

Role of physical activity in the prevention of falls and their consequences in the elderly

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Abstract This work aims to provide an inventory of the risk factors and consequences of falling in the elderly, namely fractures, and to identify strategies to prevent falls and minimise their effects. Falls in elderly people are a major cause of injuries, leading to a general fear of falling, poorer quality of life and even death. The increase in life expectancy brought by developments in the medical and health sciences has not always brought enhanced quality of life. More elderly people live with reduced functional capacities resulting in a higher prevalence of falls and associated problems for themselves and for society. Risk factors for falling, commonly resulting from normal aging processes, have already been identified through multiple studies. Exercise may play an important role in fall prevention and their consequences. Although, effective strategies are usually multi-disciplinary and focus simultaneously on several risk factors. However, only large-scale prevention programmes can have significant effective social impact. To minimise occurrence and consequences of falls, policies to systematically implement prevention programmes should be established.

Keywords Falls · Risk factors for falling · Elderly · Fractures · Physical activity

Problems of falls

Falls are a major health problem among the elderly. Thirty percent of people aged 65 and older living in community fall at least once a year [127], and this rate increases with age [108]. As life expectancy increases, there is a higher number of less healthy and less fit elderly people living longer with their infirmities [46, 89, 107]. Consequently, the risk of falls and their consequences is now greater than before [78, 129], as is illustrated by statistics from Finland [75].

Falls are the major cause of death related to mechanical injuries in the elderly, and the mortality rate increases when the individual fall rate increases [41, 45, 112]. According to Rubenstein et al. [119], about 4% of falls result in fractures and about 11% result in other serious injuries such as head trauma, soft tissue injuries and severe lacerations. Those who survive falling commonly restrict their activities due to soft tissue injuries and fractures [15, 80]. Besides injuries and more evident physical consequences, psychological consequences must also be considered: the fear of falling leads to a large percentage of the elderly individuals restricting their activities [22, 48, 130, 137]. Both of these reasons for loss of functionality can result in the “post-fall anxiety syndrome.” Less confidence in the ability to walk safely can lead to further functional decline, depression, feelings of helplessness, social isolation [83, 100, 119] and consequently a loss of quality of life [3]. Inevitably, also, falls and fear of falling are among the major reasons for the institutionalisation of elderly people [41, 49].

According to these factors, falls in the elderly and the resulting injuries have to be considered a social concern,

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not only because of health care costs but also due to psychological problems associated with behavioural modifications, which restrict functional mobility, thus promoting physical dependence and potential changes in lifestyle [135].

Risk factors for falling and fractures

Falls are defined as any incident in which a person “suddenly and involuntarily come to rest upon the ground or a surface lower than the original station” [62, 98]. Fall consequences, such as fractures, depend fundamentally on three factors:

- Risk factors related to fall occurrences, such as health problems, activity and physical environment
- Risk factors referring to bone strength, namely bone mineral density (BMD), bone structure or the spatial arrangement of the bone trabeculae and bone quality or the mechanical properties of the bone tissue
- Risk factors associated to the impact of the fall, i.e. fall severity, floor material, soft tissue surrounding the impacted bone, etc. [8, 32, 51, 84, 85, 106]

Fractures may occur in any bone of the skeleton. Humeral, fist, pelvis and hip fractures are positively correlated with age and usually result from the combined effects of osteoporosis and the fall proper [15, 76, 77, 95, 101, 105]. Fractures of the vertebrae, also common, are generally associated with osteoporosis [99] and produce a high rate of morbidity and mortality [102]. However, falls may not be the determinant factor of this occurrence in the spine. Table 1 presents the most cited risk factors for falling according to several authors [2, 3, 8, 9, 49, 51, 64, 65, 71, 72, 74, 76, 77, 85, 91, 100, 103, 106, 111, 113, 114, 116, 119, 120].

In the elderly living in communities, the majority of falls occur during usual activities, such as walking or changing position [129, 130]. They happen mostly at home, so that a “safe home” is fundamental [90, 129]. Only 5% of falls are the consequence of clearly hazardous activities, such as climbing on a chair or a ladder or participating in sport activities. About 10% of falls occur on stairs. It has been shown that going downstairs is more hazardous than climbing [129, 130]. Environmental factors are responsible for most falls, although they are not the main cause for

Table 1 Risk factors for falling

Intrinsic risk factors		Extrinsic risk factors	
Chronic	Temporary	Activity	Environmental
Age over 75 years	Loss of conscience	Usual activities	Indoor:
Incapacity and chronic diseases usually associated to the degenerative process of aging:	Medication/drugs/ alcohol	Hazardous activities	Bad lighting
Degenerations and disturbances of the nervous and muscular–skeletal system functions and consequent decrease of functional capacity: reaction speed, muscular strength, reflexes, balance, mobility, gait pattern and speed	Other hallucinogenic substances		Slippery floors, loose rugs, telephone threads, other objects
Urinary incontinence			Ladders
Deficient vision			Stairways with steep steps, without walls and/or handrails
Vestibular function disturbance			Kitchen with difficult access to utensils and movable tables
Audition loss			Bathroom without handrails for tub, shower and toilet and non-skid mat in tub or shower
Cognitive function disturbance			Bed too high or too low
Insanity			Outdoor:
Depression			Uneven pavements, streets, paths
Memory loss			Repair works, obstacles
Neurological pathologies such as Parkinson’s disease			Slippery floors
Secondary effects of medication			Rain, snow and ice
			Traffic
			Public transport
			Animals
			Footwear

falling. However, few falls result from unpredictable events [129].

According to Bath and Morgan [13], falls in outdoor and indoor environments present different risk profiles. Risk factors associated with outdoor falls are both intrinsic and extrinsic. Intrinsic risk factors include decreased functional capacities such as reduced strength and/or reduced gait velocity, while extrinsic factors are related to hazardous environments and performances outside habitual activities. Risk factors associated with indoor falls are mainly intrinsic and their occurrence increases when the elderly are housebound, due to poor health, frailty or to the use of high levels of prescribed medications. It is important to note that people falling at home present a higher mortality rate, although the relationship between causality and effect is still unclear. Table 2 provides a review of the risk factors for fractures due to falling [32, 60, 65, 74, 93, 94, 103, 105, 106, 122, 134].

Bone strength is determined 65–80% by BMD (quantity of bone mineral per square or cubic centimetre) and 20–35% by bone structure (spatial arrangement of the bone trabeculae), as well as by bone quality (the material

properties of bone tissue) [71, 106]. BMD, in turn, is determined by genetic and hormonal factors, body composition, nutrition, physical activity, chronic diseases and the use of medication [16, 29, 35, 39, 71, 106, 111, 120].

Evaluation of BMD may be performed by dual-energy X-ray absorptiometry [25]. Osteoporosis is diagnosed in post-menopausal women and in men age 50 and older if BMD expressed as T-score is -2.5 or less at the lumbar spine, total hip or femoral neck [66]. The T-score indicates how many standard deviations (SDs), above or below the average value, the result in question actually lies. The reference standard from which the T-score is calculated is the BMD of the young adult age 20–29 years. A T-score between -1.0 and -2.5 SDs indicates low bone density or mass, also usually referred to as osteopenia. Contrary to osteoporosis, people with low bone mass are not necessarily at high fracture risk [21, 74].

The risk of falling and fracture is related to the number of existing risk factors and is potentiated by the interaction and cumulative effects of multiple risks [32, 36, 128, 130]. However, many of those risk factors can be avoided [128, 134] or reduced when some contributing factors are modified by intervention programmes [114, 122, 130], particularly, when these programmes are multi-factorial [37, 90, 115].

Table 2 Risk factors for fractures due to falling

Risk factors
Risk factors inherent to the individual:
Age (specially over 75 years)
Female (vs. male)
Family history of fractures due to osteoporosis (maternal hip fracture)
Recurrent falls in previous year
Previous fracture caused by a low energy impact
Osteopenia, osteoporosis and associated disorders
Low body weight (body mass index <19 kg/m ²)
Bone structure: geometry and length
Corticosteroids treatments
Hormonal factors
Behaviour risk factors:
Nutritional factors
Low consumption of calcium (<700 mg/d)
Vitamin D deficit (low exposition to sun light)
Physical inactivity
Tobacco
Alcohol
Factors that potentiate falls impact:
Height (the taller the person the greater the impact)
Decreased muscular and fat mass
Lateral falls
Point of impact on the bone (for instance the femoral neck)
Loss of defence reflexes
Floor surface
No use of artificial shock absorber (reduction of the occurrence of fractures by 40%)

Prevention strategies for falls and fractures

Most elderly people are not aware of their predisposition to fall nor identify their inherent risk factors, and thus they cannot express their limitations to a physicians or other healthcare personnel. Consequently, as prevention is often overlooked, the risk becomes evident only after a lesion or incapacity due to a fall [19, 28].

The correct diagnosis of this reality is fundamental. The use of proficient instruments to recognize the predisposed risk factors responsible for the occurrence of serious lesions and the evaluation of behavioural risk factors allow the identification of populations and individuals at risk [44, 98, 104, 115, 123]. This knowledge leads to the setting up and implementation of efficient intervention programmes—focussed on the existing risk factors and providing answers to the needs of the individual or specific population groups (age, gender, functional competence, clinical condition, type of performed activities, etc.) [62, 98, 104, 127].

Physical exercise programmes

Independently of individual differences, fragilities or pathologies, light- to moderate-intensity exercise programmes revealed to be effective in the prevention of falls and their consequences. Tai-chi, step, strength,

agility, stretching and multi-modal training or adherence to specific programmes of exercise directed to prevent falls have reduced fall events, falls injuries and also fear of falling [2, 11, 20, 26, 27, 34, 38, 42, 86, 91, 116, 127]. Exercise may prevent falls and their consequences either in healthy old people or in elderly people with medical conditions like osteoporosis, Parkinson, diabetes, physical or visual impairment and even after a stroke [6, 10, 14, 38, 61, 82, 99, 110].

Maintenance or recovery of the elderly physical functionality through such exercise programmes [1, 27, 33, 60, 73, 86, 87, 133], besides decreasing fall rate and its consequences [18, 47, 92, 96], contribute to improving the quality of life [109]. To be effective, these programmes, performed on a daily basis, have to be focussed on functional capacities, such as coordination, agility, balance, mobility, muscular strength and flexibility [12, 50, 63, 113–115, 121, 123, 135]. They should also include multi-sensorial training [67, 116], as well as exercises like walking, stepping up- or downstairs, and carrying objects [2, 87, 116]. Training programmes aiming to improve weight-bearing bones and muscles can also improve functionality, reduce fall severity and even lower the mortality rate [24, 53, 69, 81, 124].

Regarding bone health, increase of bone strength during pre-puberty and adolescent years is fundamental for the prevention of osteoporosis and related fractures in older people [58, 72]. Mechanical loading such as high-impact and resistance exercise enhances peak bone mass during growing years and prevents bone loss during aging throughout bone formation stimulation [76, 81, 97, 124]. Recently, the use of high-frequency vibratory platforms has showed significant increase of bone mineral at the hip level, associated with an improvement of balance [57]. These exercise programmes need to be long-term projects, as any interruption will induce a reversibility of the benefits in health and function, especially at the muscle and skeleton levels [18, 23, 40, 81]. Moreover, decreases in physical performance associated with the lack of activity in the elderly are associated with dependence and the incapacity to perform daily tasks [52].

As it has been exposed, studies suggest that a moderate level of physical activity can reduce the risk of falls and prevent their consequences like fractures and other injuries [17, 55]. Even light or vigorous exercise can produce health benefits [18, 88]. However, there are no guidelines for exercise prescription, namely the optimal intensity and amount of activity necessary to prevent falls. “Staying active–staying safe” [4] does not mean the greater the amount of physical activity the better. In fact, several authors exposed that either inactivity or excessive physical activity may conduce to the occurrence of fall events, particularly when heavy tasks are involved [30, 54]. The higher rate of falls associated with inactivity seems to be due to

the usual function decline of sedentary elderly people [38, 59, 97, 125]. The higher rate of falls associated with excessive physical activity may be due to the fact that people fall when they are moving, especially performing heavy tasks in a non-controlled environment, and then the probability of the occurrence of an accidental fall is amplified [7].

Multi-disciplinary programmes

In addition to the evidence that interventions centred on physical exercise are beneficial, literature also reveals the importance of multi-faceted intervention in the prevention of falls and consequent fractures [43, 62, 90, 127]. Besides exercise, prevention programmes must include strategies to improve cognition, especially the capacity to perform dual-task walking to ensure appropriate nutrition, particularly ingestion of calcium and vitamin D, and when appropriate to change prescription of drugs with possible negative secondary effects. Home assessment performed by specialised personnel and continuous counselling about safety conditions in the house and its accesses are also recommended. Such work has to be performed in close consultation with the subjects in their local environment [5, 9, 43, 64, 68, 70, 117, 136].

It is not yet clear which is the most valuable component in a multi-factorial intervention programme. However, prevention programmes have already been implemented and are providing effective results [31, 56, 86, 103, 114, 126, 132]. Despite a universally successful prevention strategy is not applicable because falling and consequent fractures depend on each faller [62], preventive measures need to be implemented systematically and performed on a large scale [79, 118, 131].

Conclusion

For the elderly, falls and fear of falling induce loss of autonomy and reduce the quality of life. Aside from the financial costs, falls cause both physical and psychological suffering. Risk factors for falling are multiple and well documented, as are their consequences. Most risk factors are due to normal aging processes and can be attenuated or eliminated. Others are intractable, which means that the elderly must simply learn to live with them.

Physical exercise should be part of a multi-disciplinary strategy to prevent falls and their consequences to maximise intervention benefits. Although risk factors for falling have been accurately defined and some management strategies studied and, in some cases, implemented, most approaches lack continuity. What remain are the policies to raise awareness and promote the widespread, systematic implementation of comprehensive prevention programmes.

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