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Physical activity and falls in older persons : development of the balance control difficulty homeostasis model

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Chapter 1

Introduction

Incidence and consequences of falls

Among older persons many falls¹ happen each year which have a serious impact on their health, independence and wellbeing. Several studies showed that about one third of community dwelling older persons in the age of 65 years and over fall each year at least once as shown in table 1.

Table 1 *Percentage of fallers among older persons participating in six different studies*

Study	Country	Target group N; Age in years	Study design	Percentage Fallers
Prudham, D (1981) ²	UK	N=2793 65+	Retrospective study (1 year)	28%
Campbell, AJ (1981) ³	New Zealand	N=553 65+	Retrospective study (1 year)	33%
Tinetti, ME (1988) ⁴	USA	N=326 70+	Telephone Interview	32%
Blake, AJ (1998) ⁵	UK	N=1042 65+	Retrospective study (1 year)	35%
Downton, JH (1991) ⁶	UK	N=203 75+	Retrospective study (1 year)	42%
Stalenhoef, PA (2002) ⁷	The Netherlands	N=311 70+	Telephone interview (1 year)	33%

The agreement between the percentages of falls in the different studies is remarkable if we consider that these studies were conducted in various countries where physical activity patterns and environmental circumstances may vary substantially. For instance in The Netherlands, many older persons are used to frequent outdoor walking and bicycling as in the USA traveling may be more often performed by car. In addition, climate and pavement conditions may vary significantly between countries. In line with the data in table 1, in international reviews it is generally postulated that about 30% of older persons aged 65 years and older fall at least once each year.^{8,9} This implicates that falling is an event that happens to a large proportion of older persons, but the frequency per person per year is generally low. Two thirds of all fallers during a year only fall once.¹² Although this might imply that for most older persons falling does only occur occasionally, its consequences may be serious. Approximately 10% of all falls result in serious injury,^{13,14} of which 50% are fractures.^{4,13,14}

¹ As recommended by the Prevention of Falls Network Europe (ProFaNE) and Outcome Consensus Group, a fall should be defined as 'an unexpected event in which the participants come to rest on the ground, floor, or lower level'.^{10,11}

Consequently, falls put a heavy burden on the health of individual older persons and on the capacity of the healthcare system in many countries.

In the Netherlands, due to a fall about 86,000 older persons (55+) are treated each year by a general practitioner, 88,000 are treated at the emergency room of hospitals, 32,000 are admitted to the hospital and 1,800 falls are fatal.¹⁵

At the European level no direct figures are available about hospital admission due to falls among older persons (55+). Therefore, an estimation is made from the following available data. In the EU region of 27 countries every year about 5.5 million elderly (65+) sustain an injury severe enough to seek medical care, out of whom about 2 million are ending up in a hospital.¹⁶ It is estimated that older adults (65+) are hospitalized for fall-related injuries five times more often than they are for injuries from other causes.¹⁷ Therefore, in the EU each year about 1.6 million older adults are admitted to the hospital after a fall. In addition, in the EU region of 27 countries, there are probably nearly 40,000 deaths from falls among elderly each year.¹⁶ Persons at high age are at highest risk for fatal falls; persons aged 80 and over have a 6-fold higher mortality compared to elderly 65-79 years, as they are not only more likely to fall but also more frail than those aged 65-79.¹⁶

Apart from the injurious consequences, falls can also have serious social and psychological consequences. Recurrent falls are a common reason for admission of previously independent older persons to long-term care institutions.^{18,19} Fear of falling and the post-fall anxiety syndrome are also well recognized as negative consequences of falls. The loss of self-confidence to ambulate safely can result in self imposed functional limitations.²⁰⁻²² This tendency further contributes to deconditioning, weakness and abnormal gait and in the long run may actually increase the risk of falls.²³ In the next section factors that contribute to the risk of falling are presented.

Risk factors for falls

The variety of proposed risk factors for falls is huge, over 400 potential risk factors are suggested.²⁴ This large number reflects the complexity of the aetiology of falls as well as the lack of theoretical frameworks of falls causation which might limit the number of factors which should be addressed in risk factor analysis. Review studies on risk factor analyses for falls showed however, that a selection of main risk factors can be identified. In table 2 these fall risk factors, and their relative importance, are listed as reported by Rubenstein.²³

Table 2 Important individual risk factors for falls: summary of 16 controlled studies

Risk factor	Significant/ Total ^a	Mean RR-OR ^b	Range of RR-OR ^d
Muscle weakness	11/11	4.9 (8) ^c	1.9–10.3
Balance deficit	9/9	3.2 (5)	1.6–5.4
Gait deficit	8/9	3.0 (5)	1.7–4.8
Visual deficit	5/9	2.8 (9)	1.1–7.4
Mobility limitation	9/9	2.5 (8)	1.0–5.3
Cognitive impairment	4/8	2.4 (5)	2.0–4.7
Impaired functional status	5/6	2.0 (4)	1.0–3.1
Postural hypotension	2/7	1.9 (5)	1.0–3.4

^a Number of studies with significant association/total number of studies looking at each factor.

^b Relative risks (prospective studies) and odds ratios (retrospective studies).

^c Number in parenthesis indicated the number of studies that reported relative risks or odds ratios.

^d Range of Relative Risks or Odds Ratio's found in the studies reporting them (c).

Rubinstein showed that the most important of these risk factors is muscle weakness, with mean RR-OR of 4.9; indicating an increased risk of falling for persons with muscle weakness. Also problems with balance and gait were identified as important risk factors. Not included in table 2 is the use of medications, particularly the psycho-active medications, which has also been identified as a risk factor for falls (RR= 1.5-1.7).²³

The risk factors for falls that are established are mainly related to health deficits (also called intrinsic factors) which reduce the capability of older persons to control balance, as shown in table 2.²³ However, one might also expect that influences from the environment on balance control of older persons, like obstacles on pavements and skiddyness of floors may determine the risk of falling. From research, the evidence for the impact of these environmental (also called extrinsic) factors on the risk of falling among older people is limited.⁹ Some studies have reported that between 30% and 50% of falls among community dwelling older people are due to environmental causes and others that 20% of falls are due to major external factors (those that would cause any healthy adult to fall).^{25,26}

Extrinsic risk factors include:

- Environmental hazards (poor lighting, slippery floors, uneven surfaces, etc.),²⁶
- Footwear and clothing,²⁶
- Inappropriate walking aids or assistive devices.²⁷

In addition to the intrinsic and extrinsic risk factors for falls a third factor is involved in the risk of falling. This third factor is a behavioural factor which represents the exposure to the danger which is formed by the reduced balance control capability and/or balance control demands as presented in figure 1. The conceptual relevance of exposure can be illustrated by taking the example of a person who has reduced balance control capability but at the same time avoids climbing stairs and walking in crowded areas. By avoiding the exposure to these demands, the person has lower falls risk compared to a comparable person who does not avoid them. In the extreme situation that a person is not exposed to any of the intrinsic and extrinsic risk factors the falls risk equals zero.

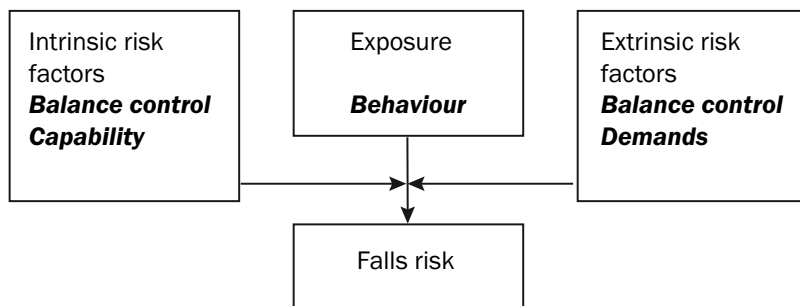


Figure 1 *Main clusters of risk factors for falls (intrinsic, extrinsic) and the involvement of exposure as a precondition for falls risk being >0*

Therefore, exposure to a danger is a precondition for an accident (fall) to happen. However, the issue of exposure to accident (falls) and injury risk is only very seldom addressed in the field of falls research. Therefore, special attention is given to this issue in the following section.

Accident or injury risk and exposure

From a general perspective, the safety of a system (or person) is the product of the probability of having an accident or injury given a unit of exposure (also called accident or injury risk) and the observed level of exposure.²⁸ A unit of exposure can be regarded as a trial. The result of such a trial is the occurrence or non-occurrence of an accident.²⁹

In most of the domains of injury prevention (traffic, occupation and sports, consumer

products), several expressions are applied to indicate the accident or injury risk. First of all, the population incidence (number of cases per 1000 person-years) is used, but also the number of cases per 1000 person-hours of involvement in related activities.³⁰⁻³³ In traffic also the number of cases per 1000 person-miles driven is used as an expression of accident risk.^{30,34,35} The denominator in each of the expressions, except for the population incidence, is used as a measure of exposure to the danger that is involved in participation in the activities related to the domains.

The significance of including exposure data in risk analysis is addressed by Hale and Glendon³⁶: “If a person carries out a particular activity many times and occasionally it goes wrong enough to result in an accident, very different interventions will be necessary to improve matters, compared with instances where a person carries out an activity infrequently, but it almost always goes wrong. Data on the exposure to the hazard or on demands for specific actions must therefore form as fundamental a part of the analytical database of health and safety as records of accidents and occupational diseases.”³⁶

Within the domain of home accidents, measures of exposure are not commonly applied and reported in literature. Specifically, in the field of falls prevention among older persons, the risk of falls is commonly only expressed as the number of falls or fallers per 1000 person-years, as recommended by Gillespie³⁷ and Lamb et al.¹⁰

No measure of exposure to falls risk is applied in this field, although Todd and Skelton⁹ addressed the issue within the discussion on risk factors: “Some studies suggest a U-shaped association, that is, the most inactive and the most active people are at the highest risk of falls.^{38,39} This reveals the complex relationship between falls, activity and risk. The type and extent of environmental challenges that an older person chooses to embrace interact with the person’s intrinsic risk factors.”⁹ According to Skelton⁴⁰ and Jorstad-Stein et al.,⁴¹ apart from beneficial balance control effects, the level of physical activity of persons can be regarded as a general measure of their exposure to hazards which put demands on balance control.

These arguments suggest that older persons might reduce their falls risk by withdrawing from physical activities which they perceive as too dangerous (too demanding) compared to their capability to control their balance. Stated this way, it means that persons might mask their difficulty in controlling their balance by reducing exposure to hazards (i.e.: by reducing physical activity).

In conclusion, the relevance of exposure to hazards as a factor which is involved in falls risk is generally acknowledged, but it has not been addressed systematically in scientific research. Therefore, it seems that in falls risk assessment the apparent significance of exposure requires further exploration. In this thesis this issue will be addressed as described in the next section.

Aim and outline of the thesis

The aim of the thesis is to explore, for falls risk research in older persons, the significance of the level of physical activity as a measure of exposure.

Three prospective follow-up studies were performed which contributed to this exploration in the period between 1994 and 2005. The main characteristics of these studies are listed in table 3.

Table 3 *Main characteristics of the prospective follow-up studies from which the data were used in several chapters of this thesis.*

Prospective follow-up study	Start, Follow up period, Community	Number and age of participants*	Type of participants	Falls registration	Data used in Chapters
'Safety observed study' (Wijlhuizen et al.) ⁴²	1994, 15 months, Leiden	1055 (65+)	Community dwelling	Telephone each month	2,5
'Safety in your own hands study' (Wijlhuizen et al.) ⁴³	1999, 2 x 10 months, Sneek, Heerenveen, Harlingen.	2080 (65+)	Community dwelling	Telephone each month	2,3,4,5
'Heerenveen night time falls prevention study' (Wijlhuizen) ⁴⁴	2004, 10 months, Heerenveen, Smalingerland.	771 (70+)	Community dwelling	Telephone each month	5,7

* At the start of the follow-up period

Before conducting the first prospective cohort study, the 'Safety Observed Study',⁴² in 1994, we required an innovative approach for longitudinal registration of falls among older persons. The main argument was that frequent registration among about 1000 older persons would require very time-consuming procedures if it was performed as usual by mail (diaries) or personal telephoning. Therefore, we developed and applied a new method to register falls in large cohorts of older community dwelling persons, using interactive voice response technology: the Telephony Inquiry System (TIS).

In chapter 2 the procedures and some results of the application of the TIS are reported, indicating its feasibility as a method for falls registration.

In 1999, we applied the TIS in the 'Safety in your own hands study'.⁴³ In this study, which is described in chapter 3, we evaluated the effect of a multifactor community intervention to reduce falls among older persons in Sneek in comparison to two

control communities (Harlingen and Heerenveen). The results of this study were interpreted by suggesting that in Sneek the intervention resulted in changes in indoor and outdoor physical activity (exposure), compared to the control group. At the same time, we assumed a relationship between the level of outdoor and indoor physical activity and the number of outdoor and indoor falls. No such data were found in literature, indicating the need for studies on the relationship between outdoor and indoor physical activity (exposure) and falls. Therefore we conducted two such studies, which are described in the chapters 4 and 5.^{a,b}

In chapter 4, the association between the 24 hour distribution of the level of physical activity in the home and falls in the home is addressed. Subsequently, in chapter 5^a the relationship between the level of outdoor physical activity (walking and bicycling) and outdoor falls during walking and bicycling is explored. Chapter 5^b is a rebuttal on two letters which questioned the correct use of the term 'mediation' in our paper; the authors expressed in their letters the need for theoretical considerations about the causal relationship between fragility, fear of falling, physical activity and falls. Because no such causal model was available from literature, a general outline of a hypothesized causal model of falls is described in this chapter. Subsequently, a more elaborate conceptual model of falls is formulated in chapter 6, from the perspective of individual behaviour in the control of balance; the Balance control Difficulty Homeostasis model of falls (BDH-model). This new model is derived from the TCI model of Fuller,⁴⁵ about driver behaviour. Based on the BDH-model, the application of a measure of exposure in the outcome variable in falls research is advocated.

Finally, in a prospective follow-up study, the 'Heerenveen nighttime falls prevention study',⁴⁴ data on balance control difficulty, physical activity and falls were obtained. Based on these data, in chapter 7 we compared two falls risk outcome measures in relation to balance control difficulty; the incidence of falls per 1000 person-years and per 1000 physically active person-days. In chapter 8 the main results of the studies are summarized and discussed.

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