

# Risk factors for falls of older citizens

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## Abstract.

**OBJECTIVE:** Fall prevention is a major issue in the ageing society. This study provides an overview of all risk factors for falls of older citizens.

**METHOD:** A literature search was conducted to retrieve studies of the past 25 years. All participants from the studies lived in the community or institutions and were aged 60 or older. The following key word combinations were used, limited to the title: elderly or older people or older adults and fall and risk. The risk factors were categorised as relevant and amendable, relevant but non amendable, inconclusive or unsupported.

**RESULTS:** In total 30 publications were studied in 2013 in Enschede, the Netherlands. The relevant intrinsic risk factors are muscle strength, balance capacity, reactive power, dual tasking and sleep disturbance. Relevant extrinsic risk factors are home hazards, wrong use of assistive devices and bad footwear. Behaviour-related risk factors are hurrying, risk taking, physical inactivity and fear of falling. Relevant symptoms that could be caused by underlying risk factors are mobility problems, gait problems, vertigo, use of assisting devices and history of falls.

**CONCLUSIONS:** Several risk factors are determined to be relevant and amendable. The provided overview could be used to create fall preventive measures for elderly.

Keywords: Aging, falls, risk factors

## 1. Introduction

The number of older citizens will increase rapidly due to the Babyboom generation in the Western world. Moreover, because of the remarkable developments in the health science field, overall life span of the people has increased considerably and seemingly will keep rising. Although our average lifetime has increased, the negative effects of ageing have not diminished. One of the effects is an increased risk of falling. Twenty to forty percent of the older citizens aged over 65 fall each year [1]. In fifty percent of the cases medical attention is required and in one out of ten the fall will result in bone fracture or other trauma [2], leading to surgery and long-term rehabilitation. The physical and psychological consequences of a fall are important: diminution of the motility, loss of confidence, limitation in the daily life activities and decrease of functional capacities. This can endanger the autonomy, leading to increased cost of medical care. Furthermore, falling constitutes the main cause of death by trauma in the older

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population. In the Netherlands, fall related medical costs were estimated at €675 million annually [3]. With an increasing population of older citizens and therefore increasing number of falls, this could overburden the healthcare system in the future due to scarcity of resources in terms of healthcare costs and healthcare workers. Fall prevention is therefore very important.

The occurrence of a fall is related to risk factors. Several studies have investigated single or multiple risk factors. An extensive overview of all risk factors, however, has not been published yet. This paper will provide insight in all risk factors.

## 2. Methods

A literature search was conducted to retrieve (review) studies of the past 25 years. The databases ScienceDirect and PubMed are used, both in the same way. The following key word combinations, limited to the title, were used: elderly and fall, elderly and fall and risk. To include studies that did not use the term elderly, other words for elderly are used as well, i.e. older adults and older people. To gather more information about specific risk factors, references mentioned in publications found with the given selection criteria are also scanned.

Limited scientific information is available about extrinsic risk factors. Therefore, after having identified extrinsic factors from scientific papers, a search is conducted for specifically these factors via the open internet (Google) in government information because it is expected to be reliable. Key words were based on identified extrinsic risk factors. For example, home hazards were stated as risk factors in one of the publications. On Google the following keywords are entered to gather more information: home hazard fall risk for elderly. Information was found from the Dutch and British government.

The studies had to meet all of the following criteria: (a) the subjects were aged 60 or older (b) the outcome results were fall incidence or fall risk (c) the outcome results were examined on statistical significance (d) the study population consisted of community-dwelling or institutionalized elderly. To identify the risk factors correctly, the decision was made to exclude trials specifically designed to reduce falls in a specific target group, like individuals who had suffered a stroke. A post hoc decision was made to exclude the few studies about outdoor extrinsic risk factors, due to the scarcity of data and a different target group. People at high risk for indoor falls differ from those at high risk of outdoor falls. Outdoor falls are associated with an active lifestyle and average or better-than-average health [4].

## 3. Results

In PubMed, the terms elderly and fall resulted in 291 hits. The combination risk and fall and elderly resulted in 106 hits. The combination with the key words older adults and older people resulted respectively in 56 and 19 hits.

In ScienceDirect the terms elderly and fall resulted in 242 hits, the combination risk and fall and elderly in 59 hits, the combination fall and older adult and risk in 33 hits and the combination fall and older people and risk in 11 hits.

The results from the literature search are represented in this section. All risk factors for falling are explained. The risk factors, the related studies and the outcomes of each study are summarized in Table 1 to Table 8. Often studies determined the risk factors either in the community or in institutions, this is stated in the tables.

Table 1  
Inconclusive intrinsic risk factors and the related studies

Risk factor	Studies	Participants	Residence	Outcomes
Dependency ADL/ care level	[21]	n.d.	n.d.	ADL dependency increases number of falls
	[16]	N = 42843, age <70–≥90	Institution	Low and medium care highest number of falls
Gender	[3]	Age ≥65	Institution	Female
	[21]	n.d.	n.d.	Female
	[16]	N = 42843, age <70–≥90	Institution	Male
	[5]	N = 1000, age 65–103	Institution	Male
	[6]	N = 12684, age ≥85	Community	Male
Osteoporosis	[7]	N = 86, C = 99, age ≥65	Community	No fall risk
	[27]	N = 13, C = 12, age ≥60, women	Community	Fall risk

N = number of participants, C = control group, n.d. = no data. Enschede, 2013.

Table 2  
Unsupported intrinsic risk factors and the related studies

Risk factor	Studies	Participants	Residence	Outcomes
Limberness	[21]	n.d.	n.d.	Fall risk
Hearing	[21]	n.d.	n.d.	Fall risk
Alcohol	[6]	N = 12684, age ≥85	Community	Consumption of at least one alcoholic beverage in past 30 days can increase fall risk

N = number of participants, C = control group, n.d. = no data. Enschede, 2013.

### 3.1. Risk factors

Three different types of risk factors can be recognised: intrinsic, extrinsic and behavioural. These relate to, respectively, the human body, the environment, and behaviour and activities. Besides these risk factors, there are symptoms that are caused by risk factors and can cause a fall as well.

The risk factors are determined to be inconclusive, unsupported, relevant but non amendable or relevant and amendable. A risk factor is inconclusive if studies have contradictory conclusions. Risk factors that are named unsupported are not supported by scientific research. A risk factor is relevant if different studies share the same conclusion. The relevant factors are divided in two: amendable and non amendable. The non amendable factors are associated with falling risk but cannot be changed or improved by fall preventive measures. The factors that are relevant and amendable are the most important risk factors, because they allow improvement. In the following sections the factors will be further explained; with some factors additional information is provided about the risk factor or about the relevance of the risk factor.

#### 3.1.1. Intrinsic risk factors

The intrinsic risk factors are related to the human body. The studies regarding the intrinsic factors can be found in Tables 1–4.

*Inconclusive* As can be seen in Table 1, different studies have different outcomes. Therefore the following intrinsic risk factors are inconclusive.

- Dependency activities of daily living (ADL)/care level
- Gender

*No conclusion can be made about gender. The fact that women would have a higher fall risk could be explained by the higher life expectancy of women [3]. There are fewer men of 85 years and*

Table 3  
Relevant but non amendable intrinsic risk factors and the related studies

Risk factor	Studies	Participants	Residence	Outcomes
Increasing age	[3]	Age $\geq 65$	Institution	Fall risk
	[16]	N = 42843, age $<70\text{--}\geq 90$	Institution	Fall risk
	[5]	N = 1000, age 65–103	Institution	Fall risk
	[6]	N = 12684, age $\geq 85$	Community	Fall risk
	[18]	N = 145, age $\geq 70$	Institution	Fall risk
Orthostatic hypotension	[16]	N = 42843, age $<70\text{--}\geq 90$	Institution	Fall risk
	[18]	N = 145, age $\geq 70$	Institution	Fall risk
	[19]	n.d.	n.d.	Fall risk
Osteoarthritis	[28]*	N = 17, age range $59.6 \pm 8.1$ , C = 14 age range $61.1 \pm 10.0$	n.d.	Reduces obstacle avoidance success rates/ Several epidemiologic studies: fall risk
Bad sight	[21]	n.d.	n.d.	Fall risk
	[5]	N = 1000, age 65–103	Institution	Fall risk
	[19]	n.d.	n.d.	Fall risk
Incontinence	[5]	N = 1000, age 65–103	Institution	Fall risk
Psychological problems	[21]	n.d.	n.d.	Fall risk
	[19]	n.d.	n.d.	Fall risk
	[10]	N = 84, C = 84, age 71–80	Institution	Depression increase fall risk
	[29]	N = 796	Institution	Dementia increases fall risk
	[30]	N = 311, age $\geq 70$	Community	Depression and other cognitive impairments increase fall risk
	[31]	N = 366, age $\geq 75$	Community	Cognitive impairments increase fall risk
(History of) specific diseases	[21]	N = 12764	Both	Cardiac diseases, locomotor system diseases, diabetes increase fall risk
	[21]	n.d.	Institution	Dementia, CVA, increase fall risk
	[21]	n.d.	Community	Respiration diseases, diseases eye and ear increase fall risk
	[32]	N = 467, C = 691, age $\geq 65$	Community	History of anaemia or stroke increase risk of fall injury event in home
	[29]	N = 796	Institution	Parkinson increase fall risk
	[5]	N = 1000, age 65–103	Institution	Parkinson increase fall risk
	[33]	N = 337, C = 101, age $\geq 65$ women	Community	Group with chronic disease twice as likely to fall as control group
	Medication	[18]	N = 145, age $\geq 70$	Institution
[34]		N = 635, age 70–105	Institution	Antidepressants increase fall risk
[10]		N = 84, C = 84, age 71–80	Institution	Anti-hypertensive drugs increase fall risk
[5]		N = 1000, age 65–103	Institution	Multiple psychoactive medications increase fall risk
[18]		N = 145, age $\geq 70$	Institution	Four or more medications increase fall risk
[19]		n.d.	n.d.	Four or more medications increase fall risk
[8]		Women	Community	Benzodiazepines and non-benzodiazepines increase fall risk

N = number of participants, C = control group, n.d. = no data, \*review different studies. Enschede, 2013.

*older and the risk of falling increases with age (see risk factor Age). But, other studies conclude differently. In institutions men would have a higher fall rate than women because men living in institutions are generally more disabled, because more men than woman have surviving spouses who can provide basic care for them at home if they get older [5]. Another study concluded that men aged 85 and older in general have a 41% greater risk of falling than women. No cause was identified [6].*

Table 4  
Relevant and amendable intrinsic risk factors and the related studies

Risk factor	Studies	Participants	Residence	Outcomes
Balance	[5]	N = 1000, age 65–103	Institution	Fall risk
	[18]	N = 145, age $\geq 70$	Institution	Fall risk
	[22]	N = 96, age 60–88	Community	Fall risk
	[26]	N = 71, age 65–87, men	Community	Fall risk
Reactive power	[21]	n.d.	n.d.	Fall risk
	[5]	N = 1000, age 65–103	Institution	Fall risk
	[15]*	–	–	Several studies: fall risk
Muscular strength	[21]	n.d.	n.d.	Fall risk
	[18]	N = 145, age $\geq 70$	Institution	Hip weakness increases the fall risk
	[30]	N = 311, age $\geq 70$	Community	Hand muscle power $\leq 12$ kg increases the fall risk
Dual tasking while walking	[11]	N = 213, age $\geq 78$	Institution	Fall risk
Sleep disturbance	[15]	N = 150, age $\geq 65$	Institution	Fall risk
	[6]	N = 12684, age $\geq 85$	Community	Fall risk
	[9]	N = 2978, age $\geq 70$ , women	Community	Fall risk
	[8]	N = 9704, age $\geq 65$ , women	Community	Fall risk

N = number of participants, C = control group, n.d. = no data, \*review different studies. Enschede, 2013.

Table 5  
Relevant but non amendable extrinsic risk factors and the related studies

Risk factor	Studies	Participants	Residence	Outcomes
Change in living conditions	[18]	N = 145, age $\geq 70$	Institution	Change in place of residence during previous 2 years increases recurrent falling
Time	[22]	N = 96, age = 60–88	Community	Most of the falls happen mid-afternoon
	[16]	N = 42843, age $< 70$ – $\geq 90$	Institution	Most of the falls happen mid-afternoon
	[35]	N = 634, age $\geq 68$	Institution	Most of the falls happen mid-afternoon

N = number of participants, C = control group, n.d. = no data. Enschede, 2013.

– Osteoporosis

*Because of their lower bone strength persons with osteoporosis have a higher risk of fall-related fractures [7]. But whether osteoporosis actually increases the fall risk itself is questionable as two studies conclude differently.*

*Unsupported* No study, only one study without a trial, or only a study with a very specific target group was found to prove the existence of the risk factor. Therefore the following risk factors are determined to be unsupported.

- Limbiness
- Hearing
- Alcohol
- Body mass index
- Smoking

*Relevant but non amendable*

- Increasing age
- Orthostatic hypotension
- Osteoarthritis

- Bad sight
- Incontinence
- Psychological problems
- (History of) specific diseases (e.g., Parkinson)
- Medication

#### *Relevant and amendable*

- Balance
- Reactive power
- Muscular strength
- Dual tasking

*The capability of simultaneously walking and performing an attention-demanding task, also known as dual-tasks, influences the risk of falling [11]. Balance control within the gait cycle requires a continuous regulation and integration of sensory inputs, which loads the higher level cognitive system. Therefore, performing dual-tasks affects balance control during the gait cycle [12].*

- Sleep disturbance

*Sleep disturbance is a common characteristic among older citizens. The sleep architecture changes significantly during ageing. Sleep initiation is more difficult, total sleep time and sleep efficiency are reduced, the duration of REM sleep is more preserved, sleep fragmentation increases and more time in bed is spent awake [13]. Sleep disorders seen in older citizens are often secondary to other factors such as medical and psychiatric illness, medication use, circadian rhythm changes and other sleep disorders such as sleep disordered breathing and REM behaviour disorder [14]. Other common contributors to sleep disturbance are: need to urinate (90%), thoughts that generate anxiety or distress (40%), noise (34%) and pain (25%) [15]. Sleep disturbance can result in daytime sleepiness, difficulty in sustaining attention, slow response times, impairments in memory and concentration or decreased (physical) performance. This can all increase the risk of falling [15]. Logically, different studies concluded that sleep disturbance is an intrinsic risk factor [6,8,9,15].*

#### *3.1.2. Extrinsic risk factors*

Extrinsic factors are environment-related. The environment is everything that interacts with human beings. The extrinsic factors are amendable or not amendable, there are no inconclusive or unsupported factors. As can be seen in Table 5 and Table 6, fewer studies are found about the extrinsic risk factors. Therefore information provided by the government about falls of elderly is scanned to gather more information and complete the overview. These references are assessed on reliability, bias and logic. To give an example, although slippery floors is only stated once as risk factor in a study without trial, it is very logical that slippery floors are a hazard for falling. Because of this logic, the factor is not determined to be unsupported.

#### *Relevant but non amendable*

- Change in living conditions
- Time of day: afternoon

*A reason for more falls in the mid-afternoon might be that residents are more tired during the afternoon, have higher activity patterns and that there is less availability of nursing staff in institutions [16].*

Table 6  
Relevant and amendable extrinsic risk factors and the related studies

Risk factor	Studies	Participants	Residence	Outcomes
Excessive demands	[17]	N = 15, age = 70–81	Community	Fall risk
Location	[16]	N = 42843, age <70–≥90	–	More falls in institutions
	[18]	N = 145, age ≥70	–	More falls in institutions
	[17]	N = 15, age = 70–81	–	More falls in institutions
	[36]	N = 36000	Community	Most falls in bathroom, shower and toilet
	[21]	n.d.	Community	Most falls in bathroom and stairs
	[19]	n.d.	Community	Most falls in bathroom and stairs
	[17]	N = 15, age = 70–81	Community	Most falls in bedroom and threshold at the door to exterior
	[10]*	–	–	Several studies: Most falls inside residents room
	[10]	N = 84, C = 84, age = 71–80	Institution	Most falls beside bed (44%), in toilets (18%) and corridors (18%)
Slippery floors	[19]	n.d.	Both	Fall risk
Bad lighting	[19]	n.d.	Both	Fall risk, bad placement as well
	[21]	n.d.	Both	Fall risk
	[33]	N = 337, C = 101, age ≥65 women	Community	Twice as likely to fall at night than control group
Inaccessible windows	[19]	n.d.	Both	Fall risk
Thresholds	[21]	n.d.	Both	Fall risk
	[33]	N = 337, C = 101, age ≥65 women	Community	Fall risk
Mobile objects	[19]	n.d.	Both	Fall risk
	[21]	n.d.	Both	Fall risk
Furniture	[21]	n.d.	Both	Fall risk
Improper assisting devices	[10]	N = 84, C = 84, age = 71–80	Institution	Falls due to improper transfer techniques and poor condition of the wheelchair
Bad footwear and clothing	[19]	n.d.	Both	Fall risk
	[21]	n.d.	Both	Fall risk

N = number of participants, C = control group, n.d. = no data, \*review different studies. Enschede, 2013.

#### Relevant and amendable

- Bad lighting
- Inaccessible windows
- Threshold
- Mobile objects
- Improper assisting devices
- Footwear or clothing
- Excessive demands

*The environment can force demands that exceed the physical abilities of a person. For example, having to step over a doorway threshold that is higher than a typical step can cause falling [17].*

- Location: institution

*Different studies say that community older citizens experience fewer falls (0.5–0.65) per year in comparison with institutionalized older citizens (1.7) [16–18].*

- Floor

*Slippery floors are of course a hazard [19]. Therefore the bathroom is often stated as most common area for falls, but this could also be a problem in the kitchen area. Thick-pile carpet flooring can*

Table 7  
All behavioural risk factors and the related studies

Risk factor	Studies	Participants	Residence	Outcomes
Physical inactivity and fear of falling	[21]	n.d.	n.d.	Fall risk
	[23]	N = 713, mean age = 64.2, women	Community	Fall risk
Risk-taking behaviour	[10]	N = 84, C = 84, age = 71–80	Institution	Fall risk
	[24]*	–	–	Several studies: fall risk
	[25]	N = 879, age $\geq 60$	Community	Type A behaviour is a fall risk
Hurrying	[22]	N = 96, age = 60–88	Community	Frequent fallers hurry a lot
Transfer	[10]	N = 84, C = 84, age = 71–80	Institution	Fall risk
Walking	[35]	N = 634, age $\geq 68$	Institution	Main activity during a fall
	[16]	N = 42843, age $< 70$ – $\geq 90$	Institution	Main activity during a fall
	[22]	N = 96, age = 60–88	Community	Main activity during a fall
Standing/Lowering	[35]	N = 634, age $\geq 68$	Institution	Second activity during a fall

N = number of participants, C = control group, n.d. = no data, \*review different studies. Enschede, 2013.

Table 8  
All symptoms and the related studies

Symptoms	Studies	Participants	Residence	Outcomes
Mobility problems	[30]	N = 311, age $\geq 70$	Community	Fall risk
	[19]	n.d.	n.d.	Fall risk
Gait problems	[35]	N = 634, age $\geq 68$	Institution	Difficulty raising foot and misplaced steps increase fall risk
	[22]	N = 96, age = 60–88	Community	Difficulty raising foot and misplaced steps increase fall risk
Slow gait	[18]	N = 145, age $\geq 70$	Institution	Fall risk
	[26]	N = 71, age = 65–87, men	Community	Fall risk
Transfer	[16]	N = 42843, age $< 70$ – $\geq 90$	Institution	Fall risk
Vertigo	[10]	N = 84, C = 84, age 71–80	Institution	Most significant predictor of falling
Use assisting device	[18]	N = 145, age $\geq 70$	Institution	Fall risk
	[35]	N = 634, age $\geq 68$	Institution	Fall risk
	[6]	N = 12684, age $\geq 85$	Community	Fall risk
History of falls	[18]	N = 145, age $\geq 70$	Institution	Fall risk
	[30]	N = 311, age $\geq 70$	Community	Fall risk
	[34]	N = 635, age = 70–105	Institution	Fall risk
	[5]	N = 1000, age = 65–103	Institution	Fall risk

N = number of participants, C = control group, n.d. = no data, \*review different studies. Enschede, 2013.

*also cause a fall by disturbing the gait [20]. But because this is only a hypothesis from one study, this risk is determined to be unsupported.*

– Bad furniture

*Furniture that is not properly altered for the person can increase risk of falling [21]. For example, a seat of a chair that is too low can cause difficulties when standing up.*

### 3.1.3. Behavioural risk factors

The behavioural factors are activity-based. Two types of factors can be recognised: behaviour that causes a fall and activity at the time of the fall. The studies regarding the behavioural risk factors can be found in Table 7.



*Relevant and amendable*

- Hurrying
- Walking
- Standing
- Sitting down and lowering
- Physical inactivity and fear of falling

*Fear of falling and physical inactivity are risk factors for a fall [21]. Between 19 and 25% of the older citizens who fall are afraid to fall once more and acknowledge that they avoid certain activities because of fear of falling [20,22]. Fear of falling may be associated with activity restriction even in non-fallers. Fall-related activity restriction can cause deficiencies in lower limb strength, this was observed in community-dwelling older people. This is correlated with poorer physical performance and reduced maximal muscle strength. This results in more falls and disability [23].*

- Risk-taking behaviour

*In a study among institutionalized older citizens 75% of the falls occurred during risk-taking activities, due to difficulties in appreciation of patient's own functional capabilities [10]. In the community the more vigorous people are more likely to take part in risk-taking behaviour involving household hazards, like changing a light bulb [24]. Type A behaviour is related to taking risks and therefore related to falling. This behaviour is characterized by excessive competitiveness, impatience, hostility and time urgency. Type A behaviour patterns in males was significantly associated with risk of falling [25].*

- Transfer techniques

*Transferring is defined as moving from one to another place. Falls from a wheelchair are often caused by improper transfer techniques [10].*

*3.1.4. Symptoms*

The following symptoms are caused by underlying risk factors. In Table 8 the studies regarding the symptoms can be found.

- Mobility problems

*In a study of mobility among institutionalized older citizens, the highest fall rate was linked to those older citizens who could rise from a chair but could not stand unaided [5]. Moreover, mobility problems can increase fear of falling [23].*

- Gait problems

*Gait is the pattern of limb movement. Gait problems and specifically slow gait are symptoms that can cause falling. Unsure, hesitant, or conscious awareness of leg movements can be indicators of slow walking gait [26].*

- Transfer

*A study among institutionalized older citizens concluded that most falls (41%) occurred during a transfer. Residents who are able to stand but then are unable to maintain an upright posture are at highest risk [16].*

- Vertigo

*Vertigo (dizziness) is stated as the most significant predictor of falling. In many studies dizziness is an indirect risk factor, for example orthostatic hypotension related dizziness causes the fall.*

- Use of assisting devices

- History of falls

#### 4. Discussion

Since fall prevention is a major research theme in Europe, many publications appear on this topic. We had to limit this review study by only looking at certain key words and only searching the titles for presence of these key words. The subjects in the publication had to be community-dwelling or institutionalized elderly of 60 years and older. The threshold of 60 years is used because it is the lowest boundary mentioned in the publications included in the review analysis. Despite these limitations we believe to have found the most important risk factors for falls. The strength of this study is that it gives an overview of all risk factors, intrinsic, extrinsic as well as behavioural. Also symptoms that are caused by risk factors and can cause a fall as well are included. This study also gives a clear distinction between factors that can be influenced, those that cannot, factors of which the importance is debatable because the resulting effects are contradictory and factors that do not have sufficient support in terms of positive research outcome yet.

In this review study the relevant and amendable intrinsic risk factors are: problems with balance, reactive power, muscular strength and dual tasking. Every risk factor is relevant in institutions and the community. A less obvious relevant intrinsic risk factor is sleep disturbance. It is not often examined in studies exploring intrinsic risk factors. The relevance can easily be clarified. Sleep disturbance can result in daytime sleepiness, difficulty in sustaining attention, slow response times, impairments in memory, concentration or decreased (physical) performance. This can increase the risk of falling.

Other intrinsic risk factors may seem relevant but are determined to be inconclusive; studies did not agree on osteoporosis, gender and ADL dependency. Because of their lower bone strength persons with osteoporosis have a higher risk of fall-related fractures which may cause body changes and higher fall risk. Different researchers who investigated participants in the community however do not agree if osteoporosis itself results in a higher fall risk. Several studies in the community and institutions concluded that the female gender is a risk factor, others concluded male gender. Most of the time, however, the studies also referred to other conditions, for example a higher fall risk among women could be explained by the higher life expectancy. This is more related to age than to gender. So, gender as risk factor is most probably only an indirect risk factor. The risk factor ADL dependency or care level is also inconclusive. One reference suggests that people that are ADL dependent have a high fall risk, but another study claims that people with low and medium care fall more often. Further investigation is necessary to provide a solid conclusion for the factors stated inconclusive. The unsupported risk factors (limbness, hearing, alcohol, BMI and smoking) could be further explored as well. Despite the thorough literature search there might be studies not incorporated in this analysis with the given search strategy.

The extrinsic risk factors can be divided in risk factors in the community and in institutions. Risk factors that are considered to be relevant in both locations are bad lighting, slippery floors, inaccessible windows, mobile objects, the afternoon, the location bedroom, bad footwear and clothing. In the community the bathroom and stairs are determined to be risky locations. Bad fitting furniture and high thresholds are risk factors as well. In institutions the change in place of residence in the past two years is a risk factor. The difference between community and institution can be explained as follows. In institutions the hazards stairs, poorly fitting furniture and high threshold are often not present. Moreover, institutionalized persons are often accompanied during washing and going to the toilet. Because the risks in the bathroom are controlled, this results in less falls than in the community. Change in place of residence is a risk factor for institutionalized persons because they are probably not familiar with the new situation and therefore fall more often. This does not apply for community-dwelling older citizens. Looking at the number of risk factors, there are more extrinsic risks in community houses. Institutionalized have lower exposure to hazards as a result of reduced activity, safer environments and increased

supervision [5]. However, the community-dwelling older citizens experience fewer falls (0.5–0.65) per year in comparison with institutionalized older citizens (1.7). This implies that the other risk factors contribute more to falls in institutions.

The behaviour risk factors can be divided in activities and behaviours. The relevant behaviour risk factors are physical inactivity, fear of falling, hurrying and risk taking behaviour. Falls can be caused by inactivity due to deficiencies in lower limb strength. Fear of falling can cause this physical inactivity. On the other hand, taking too many risks or hurrying during certain activities can cause a fall as well. This risk factor only proved to be relevant in the community. In institutions people will probably hurry less because the environment is more controlled by supervisors. Falls occur most of the time during the activities walking and transferring, followed by standing and lowering. A fall during walking and lowering can be caused by all risk factors and falling while standing is probably caused by intrinsic risk factors. Transferring can be caused by improper transfer techniques. This risk factor is only found in a study among institutionalized older citizens. Bad transfer techniques probably occur more in institutions because often people at home are healthier and do not need a transfer.

Besides risk factors several studies focused on symptoms: problems with mobility, gait, transferring, vertigo, use of assisting devices and history of falls. The studies did not look at the underlying reason for the fall. For example gait problems can be caused by weak muscles in the lower extremities but gait can also be disturbed by bad shoes. To prevent falling, the risk factors behind the symptoms are more important because these can be tackled by fall preventive measures. Further investigation about these underlying reasons is therefore necessary.

Two risk factors must be considered in the context of the potential benefit. Use of certain medicine and use of assisting devices. Benzodiazepine and non-benzodiazepine can contribute to residual daytime sleepiness and other side effects such as psychomotor impairments, amnesia and sedation. Those factors can cause falling [8]. But, these medications are taken for sleep disturbance and sleep disturbance has a higher influence on falls than hypnotic use [9]. This argument also counts for antidepressants taken by depressive persons as depressive persons are at high risk for a fall as well [10]. If people use assisting devices they have a higher fall risk. But, people use these devices for a reason, without them they would probably fall more often or could not walk at all.

## 5. Conclusion

The most important intrinsic risk factors are muscle strength, balance, reactive power, dual tasking and sleep disturbance. All factors are proven to be significantly increasing the fall risk in both the community and institutions. Relevant extrinsic risk factors are home hazards, wrong use of assistive devices and bad footwear. The behavioural factors can be divided in two types: behaviour that causes a fall and activity at the time of the fall. Behaviour-related risk factors are hurrying, risk taking, physical inactivity and fear of falling. The main activities during a fall are walking and transferring, followed by standing and lowering. Symptoms that are proven to be relevant but which are caused by underlying risk factors are mobility problems, gait problems, vertigo, use of assisting devices and history of falls. The provided overview of all relevant risk factors can be used to identify opportunities for fall prevention measures for older citizens.

## Conflicts of interest

The authors declare that there are no conflicts of interest.

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