

Physical consequences of falls in the elderly: a literature review from 1995 to 2010

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Abstract In the last decade, population ageing has been registered as a global phenomenon. A relation exists between falling and ageing, since falling frequency increases significantly with age. In fact, one in three older adult falls annually. Although ageing is generically associated with decrease and degeneration of psychological and physical functions, it is still not common for the correct identification of risk factors to lead to a clinical prognosis of the elder being in risk of falling. Therefore, the goal of this review article is to identify, categorise and analyse typical ageing and fall factors mentioned in the literature as well as to quantify the number of times they were referenced. The research considered hundreds of

publications, but analysis was then restricted to the 87 most pertinent articles written in English and published in journals or scientific magazines between 1995 and 2010. We concluded that falls among older adults can be characterised by the following: anatomic characteristics and physiological consequences of ageing; the pathologies that induce falls, which can be neurological, musculoskeletal, cardiovascular and other diseases; causes and risk factors of falls that can be behavioural, biological, environmental or socio-economic; type of physical consequences of falls, including fractures, bruises, injuries or other physical consequences; and strategies to prevent, mitigate or rehabilitate, which can be of a physical, environmental or behavioural nature.

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Introduction

Elderly are currently considered the fastest growing age group worldwide [13]. In the last decades, the number of elderly people in the world has been consistently and proportionally increasing. In 1996, there were a total of 323 million people in the world aged above 65 years [49]. That number increased in 2010 to 440 million [13] and is forecasted to be 1,555 million by 2050 [49].

The physical changes inherent to ageing can reduce autonomy and functional independence, which may directly or indirectly lead to falls. Falls are coded as E880–E888 in the International Classification of Disease-9 (ICD-9) and as W00–W19 in ICD-10, being commonly defined as “inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest in furniture, wall or other objects” [84]. About one third of the population

over 65 suffers at least one indoor fall every year [33, 47], and about half of the population in this age group who is institutionalised fall each year [33]. Among the elderly, falls are one of the main causes of injuries, physical incapacity and even death. Each year, around 37.3 million falls among elderly will require health care, and about 424,000 lead to death of the faller [19].

It is thus obvious that the problem of falls among the elderly population has epidemiological levels with a global incidence and dimension. Therefore, the following question was posed: What are the physical consequences of falls in the elderly population?

In order to answer this question, a quantitative review was conducted. This paper aims at identifying, categorising and analysing the typical ageing and fall factors mentioned in the literature as well as quantifying the number of times these factors were referenced. This study considered the incidence of the anatomic characteristics and physiological consequences of ageing, the pathologies that power falls, causes and risk factors for falls, physical consequences of falls and strategies to prevent, mitigate and rehabilitate.

This work is focused on providing an overview of the published literature to researchers, academics and practitioners, who deal with this issue; it does not cover the entire research area of elderly population falls.

Materials and methods

The research was limited to peer-reviewed articles, written in English and published in scientific journals or magazines between the years 1995 and 2010. The research was restricted to the following databases: *PubMed*, *Access Medicine*, *Science Direct*, *Oxford Journals* and *Taylor & Francis Online*. Additionally, a manual search was carried out for the other publishers in the areas already mentioned, such as *McGraw-Hill* and *BioMed Central* as well as publications edited by organisations that focus the problem of falls in the elderly people, such as the *National Center for Injury Prevention and Control* and the *World Health Organization*.

The keywords used, as title and/or abstract and/or keywords of the articles, either for searching scientific publications databases or for manual search in other online publications, were the following: “physical consequences of falls”, “senior population and falls”, “falls pathologies”, “anatomy of ageing”, “causes of falls” and “risk factors”.

After the search, the titles and abstracts were analysed in order to eliminate duplicates and publications with topics that did not meet the purpose of this review work. The remaining publications were thoroughly read and analysed, and all references to the topics addressed in the review article were identified and quantified.

Search results

A total of 87 publications were selected and analysed, from which 81 were journal publications from scientific database and 6 were articles published in book chapters or specialty reports obtained from the manual search. The publications came from 25 different countries in the world and represent all continents with the exception of Africa. The strongest geographic incidence, with about 82 % of the total publications was identified in two continents: North America and Europe. South America and Asia represent 18 % of the total publications. Publications from Turkey, Israel and Iran were considered as being from the Asian continent.

Ageing pathologies that potentiate falls

Falls are events that depend on multiple factors and can be related to the presence of pathologies. The pathologies inherent to the process of ageing, which may lead to fall in the elderly population, are numerous and diverse. Therefore, four categories were considered: neurological, musculoskeletal, cardiovascular and other pathologies (see Table 1). The neurologic and musculoskeletal pathologies were the most referenced in the analysed literature. The cardiovascular pathologies also had a considerable incidence of references, although small when compared with the former. Table 1 shows the references in the literature for each pathology type and the number of times they were referenced (in percentage).

In the selected literature, the neurological diseases, such as stroke (13.7 %), dementia (10.3 %), vestibular disorders/balance (10.3 %) and *Parkinson* (9.1 %), are the most referenced ageing pathologies as propitiating falls in the elderly population.

In terms of musculoskeletal pathologies, osteoporosis was the pathology with a higher incidence of references (16 %), followed by loss of muscle density (9.1 %) and arthritis (6.8 %). Problems in the lower extremities and joint deformities were also diseases common in the falling elderly, but with a lower incidence of references (3.4 and 2.2 %, respectively).

Cardiovascular diseases, such as orthostatic hypotension (6.8 %), arrhythmias (3.4 %) and syncope (3.4 %), are also common pathologies due to the ageing process and may also lead to falls.

In the “other pathologies” category, the following typical pathologies of ageing that can lead to falls were identified: diabetes and depression (4.5 %), pneumonia and lung infections (2.2 %) and sleep disorders (1.1 %).

The causes and risk factors of falls

Table 2 identifies multiple causes and risk factors of falls in the elderly population as well as the respective incidence in the reviewed literature. The causes and risk factors of falls are

Table 1 Identification of references for pathologies of ageing that may cause falls

	<i>N</i> (%) ^a	References
Neurological diseases		
Stroke	13.7	[13, 21, 33, 40, 44, 45, 53, 57, 63, 75, 81, 86]
Dementia	10.3	[17, 21, 33, 40, 45, 53, 60, 63, 86]
Vestibular disorders/balance	10.3	[22, 33, 40, 53, 54, 63, 64, 68, 87]
Parkinson	9.1	[6, 33, 40, 45, 53, 63, 64, 69]
Multiple sclerosis	1.1	[62]
Musculoskeletal diseases		
Osteoporosis	16.0	[4, 5, 14, 17, 24, 25, 30, 37, 40, 43, 56, 62, 63, 71]
Loss of muscle density	9.1	[14, 23, 25, 33, 40, 63, 81, 83]
Arthritis	6.8	[21, 45, 53, 63, 64, 86]
Problems in the lower extremities	3.4	[33, 45, 53]
Deformities in the joints	2.2	[33, 53]
Cardiovascular diseases		
Orthostatic hypotension	6.8	[33, 40, 53, 56, 63, 86]
Arrhythmias	3.4	[22, 45, 53]
Syncope	3.4	[53, 57, 58]
Others	8.0	[9, 13, 22, 33, 45, 53, 64]
Other pathologies		
Diabetes	4.5	[21, 53, 63, 86]
Depression	4.5	[53, 63, 64, 86]
Pneumonia and bone infections	2.2	[14, 53]
Sleep disorders	1.1	[53]

^a The percentages refers to a total of 87 publications

very diverse, and several of these factors can occur simultaneously. Due to that diversity, the causes and risk factors of falls were grouped in four categories, analogous to those adopted by the World Health Organization, in *WHO Global Report on Falls Prevention in Older Age* [84]:

- *Behavioural*, characteristics of human actions, emotions or daily choices;
- *Biological*, individual's characteristics pertinent to the human body;
- *Environmental*, interactions between the individual's physical condition and the surrounding environment;
- *Socio-economic*, related to the individual's social and economic situation.

The results of this analysis are shown in Table 2. The *behaviour causes and risk factors* most referenced in the reviewed literature were overdose of medication (with 32.1 %) and the fear of falling—without having ever fallen before or after the first fall (29.8 and 22.9 %, respectively). The reduction in physical activity (16 %), carrying out activities of daily living (11.4 %) and alcohol consumption (10.3 %) are located in the intermediate incidence group. In the smallest incident group, the following were identified: slip (6.8 %), fainting (4.5 %) as well as smoking and an inappropriate use of footwear (both with 3.4 %).

Concerning the *biological causes and risk factors*, highest incidence was on a lack of balance during gait (33.3 %),

musculoskeletal and sensory degradation (26.4 %), functional dependence in the mobility (25.2 %), cognitive impairment (24.1 %), age (19.5 %) and sex (18.3 %) with higher incidence in females. The decrease in bone density and lack of vision (with 14.9 % each), chronic diseases (13.7 %), depression (12.6 %), occurrence of dizziness and vertigo (11.4 %) and decrease of index bone mass (10.3 %), which weakens the ability to absorb and dissipate impact forces, were intermediate incidence factors. Finally, urinary incontinence, orthostatic hypotension, pain, soft tissue changes, hearing problems and body weight, with between 3.4 and 4.5 % incidence, were identified as causes and behaviour risk factors with least references in the reviewed literature.

With respect to the *environmental causes and risk factors*, unsafe domestic (17.2 %) and outdoors (16 %) environments were found to have the highest incidence. Falls from hospital beds, mobility aids (for example walkers) and the collision against objects were referenced only one to two times.

Last, the *socio-economic causes and risk factors* of falls included limited access to health and social services (2.2 %), low income and low educational level (2.2 %) and lack of social interactions (1.1 %). This category had the lowest number of references in the literature, when compared with the other categories of causes and risk factors.

If a profile is established for a senior individual with a high risk of falling based simultaneously on the causes and risk factors more referenced on the four categories, the overall risk

Table 2 Identification of references and percentage of incidence of the causes and risk factors for falls

	<i>N</i> (%) ^a	References
Behavioural		
Medication (overdose)	32.1	[3, 5, 7–9, 13, 17, 19, 21, 22, 84, 33, 39, 40, 48, 53, 55–57, 60, 61, 63, 66, 70, 71, 77, 78, 86]
Fear of falling (after the first fall)	29.8	[1, 13, 18, 20, 25, 32, 33, 37–39, 41, 47, 52, 53, 56, 62, 63, 67, 68, 70, 76–78, 81, 86]
Fear of falling (without ever having fallen)	22.9	[6, 13, 18, 20, 25, 32, 33, 38, 39, 41, 52, 53, 62, 63, 67, 76, 77, 79, 81, 85]
Reduction of physical activity	16.0	[6, 19, 20, 23, 84, 39–41, 55, 63, 71, 75, 77, 86]
Activities of daily living	11.4	[13, 20, 21, 25, 29, 36, 39, 63, 81, 86]
Alcohol consumption	10.3	[2, 13, 19, 84, 40, 53, 55, 63, 70]
Slip/slide	6.8	[23, 33, 40, 45, 46, 64]
Direction of fall (sideways)	4.5	[14, 24, 25, 49]
Fainting	4.5	[13, 33, 55, 57]
Inappropriate footwear	3.4	[17, 84, 48]
Smoking	3.4	[40, 55, 63]
Direction of fall (forward)	2.2	[14, 23]
Difficulties in dressing	1.1	[55]
Level/angle/position of the impact	1.1	[40]
Biological		
Lack of balance while walking	33.3	[2, 5–7, 9, 13, 14, 17, 19, 20, 22, 23, 31, 33, 39, 40, 45, 48, 53, 55, 62, 63, 66–70, 81, 86]
Musculoskeletal and sensory degradation	26.4	[3, 5–7, 13, 14, 17, 22, 23, 84, 40, 45, 53, 55, 61–64, 66, 69, 71, 78, 81]
Functional dependence on mobility	25.2	[7, 9, 12, 19–21, 23–26, 35, 39, 40, 50, 53, 55, 56, 62, 67, 71, 77, 78]
Cognitive impairment	24.1	[6, 7, 9, 13, 17, 19–23, 84, 45, 55, 59, 63, 64, 69, 70, 75, 77, 81]
Age	19.5	[5, 10, 12, 84, 34, 36, 40, 49, 55, 56, 63, 66, 70, 71, 78, 86]
Sex (higher incidence in females)	18.3	[3, 5, 13, 84, 35, 40, 43, 48, 49, 56, 63, 67, 70, 78, 80, 86]
Decreased bone density	14.9	[5, 14, 24, 25, 84, 34, 40, 43, 49, 56, 62, 63, 71]
Lack of vision	14.9	[7, 13, 17, 22, 40, 48, 53, 55, 56, 63, 77, 86, 87]
Chronic disease	13.7	[9, 13, 22, 84, 33, 40, 48, 55, 63, 69, 70, 86]
Depression	12.6	[2, 13, 17, 26, 33, 55, 63, 67, 70, 77, 81]
Dizziness/vertigo	11.4	[7, 13, 17, 22, 40, 48, 53, 55, 56, 63, 77, 86, 87]
Decrease in body mass index	10.3	[5, 7, 10, 25, 29, 40, 49, 55, 71]
Pains	4.5	[3, 6, 35, 56]
Changes in soft tissues	4.5	[14, 40, 57, 64]
Urinary incontinence	3.4	[33, 56, 61]
Postural hypotension	3.4	[17, 56, 61]
Weight (body mass that falls)	3.4	[25, 40, 63]
Hearing problems	3.4	[13, 55, 63]
Environmental		
Unsafe home environments	17.2	[5, 7, 15, 17, 22, 25, 84, 33, 48, 55, 63, 65, 66, 71, 86]
Unsafe outdoors	16.0	[5, 7, 15, 17, 19, 22, 25, 84, 33, 48, 55, 66, 71, 86]
Height of fall	2.2	[14, 25]
Collision with objects	2.2	[23, 55]
Mobility aids	2.2	[40, 63]
Falls hospital beds	1.1	[27]
Socio-economic		
Level of education and income	2.2	[84, 78]
Access to social services and health	2.2	[84, 78]
Lack of social interaction	1.1	[84]

^a The percentages refer to a total of 87 publications

of falling and consequent injury gravity for that individual can be expected to be very high.

Physical consequences of falls and physiological effects

Falls among the elderly are associated with a large diversity and heterogeneity of undesired physical consequences, which can be more or less severe. Four main categories were considered for the physical consequences: fractures, bruises,

injuries and “other” physical consequences. A fifth category was also defined, focused on the physiological effects associated to the physical consequences of falls.

The results concerning the physical consequences and the physiological effects of falls are shown in Table 3. It was observed that *fractures* (as consequences of falls) can occur in almost every region in the body. However, the hip fracture and undifferentiated bone fractures are the most referenced in the literature, with 37.9 and 27.5 % incidence, respectively.

Table 3 Identification of references of physical consequences of falls and its physiological effects

	N (%) ^a	References
Fractures		
Hip fracture	37.9	[1, 2, 4, 5, 10, 11, 14, 16, 21, 24, 25, 30, 84, 33, 36, 40, 42, 47, 49, 53, 55, 57–59, 62, 64, 70–72, 80, 81, 86, 87]
Undifferentiated bone fractures	27.5	[5, 13, 14, 21, 25, 33, 35, 37, 40, 43, 47, 58, 61, 63, 64, 70, 74, 75, 77, 78, 80–82, 86]
Trochanteric femoral fractures	5.7	[33, 40, 57, 58, 74]
Fractures in the trunk	4.5	[14, 33, 40, 47]
Neck fractures	4.5	[14, 47, 57, 58]
Fractures of the upper limbs	3.4	[14, 40, 47]
Fracture of the humerus	2.2	[33, 40]
Fractures in the chest	1.1	[82]
Broken knee	1.1	[40]
Bruises		
Head bruises	10.3	[13, 14, 35, 53, 58, 62, 70, 77, 86]
Bruises and abrasions	3.4	[35, 47, 75]
Bruises with blood loss	1.1	[70]
Injuries		
Soft tissue injuries	6.8	[14, 33, 35, 43, 62, 86]
Injuries in the upper extremities	5.7	[14, 40, 62, 64, 75]
Traumatic brain injury	4.5	[14, 84, 70, 75]
Injuries in wrists	4.5	[14, 33, 40, 47]
Injuries in the lower extremities	3.4	[33, 62, 75]
Injuries in the elbow	2.2	[14, 40]
Physiological effects		
Death or morbidity	21.8	[5, 9, 22, 25, 84, 33, 35, 47, 49, 51, 55, 60, 62–64, 66, 67, 71]
Functional decline	20.6	[5, 13, 23, 25, 35, 40, 41, 49, 52, 53, 55, 64, 67, 70, 71, 76, 78, 81]
Inactivity	14.9	[3, 6, 13, 35, 41, 47, 52, 53, 63, 67, 70, 77, 81]
Functional dependency and loss of autonomy	13.7	[84, 33, 35, 41, 49, 52, 71, 76–78, 81, 86]
Depression	10.3	[13, 84, 35, 53, 55, 63, 67, 70, 81]
Loss of self-confidence	5.7	[25, 33, 35, 67, 76]
Loss of self-efficacy	2.2	[41, 67]
Others		
Lacerations	8.0	[35, 47, 58, 62, 70, 75, 86]
Dislocations	5.7	[14, 41, 70, 77, 81]
Sprains	3.4	[14, 35, 70]
Pains	2.2	[35, 70]
Hematoma	1.1	[33]

^a The percentages refer to a total of 87 publications

The head bruises due to falls, with 10.3 % incidence, were the more referred physical consequence in the *bruises* category.

For the *injuries* category, the incidence of references in the literature is more homogeneous than in other categories. The most referenced injuries are soft tissues and the upper extremities, respectively with 6.8 and 5.7 % incidence. Injuries on the elbows are the ones that had the least incidence, namely 2.2 %.

For *other consequences*, lacerations with 8 % and dislocations with 5.7 % incidence were the most referenced in the literature. This category also included sprains, hematomas and pain, but these were identified in the literature to a smaller extent.

The *physiological effects* of elderly falls were also identified. The two effects with higher incidence of references were death and morbidity, with 21.8 %, and functional decline, with 20.6 %. Other still significant effects were inactivity, with 14.9 %, functional dependence and loss of autonomy, with 13.7 %, and depression, with 10.3 % incidence.

This analysis reveals a possible cause–effect relation between the different physiological effects. For example, depression can lead to higher functional dependence; in the same way, inactivity can lead to functional decline. On the other

hand, the state of physical incapacity and functional dependence as a result of a fall can retract the ability to participate in everyday life activities and increase the chance of depression. These interrelations between causes will be further explored in future work.

Interventions for prevention, rehabilitation and minimization of falls

Many actions, strategies and mechanisms can—and have been—employed for the prevention, minimization and rehabilitation aspects of elderly falls. The different interventions can be categorised into three groups: the first group consists of physical interventions, the second of environmental interventions, and the third with behavioural interventions. For each of those, one can correspond them to the three stages associated with falls: the moment before the fall (interventions to prevent falls), the time during the fall (interventions to minimise the consequences of falls) and the moment after the fall (interventions related with the rehabilitation of the consequences of falls).

The different interventions, related to falls, as well as the respective percentage of references incidence are indicated in

Table 4 Identification of references and percentage of incidence, for physical, environmental and behavioural interventions for prevention, minimization and rehabilitation of falls in the elderly

	Pr	Mi	Re	N (%)	References
Physical interventions					
Adjustment of medication	x		x	18.3	[8, 13, 17, 19, 25, 84, 33, 35, 39, 53, 55, 61, 63, 72, 81, 86]
Protective coating systems can reduce hip fracture risk in the event of a fall.		x		17.2	[5, 7, 10, 11, 16, 17, 19, 25, 30, 35, 40, 42, 59, 62, 63]
Use of nutrition programmes (calcium and vitamin D)	x	x	x	11.4	[4, 5, 17, 19, 25, 33, 35, 51, 53, 63]
Mobility aids	x	x	x	5.7	[5, 17, 19, 24, 62]
Increase and maintain bone mass and strength through exercise	x	x		4.5	[23, 25, 61, 81]
Vision interventions (cataract surgery)	x			4.5	[17, 19, 35, 73]
Use of appropriate footwear	x		x	4.5	[5, 17, 35, 48]
Environmental interventions					
Changes in the home and public environment to reduce the risk of falling	x			11.4	[1, 5, 17, 19, 28, 84, 35, 65, 71, 73]
Removal of obstacles in the household	x			4.5	[28, 33, 55, 62]
Behavioural interventions					
Increased physical activity and exercise	x	x	x	21.8	[2, 5, 6, 13, 14, 17, 19, 23, 25, 84, 33, 35, 51, 53, 55, 63, 66, 71, 73]
Methods based on the rehabilitation gait training			x	14.9	[5, 17, 28, 33, 35, 44, 45, 53, 55, 62, 71, 79, 81]
Evaluation and management of risk factors for multiple falls	x			10.3	[33, 39, 51, 56, 58, 60, 71, 74, 76]
Evaluation of the people who have fallen or at risk of falling, to identify modifiable risk factors	x		x	5.7	[35, 39, 53, 60, 76]
Strategies to modify risk behaviours of the patient falling	x			5.7	[17, 28, 39, 60, 76]
Mechanisms that characterise the cognitive changes associated with ageing.	x			4.5	[39, 45, 63, 86]

^a The percentages refer to a total of 87 publications

Pr prevention, Mi minimization, Re rehabilitation

Table 4. For each type of intervention (physical, environmental and behavioural), Table 4 also shows at which stage of the fall event they can be applied (prevention, minimization and rehabilitation). Note that these stages are not mutually exclusive.

The physical interventions are those that represented the highest incidence: most notably, adjustment of medication with 18.3 % incidence, hip protection coating systems with 17.2 % incidence and the use of strengthening nutrition programmes with 11.4 % incidence.

The environmental interventions were those that exhibited the lowest incidence and were essentially limited to changes in the home and public environments to reduce the risk of fall, with 11.4 % incidence. Note also that the other intervention “removal of obstacles in the household” is directly related to the former.

Finally, in the behavioural interventions, the highest incidence, of 21.8 %, was found for carrying out activities and exercise. The use of rehabilitation methods based on gait training and management of risk factors of multiple falls, with an incidence of 14.9 and 10.3 %, respectively, were also relevant types of behavioural interventions.

Concluding remarks

In this review article, we have quantitatively characterised relevant research efforts on this issue of great social relevance over the last decade and a half, by identifying the incidence of articles concerning the anatomic characteristics and physiological consequences of ageing, the pathologies that propitiate falls, the causes and risk factors for falls, the physical consequences of falls and the strategies to prevent, minimise or rehabilitate.

This study will be useful both for those who want to identify key research issues and those who study ageing from the perspective of social sciences. In the future, repeating this study for the period of 2011–2025 will provide a historical time frame for analysis and comparison.

In subsequent work, we aim to study the economic impact of falls, from the individual and societal perspectives.

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