25% reduction in the risk of falling (Province et al., 1995) and one site that looked at Tai Chi found that it delayed the onset of the first or multiple falls by 47.5%, significantly better than computerised balance training or no exercise (Wolf et al., 1996).

The specificity of training will, therefore, dictate the exercise response. Fall management requires a constant overload stimulus that stresses the systems involved in the control of balance, both static and dynamic.

Supervised sessions, home-based sessions, and telephone contact

No fall-related research has compared home and supervised sessions. Home exercise is effective if the safety concerns at the lack of supervision are adequately addressed. Campbell et al. (1997) used an individualised approach, with adequate initial instruction on exercise postures. They made telephone contact regularly to maintain motivation and monitor progress. At 1-year follow-up 42% were still doing at least three sessions of exercise a week.

The majority of effective exercise studies have used supervised sessions. Qualitative research on older people showed that the social aspects of a class format were a prime motivator for older exercisers (Finch, 1997). Belonging to a group seems to promote better adherence to exercise in the community following a research trial. A supervised class also seems to allow faster progression of training, greater individual feedback, a secure environment, peer support, an opportunity for social interaction, acceptable touching, and a reduction in feelings of isolation (Young & Dinan, 1994). The psychological and health benefits of a regular class environment should never be ignored in preference for a seemingly more cost-effective intervention (Young & Dinan, 1994, Nicholl et al., 1994). A class provides a valuable opportunity for weekly reporting back, and reinforcement of exercise technique and intensity, all of which help to sustain adherence and effectiveness of the home exercise sessions. The home exercise sessions are utilised as a method to maintain regularity of strengthening and flexibility exercises.

It seems sensible to utilise both home and supervised sessions to enhance effectiveness, safety, and adherence in a falls management strategy. Telephone support may also be important in the early days of the programme.

Reducing the risk of falling during exercise

The foremost worry for any health professional working with unstable older people is that the person falls whilst exercising. A recent trial considering the effect of brisk walking on osteoporosis found that the cumulative risk of falling while walking was higher in the intervention group (Ebrahim, Thompson, Baskaran, & Evans, 1997). Qualified, experienced exercise practitioner supervision together with a graded strengthening

and walking programme prior to commencement of walking outdoors may contribute to better outcome measures.

For many older people, fear of a further or more injurious fall tends to constrain movement and may limit exercise gains during a supervised class. One method of reducing injury risk during supervised and unsupervised sessions is the use of the hip protector underwear SAFEHIP ©[1]. Hip protectors have been shown to reduce hip fractures by 50% in nursing homes but were worn infrequently (Lauritzen, Petersen, & Lund, 1993). A new design of hip protector has shown a better user rate of 73% in orthopaedic patients aged 74 and over in Denmark (Lauritzen, Hindsø, Askegaard, & Sonne-Holm 1996). They are also effective in a community setting (Villar et al., 1998). However, their use in allowing safer, more effective exercise in a supervised environment is one that is not being adopted to full potential, considering the confidence they give to the teacher and the exerciser to work harder. Currently, within the FaME programme, about 70% of the women wear hip protector pads during the exercise sessions.

Another way to reduce risks and fear during exercise is to work in a low-risk environment. One study looked at exercise in water (Simmons & Hansen, 1996). They considered two exercise groups, one "water-based" and one "land-based" both of which exercised for 5 weeks. The "water-based" group increased their functional reach to a greater extent than the "land-based" group (Simmons & Hansen, 1996), probably because of the increased confidence and reduced fear of a fall allowing larger, more dynamic movement during the exercise. Water-based exercise can greatly reduce risk and anxiety, changing water depth can allow progression of resistance, and warm water increases muscle efficiency (Lord, Mitchell, & Williams, 1993). But adverse elements such as inability to swim, pools that are too noisy and/or too cold for comfort, slippery pool sides and inadequate safety on entry into and exit from the water, may render this option inaccessible for many in this vulnerable group (Finch, 1997).

Tai Chi is another way of increasing confidence by reducing fear of falling (Wolf, Barnhart, Ellison, & Coogler, 1997). This may be due to its combination of safe, tranquil, achievable, low impact moves, improved breathing patterns, and increased feeling of well-being (Kutner et al., 1997).

Balance training

Balance training has been shown to be more effective than a general exercise class at reducing the risk of falls (Province et al., 1995). Tai Chi, in addition to offering safety and fear reduction, appears to be extremely effective at enhancing postural stability (Wolf et al., 1996, 1997; Wolfson et al., 1996). Tai Chi-based exercise may be effective for a number of reasons. Forrest (1997) showed that following Tai Chi training there is "counterintuitive reduction in anticipatory postural adjustments and greater stability of standing posture". Forrest interpreted this as a greater use of the elasticity of the peripheral structures (involving muscles, ligaments, and tendons). Tai Chi has also been shown to delay the onset of the first or multiple falls, it does not, however, appear as efficient as computerised balance training at reducing sway (Wolf et al., 1997).

The three-dimensional continuous, controlled, repetitive nature of the Tai Chi movements, together with the change of head and eye position and weight transference may be significant in improving postural stability. It should also be noted that these specific components of movement are also seen in Hatha Yoga, Chi Kung, and slow dance sequences (adage).

The growing interest in Tai Chi must be tempered with caution. To be most effective Tai Chi should be considered as part of a comprehensive falls management strategy rather than being advocated as the only exercise form. Ideally, Tai Chi teachers, like all exercise practitioners, should be trained and experienced at adapting the moves for older people and, when working with fallers, should have awareness of the safety issues relating to this vulnerable group. Health professionals should ensure that current exercise warm-up and cool-down guidelines (American College of Sports

[1] SAFEHIP hip protector pads, Robinsons Health Care, 01246 220022

Table 1
Exercise training strategies

Fitness components	Programming guidelines
General population	
Strength/power/bone	Qualified instructors
Endurance	Effective: intensity, duration
Flexibility	Regular
Balance/co-ordination	Specific
	Balanced
	Individually tailored
	Progressive
	Educational
	Enjoyable
	Active lifestyle approach
Older people	
All of the above plus targeted exercise	
Bone loading (main fracture sites)	Specialist instructors
Functional, postural, and pelvic floor muscles	Home-based programmes
Co-ordination, balance, and reaction time	Utilise touch
Body management in everyday situations	
Correction of muscle imbalance and asymmetry	
Relaxation techniques	
Opportunities for socialisation	

At any age, the aim of a Physical Training Programme must be to achieve a training effect. To do this it must include all the components of fitness and follow recommended programming principles.

Medicine Position Stand, 1998a) are being observed and additional strength, stretching, balance, and bone-loading work are advocated.

COMPONENTS OF THE FaME PROGRAMME

The FaME programme includes the basic fitness components and programming adaptations that would be seen in any seniors'exercise class (Table 1). In addition, however, there are specific, progressive falls management strategies that attempt to bring together the evidence in a comprehensive programme (Table 2) whilst ensuring that safety and comfort have the highest priority. These strategies could easily be included in specialist seniors' sessions once disseminated to appropriate health and exercise professionals. A glossary of technical terms is to be found in Box 1.

The programme utilises a combination of supervised group and self-directed home-based sessions supported by structured telephone

Table 2
Exercise training strategies for accident prevention

Falls management in older people	
All the Fitness components and principles for older people plus progressive programming of	
Tai Chi adapted moves	Specialist falls management instructors
Open, closed, and backward chain exercises	Balance of supervised home-based sessions
Functional and floor work	Telephone follow-up
Postural and gait training	Pre-/post-fall coping strategies
Supported balance work	Accident prevention education
Supported endurance work	Opportunities for falls specific group discussion/ feedback
Tasks to improve kinesthetic awareness	`Befriender' system
Tasks to improve visual, vestibular, and sensory input	Liaison with physiotherapist and primary health care professionals
Wide variety of static and dynamic balance	
Confidence building	

Box 1
Glossary

Fartlek training approach	A variation in pace, e.g. a burst of faster movement alternating with a passage of more moderate action, to avoid undue fatigue.
Compound exercises	Multi-joint exercises.
Bone-loading work	Weight-resisted exercises, e.g. weight training, impact work, etc.
Functional floor capacity	Exercises to increase floor confidence, e.g. crawling, getting up and down, fitting a plug, cleaning the skirting boards, etc.
Periodised	Programmed progression over period of time using specified increments and combinations of intensity.

contact. The home-based sessions are aided by an exercise booklet (taking exercises from two specific books: Skelton, 1998; Sharp & Dinan, 1996) in large print with illustrations of the correct technique for each exercise. Each exercise is taught and checked for correct technique during the supervised class. Qualified specialist seniors' teachers with additional falls management training, together with Hip Protectors worn during the class, were considered essential to keep risks to a minimum. Quality and consistency is assured through regular monitoring and training by research staff.

The programme aims to provide repeated, varied, progressive opportunities to integrate the balance systems. The exercise strategies have evolved around a four-point plan to:

1. Increase balance.
2. Increase functional capacity.
3. Increase bone and muscle mass.
4. Increase confidence (reduce fear of falling).

The progression is arranged in the three phases, which have been named:

1. "Skilling up"—weeks 1–11.
2. "Training gain"—weeks 12–33.
3. "Maintaining the gains"—weeks 34–38.

The names of the phases act as indicators to the exercise content, programming principles, and ongoing assessment of each individual's progress. These guidelines (see Table 3) are, however, only guidelines and careful attention is paid to individualising or "fine tuning" the programme to meet the diverse levels of ability, medical conditions, and exercise and training response found within the study subjects.

Although balance, strength, flexibility, and movement training are the core of the programme, specific low-impact endurance training is included. This is not only because of the health benefits of reduced cardiovascular risk, decreased risk of postural hypotension, improved energy, vitality and sleep, and possible reduction in the need for medication (Dinan & Messent 1997), but also because the authors feel it has specific balance assets such as improving gait, motor control, reaction times, dynamic body management, range of movement, and self-confidence.

Warm-up/endurance/cool-down

The FaME programme, whilst falls-focused, attempts to take into account special considerations necessary for working with vulnerable older people (see Table 4) (Young & Dinan, 1994), and also staying comfortably within the American College of Sports Medicine's (1998a) guidelines for cardiovascular exercise for older people.

As with all seniors' sessions, adaptations to structure and content are important for the safety of the participants. These include a longer warm-up and cool-down period; greater variation of pace; the integration of stretches with strengthening exercises to give active rests; and the extensive use of supported balance work. Further examples of adaptation are the exclusion of steps with a high risk of falling (e.g. cross-steps);

Table 3
Progressive Falls Management Programme

"SKILLING UP"	
Weeks 1–2	
Aim	To improve neuromuscular function, technique, and safety during exercise
Equipment	Chairs and theraband (elastic resistance bands)
Warm-up	18–20 minutes (including stretches and rewarmer)
Workout and cool-down	15–20 minutes (including chair walking, local muscular endurance, seated and chair supported sway work, seated flexibility for selected muscle groups and Tai Chi)
Weeks 3–11	
Aim	To improve progressively neuromuscular adaptation, lower and upper limb strength, postural alignment, and gait technique
Equipment	Chairs and harder resistance therabands, hands balls, and large soft footballs, mats
Warm-up	15 minutes (including standing work and stretches, pelvic mobility, additional flexibility stretches)
Workout and cool-down	20–30 minutes (including strengthening for quadriceps, hamstrings, gluteals, abductors, erector spinae, transverse abdominus, ankle dorsiflexors, and supraspinatus plus supported standing, functional (e.g. sit to stand); increasing intensity and duration of supported endurance work and/or dynamic balance, weight transference, walking forwards, marching to change direction, side stepping, functional reach in sitting, hand–eye co-ordination, standing Tai Chi basics, and relaxation)
Demonstration	How to get up off the floor safely
"TRAINING GAIN"	
Weeks 12–23	
Aim	To improve functional ability through progressive resistance and flexibility training, dynamic balance and sensory input, transition to free standing, and travelling
Equipment	Chairs (same as weeks 3–11, harder resistance bands, hand-weights and large balance ball, steps)
Warm-up	15 minutes (including standing work, chair, and standing stretches)
Workout and cool-down	35–45 minutes (including circuit, speed play, Fartlek "big body movements", longer stride, faster pace shuffle walking, quarter turns, lunges, step on and off and backwards, sensory stations, introduce floor activities in stages, progress weights to muscle failure where possible, developmental stretches, Tai Chi)
Demonstration	Safe, effective floor work principles
Weeks 24–33	
Aim	To improve transition to multisensory skills, further increase strength, improve/maintain bone density, improve functional balance capacity
Equipment	As weeks 12–23, harder resistance bands, heavier weights
Warm-up	As weeks 12–23
Workout and cool-down	35–45 minutes (as weeks 12–23 plus add repetitions/sets, skill challenges, walking backwards, different walking surfaces (e.g. mats), moving gaze and/or head while walking forward, increase step height, travelling lunges and squats, functional reach, balancing on a ball or standing, rolling, crawling in sitting and lying, forward, in reverse and sideways, post-fall strategies
Demonstration	"How to fall" is demonstrated but not practised. Recovery strategies are progressed
"MAINTAINING THE GAINS"	
Weeks 34–38 (and onwards)	
Aim	Transition to multi-sensory skills, maintain/increase muscle strength, and bone density, increase frequency, intensity, time and type of challenges
Equipment	As weeks 24–33
Warm-up	As weeks 24–33
Workout and cool-down	35–45 minutes (adding skill challenges, increasing moves, walking different surfaces (objects under mat), moving gaze and head while walking (in a line, circle, square) and squatting, increase step height, build step mountains, introduce incline walking, propulsive/rebounding/springing actions if appropriate; also "scramble" principle, games approach, line and diamond circuits, safe agility challenges, progress back extension work (i.e. four sets of at least five repetitions and prone functional abdominal work, functional reach on the move, standing resistance without chair, progress Tai Chi)
Fit talk	Future recreational exercise opportunities, link system with participants

Table 4
Special considerations for a "falling" group

Considerations
More individualised
More progressive
Focus on compliance vs. intensity issues
Injury prevention the highest priority
Continual skilled observation—watch for dizziness, overheating, undone laces, misalignment
Hazards—more attention to environment
Protection—chairs, mats, and hip protector pads
Class location and facilities
Practice emergency procedures (who calls 999, fire escapes, ice packs, etc.)
Know fall, fracture, cognitive impairment, and cardiovascular status
Constant feedback on change of health and exercise effects
Social interaction, peer support and "fall management" talks
Fall and fracture additional teacher training essential

biomechanically unsound exercises (e.g. abdominal curl ups); and longer time in the seated position following prone or supine lying to allow for regulation of blood pressure.

In every phase of the programme, the warm-up starts with mild, rhythmical, low-tension walking either standing or chair-based prior to mobilising the joints, rehearsing skills, and increasing demand on the heart and lungs before finally stretching the muscles. Particular care is taken to rewarm at a slightly brisker pace after the stretches and before the endurance and resistance training begins. Cool-down consists mainly of slow rhythmic exercises to preserve venous return as muscle and skin vasodilatation gradually return to resting levels, but also incorporates held stretches, sway and other balance training methods, functional activities, additional chair and floor body management exercises and, finally, an adapted Tai Chi sequence. Many of the activities relate closely to lifestyle and to maintaining independence. Longer recovery time is given to remobilising activities at the end of a class to reduce the risk of a post-exercise fall.

In addition to these adaptations specific to seniors, there are falls-management design modifications. Initially, in weeks 1–3, the majority of the warm-up, cool-down and endurance training is performed on a chair and then as the groups "skill-up" (Table 3), longer standing sections are added. The standing endurance work is significantly adapted, being chair or wall supported at first; participants are encouraged to work with two hands supporting, then one, then fingertips and finally, after perhaps months for some, to work without support but with the chair still well within reach. Low impact moves form the basis of the endurance training, e.g. controlled knee lifts (raising the foot 1–2 inches off the floor initially and increasing the range to 90° hip flexion as skill improves), marching on the spot, hip extension and abduction, marching away from and back to the chair and, finally, once confidence and skills are improved, backwards walking. Lateral moves such as side-steps are used as soon as possible to increase proprioceptive input from the hip joints. Although the full range of options is demonstrated, the teacher performs mainly the lower option to motivate less able participants. The exercises are performed at circuit stations arranged in lines, rectangles, circles, and semi-circles as well as the more traditional group format of the teacher sitting at the front of a class. A Fartlek training approach (speed play) is utilised to accommodate the lower anaerobic thresholds found in older people. This allows participants to continue for longer without undue fatigue (Table 5, Box 1).

The transition to free-standing and/or partial support whilst performing dynamic travelling moves is viewed as a significant progression, i.e. a "training gain" (Table 3). When first introduced, intensity and duration will almost invariably need to be adjusted for a week or two until confidence, stability, and endurance are restored. Endurance training progress continues in the final "maintaining the gains" phase through the use of an increased variety of pace, intensity, transition, spatial and floor patterns, and the inclusion of travelling compound exercises (e.g. squats) to challenge dynamic balance as well as endurance.

An endurance training range of 55–70% of heart rate reserve (HRR), three to four times a week, for 5–20 minutes is recommended by the American College of Sports Medicine (ACSM) (Table 5) for older adults. It is generally acknowledged that with the levels of deconditioning and frailty found among many older people in general, and fallers in particular, together with the fact that

Table 5
Resistance training and endurance guidelines as part of the Falls Management Programme

"Skilling up"		"Training gain"
Initial intensity	Progressive intensity	Progressive intensity
Approximately 4–6 weeks No muscle failure 12–13 RPE * (somewhat hard)	Approximately 7–11 weeks No muscle failure 14–16 RPE* (hard)	Approximately 12 weeks onward To voluntary muscle failure 14–16 RPE* (hard)
Low to moderate intensity Approximately 45–60% MHR 10–11 RPE* (light to moderate)	Moderate intensity Approximately 55–70% MHR 11–13 RPE* (moderate to somewhat hard)	Vigorous intensity Approximately 55–80% MHR 14–16 RPE* (hard)

Particular care is taken:
- When performing knee extensions or exercises that use the rotator cuff, particularly shoulder abduction, also when progressing to higher workloads and new exercises.
- To ensure leg strength is established prior to free standing lunge and squatting actions
- To ensure safe content (e.g. cross steps, pivot turns, high impact work are excluded)

Towards the end of the study some medium impact, "propulsive", "rebounding" and "springing" or heel drop activities may be included only if adaptation has occurred, technique is maintained and there is no contraindication (e.g. arthritis, hip replacement, etc.)
Adapted from American College of Sports Medicine Position Stand (1998a and 1998b)
MHR, maximum heart rate, RPE, rate of perceived exertion.
* Borg, 1982.

many older people are newcomers to exercise, an even lower starting point may be advisable (Table 5). Intensity of both resistance and endurance is monitored through rate of perceived exertion (RPE), a self-assessment scale that accommodates the greater individual variation in heart rate response to exercise and to training that results with the ageing process (Borg, 1982). With training in the use of the scale a person learns to listen to and act on their body's responses to exercise. The endurance programme aims for an RPE of around 10–11 (light to moderate) for the first 6 weeks, then 12–13 (moderate to somewhat hard) up to 11 weeks, and then 14–16 (hard) in subsequent weeks (Table 5).

Resistance training

Guidelines produced for physiotherapists and occupational therapists working with older people who have fallen suggest strengthening the muscles around the hip, knee, and ankle. (Simpson, Harrington, & Marsh, 1998; Simpson, Marsh, & Harrington, 1998). Campbell et al. (1997) trained the hip extensors and abductors, knee flexors and extensors including inner range quadriceps, ankle plantarflexors, and dorsiflexor muscles. The authors felt that certain additional muscle groups were important for a combination of postural control, improved gait and respiratory function, functional floor capacity, and targeted bone loading work. This includes specific strengthening work for the erector spinae (sacrospinalis), trapezius (upper, middle, and lower), rhomboids, latissimus dorsi, abdominals (rectus abdominus, internal and external obliques, and, in particular, transverse abdominus resulting in co-contraction of the multifidus muscle), iliop psoas and piriformis, supraspinatus, triceps (at different rates of contraction), and wrist extensors and flexors.

Strength-training progression must be slow initially to avoid excessive muscle discomfort (especially in the early stages of exercise), to allow time for muscle and soft tissue adaptation, and to avoid demotivation (Kramer & Harman, 1998). Fallers often have such low baseline strength that gains will be apparent quickly, so although the ultimate goal is to use heavier loads (to activate the high threshold motor units important to muscle power), it is important to progress slowly and increase duration between sets and sessions if soreness is reported.

A starting point of one set of 10–15 repetitions of 8–10 exercises, performed two to three times a week at 30–40% of one repetition maximum (1RM) is recommended by ACSM (Table 5) for

older adults. To promote adaptation and decrease the risk of injury, older adults just beginning an exercise protocol should stop after 10–15 repetitions without going to voluntary muscle failure. After 12 weeks of training the participants can begin to progress to voluntary muscle failure unless they are unable or unwilling. Two or three set protocols are used to target specific areas.

The FaME programme is periodised in a non-linear way as the variation in intensity and volume allows for greater fun and better recovery from higher levels of fatigue than a programme periodised with a set intensity and volume (linear) (Box 1). Progressive resistance elastic bands (which appear more acceptable, at the start of a regimen, than free weights to sedentary older women) are used throughout the programme with a transition to hand weights for upper body exercises in the "training gain" and "maintaining the gains" phases.

Technique and the importance of responding to day-to-day fluctuations in health, energy, mood and/or alertness are constantly emphasised as essential for injury prevention and gaining optimal benefits. The rate of perceived exertion (RPE) is again used as a guide to exercise intensity, the senior participants having been fully familiarised with its use in a resistance training context. The RPE should be around 12–13 (somewhat hard) for the first 4–6 weeks, then rise to 14–16 (hard) in subsequent weeks. Emphasis is constantly placed on being aware of the signs of a muscle reaching fatigue ("burn", ache, or loss of co-ordination). When isometric contractions are used to target particular areas (e.g. pelvic floor, vastus medialis, sacrospinalis, supraspinatus, transverse abdominus, and wrist extensor and flexor work) it is advisable not to hold contractions for more than 5–6 seconds as participants tend to hold their breath at the same time. This can lead to a sudden, sharp rise in blood pressure. They are reminded not to hold their breath, and are encouraged to count out loud, an effective way of counteracting this tendency.

Additional home practice exercises are recommended to any women with poor ankle dorsiflexion or plantarflexion, poor foot response, or poor movement control in response to instruction.

Multiple-task practice, co-ordination and reaction speed

One of the strong predictors of fall status is the test "stops walking when talking" (Lundin-Olson, Nyberg, & Gustafson, 1997). Obviously, multiple tasks performance becomes much harder with disuse, older people tend to avoid doing more than one thing at once. Indeed, one study showed that those people taking significantly different times to perform the timed up and go and then the timed up and go carrying a glass of water were more prone to falls (Lundin-Olsson, Nyberg, & Gustafson, 1998). In our opinion the only way to retrain multiple task performance is to practise it; even the most unlikely skills such as patting the head and rubbing the tummy at the same time, become possible with practice. Even in the "skilling-up" section, where basic techniques are being mastered and the work is relatively simple, we deliberately bombard the exercisers with multiple tasks during the session. For example, whilst on a circuit walk around the room the teacher might ask all the women to catch up to someone in front of them and say hello, or to clap every five steps, or to stop, turn and look to their left, then ahead, then to their right, and then walk on. Progressively challenging multiple tasks are filtered into the class over a couple of months to assess progress whilst at the same time taking care never to overstress the exercisers or make them feel uncomfortable within the class. The multiple task practice is combined with specific exercises to enhance reacquisition of motor skills, co-ordination and reaction speed, especially hand–eye and foot co-ordination.

Functional floor work

Functional floor work is an essential component of the FaME programe. The mat work is a combination of sequenced rolling, curling, crawling actions in sitting, lying and, wherever possible, the all-fours position. Tasks such as getting from lying to sitting and sitting to lying are broken down into small segments that are practised and then put together and practised repeatedly. Moves are performed forwards, in reverse, sideways, and in specific floor patterns. For those for whom this is not

appropriate, chair options are provided. The floor-based activities also include strengthening exercises (see section on resistance training) and a sequence of stretches (in supine, full body, hamstrings, tensorsascia lata; in prone, quadriceps and functional abdominal work).

Techniques of lifting, reaching, stepping on and off curbs, and negotiating progressively challenging obstacle courses are discussed, learnt, and practised in a safe environment. Explicit and constant cross-reference is made to everyday life and how to incorporate certain exercises into daily activities. A neutral, lengthened spine, static abdominal contractions, and a heel through to toe brisk walking action are weekly reminders that seem particularly effective in motivating practice between supervised sessions.

Flexibility, posture

Flexibility (range of motion) and postural control is emphasised during all training phases. The aim is statically to stretch key muscles (e.g. hamstrings, rectus femoris, and iliop psoas, gastrocnemius, soleus, pectoralis major, external and internal obliques, and latissimus dorsi) three times in the course of the session. Daily, chair-based stretching is advocated and although initially all stretches are held for 8–10 seconds, longer, developmental stretches (10–30 seconds) are introduced during the cool-down of the "training gain" phase.

Balance and gait

Campbell et al. (1997) used balance tasks such as walking heel to toe, walking on heels, walking backwards, and sideways, and turning, bending, stair climbing (where stairs were available), and standing flexibility work. In the FaME, specific balance challenges are introduced towards the end of the "training gain" phase. These include closed chain exercises on progressively unstable surfaces; reaching forward while sitting on a chair then while sitting on a large balance ball, and finally while standing. There are obstacle courses with changes in surface, height, pace and even lighting, walks on a straight or curved line with a glass of water and, if possible, the ultimate challenge, walking backwards without spilling a drop! The "maintaining the gains" phase concentrates on challenging the visual, somatosensory, and vestibular mechanisms of balance to improve the righting reflexes, spinal reflexes, and kinesthetic awareness (Table 3). Home-based exercise is extended with the introdution of the Cawthorne-Cooksey regime of head exercises for vestibular rehabilitation (Dix, 1979). With age, a person is less likely instinctively to know where their body is in space and this may be why the integrated approach to balance training through Tai Chi (with its controlled, flowing, repetitive, three-dimensional weight transferences and head and gaze alterations) has been so effective in falls management trials. For study purposes we have adapted the first sequence of Tai Chi Chuan Yang Style long-form.

Balance improvements can also be made by placing elastic resistance tubing around the waist while engaged in a normal activity such as reaching for a ball. This obviously needs to be done on a one-to-one basis and works well in improving skill and confidence. Any asymmetry can be corrected by gently pulling the tubing in an opposing direction to stimulate the balance mechanisms.

Gait training is approached in a number of ways. These include correction of walking technique during endurance work; specific, controlled mobility work for the pelvis (rotation; anterior, posterior and lateral tilting; pelvic clocks, etc.); as well as specific strengthening and stretching exercises (e.g. gastrocnemius and ankle dorsiflexor, etc.) referred to earlier. These activities are done in standing, sitting, and lying positions. Coaching focuses on increasing stride length and improving postural alignment, rhythm, and efficiency.

Teachers

For the purposes of the study, the teaching team are experienced, senior specialist teachers with over 20 hours additional training on the needs of this vulnerable group. Training is revised before progression to the next programme phase or on participants' request, such as when one group is progressing quickly or specific concerns arise. Quality assurance visits ensure the content is consistent and sufficiently challenging.

Group discussion about any recent falls is encouraged within the class. Specific exercise advice is given by the teacher, if appropriate, to aid recovery.

Evaluation Study

The Falls Management Exercise (FaME) Programme described in this paper is currently being evaluated in a research trial being conducted at Imperial College School of Medicine, London. The study volunteers are community dwelling women, aged 60 and over, with a history of three or more falls in the previous year. Participants act as their own controls passing through three stages of the study: a 10-month control with prospective fall data collection, followed by a 10-month intervention (the FaME programme), and finally, a 10-month follow-up period. The programme had to be designed to encompass the range of baseline fitness and mobility levels. It also had to maximise confidence and compliance in a group wary of any activities that may lead to a fall. Although this programme is part of a research trial, the principles are sufficiently practical to be applied at local level through appropriate collaboration between primary care, health promotion, and exercise professionals.

CONCLUSION

With research suggesting that only 11% of carers implement environmental modifications recommended by occupational therapists after a 30-minute fall risk assessment in a faller's own home (Buri, Shaw, Dawson, & Kenny, 1999) there is a need to encourage other strategies such as correctly targeted, specific, and progressive exercise interventions.

This paper describes the tailored, progressive falls management exercise protocol (FaME) that is being used in a long-term follow-up trial of the effects of specific exercises on falls and fall-induced injury in older women at imperial College School of Medicine at St. Mary's Hospital. The rationale for the specific nature of the exercise regimen is sound but as the trial is still in progress the exercise regimen itself still has to be proved effective. The subjective reports are, however, encouraging. At the time of writing this paper, some 30 women were entering the "training gain" phase of the trial and 70 women are due to start the "skilling up" phase over the next 10 months. Subjective reporting from both teachers and participants indicates improved gait, balance, confidence, correction of trips and slips without falls, and reduced anxiety about falling. To date, there have been no falls in either the supervised or home exercise sessions.

This rationale for an exercise programme for falls management and the exercise protocol itself is presented as a discussion point for further debate.

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