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Exercise and injury prevention in older people

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This review aims to provide the reader with up to date evidence in relation to the role of exercise in the reduction of risk factors and the prevention of falls and injuries. Falls and injury may lead to a spiral of inactivity and decline that take older people close to or below the critical "thresholds" of performance necessary for everyday activities. Yet, low strength and power, poor balance, poor gait and functional ability, and fear of falling are all risk factors for falls modifiable with tailored exercise. Although the evidence on types, amounts and specificity of exercise to prevent falls is not complete, recommendations have been published that have been effective, either as an exercise stand-alone intervention or with exercise as part of a multifactorial intervention. It is clear that the target population must be at risk or already fallers, they must be "not too fit" and "not too frail". Supervised home-based exercise programs may be effective in those aged over 80 because they fall more frequently, injure more easily, and recover more slowly. In younger, community-dwelling, fallers multifactorial group interventions including targeting of balance, strength, power, gait, endurance, flexibility, co-ordination and reaction may be more effective. There are, however, research questions that still need answering – whether there are certain types of exercise harmful in certain subgroups of older people, what is the ideal intensity, frequency and duration of exercise for different subgroups of older people (primary and secondary prevention) and the relative value of the different components of fitness to prevention of falls and injuries. This review highlights the necessity of tailored, specific balance and strength exercise in the multidisciplinary prevention of falls and injuries.

This review aims to provide the reader with up to date evidence in relation to the role of exercise in the reduction of risk factors and the prevention of falls and injuries. A third of people aged 65 and over and a half of those aged 80 and over fall each year (Feder, Cryer, Donovan, Carter, 2000). Without effective intervention, demographic trends alone will result in substantial increases in the number of falls, falls injuries, and fall-related deaths amongst older people (Kannus, Niemi, Parkkari, Palvanen, Vuori, Jarvinen, 1999) and presently there appears to be a rise in prevalence of hip fracture over and above the expected rise in number of older people (Grimley-Evans, Seagroatt, Goldacre, 1997; Kannus et al., 1999). A fall and/or injury can have a devastating effect on the individual's independence and quality of life, often leading to a spiral of inactivity and further decline. The consequences of falling include injury (the most serious of which is fracture of the proximal femur), fear of falling, decreased activity, functional deterioration, social isolation, depression and reduced quality of life, institutionalization, and death (Gregg, Pereira, Caspersen, 2000; Lord, Sherrington, Menz, 2000). Nearly half of nursing home admissions are due to falls and postural instability and 80% of over 80s would rather be dead than suffer the loss of independence that a hip fracture and subsequent nursing home admittance may bring (Salkeld et al., 2000).

Falls in the over 65s account for over 10% of the total London Ambulance Service workload, though nearly 40% are never admitted to hospital (Halter, Close, Elrick, Brain, Swift, 2000). For many a "long lie" has occurred, some of the difficulty of rising from the floor may be due to shock or injury but for many it is simply lack of fitness (Skelton & Dinan, 1999). Being unable to rise from the floor is an intrinsic risk factor for complications following a fall. Risk factors for falls have been classified into two types: intrinsic and extrinsic factors (Feder et al., 2000; Lord et al., 2000).

Intrinsic risk factors, i.e., traits of an individual that increase their risk of falling, are more important among the older groups, e.g., people aged 80 and over (Luukinen, Koski, Hiltunen, Kivela, 1994). Extrinsic factors are social and physical factors that relate to the external environment. Falls among older people under 75 are more likely to be due to extrinsic factors than for those aged 75 and over (Feder et al., 2000; Lord et al., 2000). As the majority of falls in the

home-dwelling elderly takes place during periods of maximal activity (Luukinen et al., 1994), there may be a U-shaped relationship between the amount of physical activity and the number of falls, with a higher incidence of falls in the least active and the most active as suggested in one study (Gregg, Cauley, Seeley, Ensrud, Bauer, 1998). However, in contrast the age-adjusted risk of hip fractures may be up to 40% lower in the most active compared with the least active people (Gregg et al., 1998).

Fear of falling is also a risk factor for falls and for injury. Prevalence of fear of falling ranges from 29 to 55% in the home dwelling elderly and may be as high as 50–65% among people who have previously fallen (Tinetti, Mendes de Leon, Doucette, Baker, 1994). Prospective studies have shown that fear of falling, and loss of confidence in balance capabilities, predict deterioration in physical functioning (Arfken, Lach, Birge, Miller, 1994; Vellas, Wayne, Romero, Baumgartner, Garry, 1997), decreases in activity, fractures (Arfken et al., 1994), and even admission to institutional care (Vellas, Cayla, de Bocquet, Albarede, 1987; Cumming, Salkeld, Thomas, Szonyi, 2000). Fear of personal injury is often cited as a reason for people not taking part in regular indoor and outdoor physical activity (Finch, 1997).

Whilst it is acknowledged that some risk factors are not modifiable (i.e., age, gender, social class, chronic medical conditions, irreversible vision problems), others, such as physical activity, environment and the effects of medication, can be positively influenced through appropriate education and intervention (American Geriatric Society et al., 2001). Other modifiable risk factors include low strength and power, especially in knee extension and ankle dorsiflexion (Whipple, Wolfson, Amerman, 1987), asymmetry between lower limb power (Skelton, Kennedy, Rutherford, 2001), fear of falling, poor balance (Skelton et al., 2001), poor gait and functional ability, postural hypotension, urinary urgency and incontinence, depression, and multiple medications (Lord et al., 2000) (fig. 7).

Sarcopenia and power in old age

The maintenance of physical performance as we age is important not only to prevent a fall but in the event of a fall, to have the functional capability to get up from the floor, and in the long term, repair from injury and regain confidence and independence. Ageing is associated with loss of muscle mass (sarcopenia) with a corresponding reduction in maximal muscle strength (Lindle et al., 1997). Sarcopenia occurs even in fit, athletic elderly adults who continue to lose lean mass and muscle mass despite retaining functional status (Harridge, Magnusson, Saltin, 1997). However, some age related changes that were once thought to result solely from aging are now known to be the result of disuse and are therefore potentially reversible.

Muscle power may be even more important than maximal strength in older people. The ability to develop high force rapidly contributes to successful performance in activities such as rising from a chair, climbing stairs or regaining balance after tripping to avoid an impending fall. While cross-sectional data suggest that healthy women in their 70s retain 40–50% of the handgrip strength found in young adults (MacLennan, Hall, Timothy, Robinson, 1980) they may retain as little as 26% of the power, assessed by squatting jumps (Bosco & Komi, 1980). In 65–84-year-old individuals, isometric strength showed a decline of approximately 1.5% per year while the loss in power was approximately 3.5% per year (Skelton, Greig, Davies, Young, 1994). The decline in power is steeper than force because it is magnified by the loss of velocity due to the selective loss of type II fibres, and this is also consistent with the greater percentage loss of isokinetic torque at high speed with ageing (Harries & Bassey, 1990).

While greater strength is found among the physically more active (Rantanen et al., 1999) it is known that a few weeks of immobilization or disuse has a detrimental effect on muscle mass, muscle strength and power in young people (Appell, 1990; Bloomfield, 1997). The decrease in muscle strength is greatest during the first week of immobilization, 3–4% per day, and up to a 40% decrease in isokinetic muscle strength has been seen in young people after 3 weeks of immobilization (Appell, 1990). One of the main causes for this is the reduction of gravitational effect on the muscles. Especially, vulnerable to immobilization and inactivity are the antigravity muscles of the lower extremities and the faster type II muscle fibres (Bloomfield, 1997).

Bone in old age

Almost 90% of hip fractures result from the impact of a fall (Grisso et al., 1991). Hip fracture tends to occur only in 1% of falls, yet hip fractures account for a large proportion of disability, death and medical costs associated with falls. In 1990 there were an estimated 1.66 million hip fractures worldwide (Cooper, Campion, Melton, 1992) and the numbers are expected to reach 6.26 million by 2050. Wrist fractures are less common in the more elderly person with slower reaction times because they are less likely to extend an arm to break a fall. Spinal fractures can occur gradually and lead to a progressive loss of height and deformities. When immobilized, bone is not loaded and some degree of bone loss occurs: 27 days of bed rest has lead to the loss of 0.9% of bone mineral per week (Frost, 1990). High rates of inactivity in older people, especially those in residential or nursing accommodation will lead to an increased loss of bone with increasing age.

GUIDELINES FOR THE PREVENTION OF FALLS IN PEOPLE OVER 65 – Positive recommendations for exercise.

- Individually tailored exercise programmes administered by a qualified professional* reduce the incidence of falls in a selected high-risk group living in the community.
- Exercise programmes reduce the risk of falls in a selected group of older people with mild deficits of strength and balance living in the community.
- Tai Chi classes with individual tuition can reduce the risk of falls in older people.
- Programmes that combine interventions (multifaceted – most that include exercise) reduce falls.

**physiotherapist, nurse trained in specific one to one balance work (or an exercise instructor with seniors exercise and specific postural stability training for the older adult qualifications).*

Reproduced from Feder et al., 2000 with permission.
The guidelines are based on evidence from randomised controlled trials.

Fig. 1. Current guidelines on exercise in the prevention of falls.

Exercise to reduce modifiable risk factors

Decreasing physical capacity takes older people closer and closer to critical "thresholds" of performance necessary for everyday activities and maintenance of upright posture (Young & Dinan, 2000).

Strength and power

Studies have shown that muscle strength can be improved by high-intensity resistance training, even in the oldest old (Fiatarone, Marks, Ryan, Meredith, Lipsitz, Evans, 1990; Charette et al., 1991; Skelton, Young, Greig, Malbut, 1995). Muscle power is also improved within 12 weeks with strength training (Skelton et al., 1995). However, strength training studies in older people differ with respect to training intensity, volume, frequency and training period. One study with healthy elderly women found no difference in the amount of increase in dynamic strength after 12 months training with high-intensity (80% of 1 RM) and low-intensity (40% of 1 RM), respectively, when the total work was the same (Pruitt, Taaffe, Marcus, 1995). Some studies of low-intensity strength training have resulted in increased muscle strength in nursing home residents, frail elderly and elderly with comorbidity (McMurdo & Rennie, 1994; Lord, Lloyd, Nirui, Raymond, Williams, Stewart, 1996) but no or very little effect in healthy elderly (Jette et al., 1996; Krebs, Jette, Assmann, 1998).

Most resistance exercise studies have used three sets of each exercise, however, a review by Carpinelli et al. (1998) found no significant difference in the increase in strength (1 RM) or hypertrophy as a result of training with single vs. multiple sets in studies on younger adults where the training period was up to 25 weeks long. In contrast, in healthy elderly, Buchner, Cress, deLateur, Wagner (1993) found lower gains in thigh muscle strength (isokinetic torque) after 6 months training with one set of 10 repetitions compared to two sets of 10 repetitions (at the same intensity).

The training frequency has been three days per week in most resistance exercise studies using moderate to high loads (Frontera, Meredith, O'Reilly, Knuttgen, Evans, 1988; Judge, Whipple, Wolfson, 1994; Lexell, Downham, Larsson, Bruhn, Morsing, 1995; Ettinger et al., 1997; Brandon, Boyette, Gaasch, Lloyd, 2000) but the strength gains were not substantially lower in three studies that used a lower training frequency (McCartney, Hicks, Martin, Webber, 1995) or combined supervised training with home-exercise (Skelton et al., 1995; Skelton & McLaughlin, 1996).

The training period varies from 8 weeks (Fiatarone et al., 1990; Skelton & McLaughlin, 1996) to 88 weeks (McCartney, Hicks, Martin, Webber, 1996) but training periods of 12 weeks seems to be the most common in moderate to high-intensity strength training studies (Frontera et al., 1988; Charette et al., 1991; Judge et al., 1994). In contrast training periods of 22–25 weeks seems to be most common in training studies using light resistance combined with other training modes (Agre, Pierce, Raab, McAdams, Smith, 1988; McMurdo & Rennie, 1994; McMurdo & Johnstone, 1995; Lord et al., 1996; Krebs et al., 1998).

Bone

Some forms of exercise have been shown to be beneficial for slowing or reversing the age-related loss of bone (Rutherford, 1999). These include brief bouts of weight-bearing exercise such as intermittent jogging (Kohrt et al., 1995), exercise classes (Welsh & Rutherford, 1996) and also weight training using weights in excess of 80% of personal maximum (1 RM) (Kerr et al., 1996). However, walking alone does not increase bone density, merely helps maintain it (Rutherford, 1999). Epidemiological studies have shown that a lifetime's history of regular physical activity can reduce the risk of hip fracture by up to 50% and much of this benefit is thought to result from a reduction in falls (Law et al., 1991). A one 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).

Functional ability

Muscle weakness is one of the underlying mechanisms of poor function and it is documented that muscle strength correlates with several measures of functional status (Skelton et al., 1994; Morey, Pieper, Cornoni-Huntley, 1998). It would thus be reasonable to assume that an increase in muscle strength would lead to an improvement in function. However, improvements in strength do not always translate into improvements in daily functioning in all older people (Skelton et al., 1995; Keysor & Jette, 2001). Combining strength training with more functional training have resulted in more functional gains both in non-frail elderly (Lord et al., 1996; Skelton & McLaughlin, 1996) and frail elderly (Hauer, Rost, Rutschle et al., 2001).

Balance

One cross-sectional study shows close positive association with the amount of physical activity reported and postural stability in postmenopausal women (Brooke-Wavell, Athersmith, Jones, Masud, 1998). The period of life during which physical and sporting activities are practised seems also to be of importance (Perrin, Gauchard, Perrot, Jeandel, 1999). Recent periods of activity in over 60 years olds have greater beneficial effects on postural stability than activities performed only at an earlier age (30–40s). People who had only taken up physical activity after retiring had responses close to those who had always been active but were better than those who had become sedentary in their 30–40s or those who had never been particularly active (Perrin et al., 1999). Static balance can be improved within 8 weeks in older people with comorbidity (Skelton & McLaughlin, 1996) and sway and dynamic balance improved with gait and strength training (Judge et al., 1994; Lord et al., 1996) as well as Tai Chi and computerized balance training (Wolfson et al., 1996; Buchner et al., 1997; Wolf et al., 1997).

The need for specificity – dynamic balance training

Many general forms of exercise do not appear effective at reducing falls, even if they address certain risk factors (Gardner et al., 2000; Gillespie et al., 2001). A long-term (10 years) follow-up of regular walkers again showed the importance of specificity, for although the health and mobility 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 walking regularly (Pereira et al., 1998). Other trials considering seated exercise work (exercise bicycles, seated strength training) or forms of exercise that concentrated on strength or endurance rather than balance have also been shown to not be effective in reducing falls even if they address certain risk factors (Gillespie et al., 2001; Kerschan et al., 1998).

The need for specificity of training, and in particular the need to include balance training, was seen within a large series of randomised, controlled trials called the FICSIT programme (Province et al., 1995). The combined reduction in risk of falls for a series of seven exercise interventions was 10%. The four interventions that considered balance training decreased the risk of a further fall by 25%. The one intervention that considered Tai Chi (fig. 2) alone found that it delayed the onset of the first trip or multiple falls by half. However,

Fig. 2. A group of over 70s performing Tai Chi based exercise.

it should be noted that the effect of training on falls disappeared when trips were not included in the analysis (Buchner et al., 1997). Forrest (1997) showed that after Tai Chi training there is a counterintuitive reduction in anticipatory postural adjustments and greater stability of standing posture. The three-dimensional continuous, controlled, nature of the Tai Chi movements, together with the change of head and eye position may also be significant (Skelton & Dinan, 1999).

Exercise that works to reduce falls and injuries

Apart from the FICSIT trials (Province et al., 1995), other balance specific exercise programmes have been successful. An individually tailored and supervised year-long home-based programme of strength and balance exercises (twice per week) and 5 min walking (everyday) can reduce falls in women aged over 80 without a previous history of falls (Campbell et al., 1997). This trial originally involved Physiotherapists, then involved nurses leading the exercise session. The home exercise regimen concentrated on strengthening ankle and leg muscles, transfer skills and balance specific functional task practice, such as stepping over a slipper then bending down and picking it up, tandem walking and side-steps behind the chair. The programme has been shown to be effective in reducing risk of falls and injury in over 65s and is cost-effective in those aged over 80 (Robertson et al., 2001). Interventions targeting those aged over 80 may also see more significant changes to quality of life because they are targeting those who fall more frequently, injure more easily and recover more slowly. Perhaps in community dwelling younger fallers interventions targeting just strength or just gait (walking) may be less effective than those which target balance, strength, power, gait, endurance, flexibility, asymmetry, co-ordination and reaction and floor coping skills (fig. 3) (Skelton & Dinan, 1999). A recent randomised factorial controlled trial investigated the relative importance of a 15-week group based exercise programme, a vision check and treatment intervention, and a home hazard check and advice intervention, in preventing falls in community dwelling elderly people over 70 years (Day et al., 2002). This trial showed a significant reduction in falls risk in the exercise only group, while there was no reduction of risk in those people allocated the other two interventions. However, falls risk was reduced to a greater extent when people received all three interventions.

Although the evidence on types, amounts and specificity of exercise is not complete, recommendations have been published, based on current randomised, controlled trials that have been effective, either as an exercise stand-alone trial or with exercise as part of a multifactorial intervention (Feder et al., 2000; Gardner et al., 2000; Gillespie et al., 2001).

There are still many research questions that need answering (Tinetti, 1994), such as "are certain types of exercise harmful in certain subgroups of older people", "what is the ideal intensity, frequency and duration of exercise for different subgroups of older people" and the "relative value of different components of fitness to prevention of falls". Although there is evidence that strength training reduces disability in patients rehabilitating after proximal femur fracture (Mitchell et al., 2001) there is a need to further explore the use of exercise to reduce risk of further falls in particularly frail groups or indeed, before elective hip replacement.

Reducing the risk of falling during exercise

The foremost worry for any health professional working with older people with postural instability is that the person may fall whilst exercising. Indeed one trial did show an increased risk of future fracture with an outdoor walking programme (Ebrahim et al., 1997). It is recommended that people with a history of injurious falls are referred to specialists such as Physiotherapists, Occupational therapists or experienced Exercise Instructors qualified in working with

The Components of a holistic exercise programme for prevention and management of falls

COMPONENTS OF FITNESS TO INCLUDE:

- Strength / Power
- Balance / Postural stability
- Bone loading (weight resisted)
- Endurance / Gait
- Flexibility
- Floor work

BUT MUST BE:

- Regular
- Individually tailored
- Progressive
- Educational
- Enjoyable

NEED TO TARGET:

- Main fracture sites, bone loading
- Functional, postural and pelvic floor muscles
- Co-ordination, balance and reaction time
- Body management in everyday situations

AND ENSURE :

- Opportunities for socialisation
- Fun
- Specialist instruction
- Tai Chi practice

Adapted from Skelton & Dinan, 1999, with permission. Based on components of fitness from successful interventions (Province, 1995; Lord, 1996; Campbell, 1997; Wolf, 1997; Skelton, 1999; Robertson, 2001; Hauer, 2001) and reviews of major risk factors and interventions (Gillespie, 2001; Feder, 2000; Lord, 2000; Dinan, 2001).

Fig. 3. Holistic falls prevention exercise recommendations.

older people with a history of falls (Dinan, 2001). Failure to assess or account for an individual's condition in a structured exercise class puts them at unnecessary risk. The wearing of hip protectors during exercise could potentially reduce the risk, as they are known to be effective in the prevention of fractures when the person is compliant (Kannus et al., 2000). Moreover, the wearing of protectors appears to improve confidence in the person and the instructor (Skelton & Dinan, 1999).

Tai Chi has been recommended as "preventative" exercise for older people with mild deficits of strength and balance (Feder et al., 2000). The problem with blanket prescribing of Tai Chi to people with postural instability is that many Tai Chi classes are aimed at a younger population with better postural stability and better strength. Also, few practise current exercise warm-up guidelines or adapt the moves appropriately for older people. A frail older person will find this level of Tai Chi class too demanding and may well be at risk of a fall during the class. Tai Chi teachers should be trained or experienced with working with older people and should adapt the class to progress slower and to improve strength and balance before the more demanding moves of Tai Chi are applied (Skelton & Dinan, 1999).

Conclusion and perspectives

Through all the inconsistencies regarding mode, frequency and intensity of training – there remains one clear fact – muscle function and fitness are essential to an independent life. Physical activity must be specific to it is purpose. To improve health and modify certain risk factors for falling (such as strength and balance), moderate physical activity is appropriate. To reduce falls the activity should include training in balance, strength, co-ordination and reaction times but to reduce fractures, weight resisted exercise is necessary (Skelton & Dinan, 1999; Gardner et al., 2000).

Prevention of a first fall and future falls can be influenced by community exercise opportunities, provided

that they are accessible, quality assured and, where appropriate, multidisciplinary, to allow re-referral back to the therapy setting. For those who have fallen, the physical risk factors for falls can be modified with graded, progressive, individually tailored, evidence-based and enjoyable exercise programmes, supervised by appropriately qualified exercise professionals. With the increasingly older population this must be a priority for all health providers, age-related agencies and health and fitness professionals working with older people.

Key words: exercise; balance; falls; risk of falling; fall prevention; injury prevention; aged.

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