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# Falls and dizziness in frail older people

Predictors, experiences and the effects of  
a case management intervention

Ulrika Olsson Möller



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<p>Abstract</p> <p>Falling in old age may have a large impact on daily life. Falls can lead to injuries, reduced mobility and reduced quality of life. The risk of falls increases with age and frailty level. Dizziness is a strong risk factor for falls, and preventing falls and dizziness in older people is essential. The overall aim of this thesis was to investigate risk factors for falls or dizziness and to explore older people's experiences of living with chronic dizziness. Furthermore, the aim was to evaluate the effects of a home-based case management intervention on falls in frail older people. The thesis comprised three studies. Study I was a longitudinal cohort study, the Swedish National Study on Aging and Care (SNAC), with 1,402 participants in 10 age cohorts from 60 to 96 years. The study started in 2001 and follow-up was done after 3 and 6 years. The sample was divided into subjects aged 60-78 years and 80-96 years and the prevalence and predictors of falls or dizziness were investigated (Paper I). Study II was a qualitative study exploring the experiences of living with chronic dizziness in old age and included 13 people (7 women and 6 men, aged 73 to 87 years). Interviews were conducted and were analysed by content analysis (Paper II). Study III was a randomized controlled trial (RCT) including 153 participants randomly assigned to a case management intervention (n=80) or a control group (n=73). The study included people aged 65+ years who lived in their ordinary homes with functional dependency and repeated health care contacts. The intervention included home visits by a nurse and a physiotherapist at least once a month during 12 months. Data from this study were used in two papers. Paper III investigated predictive validity for falls and optimal cut-off scores for the Downton Fall Risk Index (DFRI), Timed Up and Go (TUG) and the Romberg Test (RT). Paper IV investigated the effects of the case management intervention on falls, injurious falls and falls resulting in medical care.</p> <p>The results in Paper I show almost doubled prevalences in the older age cohort. In the younger age cohort 16% reported falls and 18% reported dizziness. In the older age cohort 32% reported falls and 31% reported dizziness. The strongest predictors differed between the age cohorts. The strongest predictors for falls were use of neuroleptics and personal activities of daily living (PADL) in the younger age cohort, and history of falling and instrumental activities of daily living (IADL) in the older age cohort. The strongest predictors for dizziness were history of dizziness and feeling nervous (younger age cohort) and history of dizziness and history of falling (older age cohort). In Paper II the experiences of the interviewees were interpreted as fighting for control in an unpredictable life. This included fumbling for a cure and improvements, struggling to maintain an ordinary life and a restricted everyday life with constant threats. Health care had not been able to meet the needs of older people with chronic dizziness. The results in Paper III show that no test had high predictive validity for falls. DFRI (cut-off <math>\geq 3</math> points) and TUG (cut-off <math>\geq 12</math> seconds) showed about 80% sensitivity and 30% specificity. RT show low sensitivity and is not recommended to be used in frail older people at home. The home-based case management intervention in Paper IV did not show any effect on falls, injurious falls and falls resulting in medical care.</p> <p>Falls and dizziness are common, serious health complaints in frail older people and deserve attention. The complex interaction between falls, dizziness and related factors suggests that fall prevention interventions should be individualized. Older people with chronic dizziness have, in spite of frequent health care contacts, needs that are unmet. Besides identifying and treating the underlying cause of dizziness, managing older people with dizziness may also focus on appropriate coping strategies in daily life and should not end until the individual has regained control of their daily life. DFRI and TUG were not able to correctly identify people with and without a high fall risk. They may be used as screening tools, but a comprehensive assessment of a person's risk factors for falls is needed before a fall prevention intervention is introduced. Preventing falls in frail older people is challenging. The home-based case management intervention did not show any effect on falls, injurious falls and falls resulting in medical care, and further research is needed on how to prevent falls in frail older people living at home.</p>		
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Predictors, experiences and the effects of  
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*Till alla goa gummor och gubbar*



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# Abstract

Falling in old age may have a large impact on daily life. Falls can lead to injuries, reduced mobility and reduced quality of life. The risk of falls increases with age and frailty level. Dizziness is a strong risk factor for falls, and preventing falls and dizziness in older people is essential. The overall aim of this thesis was to investigate risk factors for falls or dizziness and to explore older people's experiences of living with chronic dizziness. Furthermore, the aim was to evaluate the effects of a home-based case management intervention on falls in frail older people.

The thesis comprised three studies. Study I was a longitudinal cohort study, the Swedish National Study on Aging and Care (SNAC), with 1,402 participants in 10 age cohorts from 60 to 96 years. The study started in 2001 and follow-up was done after 3 and 6 years. The sample was divided into subjects aged 60-78 years and 80-96 years and the prevalence and predictors of falls or dizziness were investigated (Paper I). Study II was a qualitative study exploring the experiences of living with chronic dizziness in old age and included 13 people (7 women and 6 men, aged 73 to 87 years). Interviews were conducted and were analysed by content analysis (Paper II). Study III was a randomized controlled trial (RCT) including 153 participants randomly assigned to a case management intervention (n=80) or a control group (n=73). The study included people aged 65+ years who lived in their ordinary homes with functional dependency and repeated health care contacts. The intervention included home visits by a nurse and a physiotherapist at least once a month during 12 months. Data from this study were used in two papers. Paper III investigated predictive validity for falls and optimal cut-off scores for the Downton Fall Risk Index (DFRI), Timed Up and Go (TUG) and the Romberg Test (RT). Paper IV investigated the effects of the case management intervention on falls, injurious falls and falls resulting in medical care.

The results in Paper I show almost doubled prevalences in the older age cohort. In the younger age cohort 16% reported falls and 18% reported dizziness. In the older age cohort 32% reported falls and 31% reported dizziness. The strongest predictors differed between the age cohorts. The strongest predictors for falls were use of neuroleptics and personal activities of daily living (PADL) in the younger age cohort, and history of falling and instrumental activities of daily living (IADL) in the older age cohort. The strongest predictors for dizziness were history of dizziness and feeling nervous (younger age cohort) and history of dizziness and history of falling (older age cohort). In Paper II the experiences of the interviewees were interpreted as fighting

for control in an unpredictable life. This included fumbling for a cure and improvements, struggling to maintain an ordinary life and a restricted everyday life with constant threats. Health care had not been able to meet the needs of older people with chronic dizziness. The results in Paper III show that no test had high predictive validity for falls. DFRI (cut-off  $\geq 3$  points) and TUG (cut-off  $\geq 12$  seconds) showed about 80% sensitivity and 30% specificity. RT show low sensitivity and is not recommended to be used in frail older people at home. The home-based case management intervention in Paper IV did not show any effect on falls, injurious falls and falls resulting in medical care.

Falls and dizziness are common, serious health complaints in frail older people and deserve attention. The complex interaction between falls, dizziness and related factors suggests that fall prevention interventions should be individualized. Older people with chronic dizziness have, in spite of frequent health care contacts, needs that are unmet. Besides identifying and treating the underlying cause of dizziness, managing older people with dizziness may also focus on appropriate coping strategies in daily life and should not end until the individual has regained control of their daily life. DFRI and TUG were not able to correctly identify people with and without a high fall risk. They may be used as screening tools, but a comprehensive assessment of a person's risk factors for falls is needed before a fall prevention intervention is introduced. Preventing falls in frail older people is challenging. The home-based case management intervention did not show any effect on falls, injurious falls and falls resulting in medical care, and further research is needed on how to prevent falls in frail older people living at home.

# Thesis at a glance

Study	Aim	Method	Results
I	<p>What are the prevalences of falls and dizziness in different age cohorts in older people?</p> <p>Do predictors of falls and dizziness differ between different age cohorts in older people?</p>	<p>Longitudinal cohort study including 1402 participants in 10 age cohorts (60-96 years, mean age 76.7 [SD 10.2], 58% women). The sample was split in aged 60-78 years of age and aged 80-96 years of age.</p> <p>Multiple logistic analysis with independent variable (falls vs. no falls, dizziness vs. no dizziness) at the 3- and 6-year follow-ups and risk factors for falls or dizziness at baseline</p>	<p>A quarter of the participants reported falls or dizziness, with an almost doubled prevalence in the older age cohort.</p> <p>The strongest predictors for falls or dizziness, respectively, differed between the age cohorts. For falls: use of neuroleptics and PADL vs. history of falling and IADL. For dizziness: dizziness and feeling nervous vs. history of dizziness and history of falling.</p>
II	<p>How do older people experience living with chronic dizziness?</p>	<p>Thirteen individual interviews in 7 women and 6 men (aged 73-87 years of age) with chronic dizziness (<math>\geq 3</math> months), analysed with content analysis</p>	<p>Living with chronic dizziness in old age was interpreted as fighting for control in an unpredictable life.</p> <p>This included fumbling for a cure and improvements, struggling to maintain an ordinary life and a restricted everyday life with constant threats.</p> <p>Health care has not been able to meet the needs of older people with chronic dizziness.</p>

<p>III</p>	<p>What is the predictive validity for falls of the Downton Fall Risk index (DFRI), Timed Up &amp; Go (TUG) and Romberg test (RT) when they are used in in-home assessments in frail older people?</p> <p>Which are the optimal cut-off scores for the scales?</p>	<p>Prospective study including 153 participants (66-94 years, mean age 81.5 [SD 6.39], 67% women).</p> <p>Physical performance tests at baseline and number of falls during a 1-year follow-up</p>	<p>No test showed high predictive validity. DFRI cut-off <math>\geq 3</math> points) and TUG (cut-off <math>\geq 12</math> seconds) showed 80% sensitivity and 30% specificity. It is not recommended that RT be used in this context.</p>
<p>IV</p>	<p>What are the effects on falls of a 1-year case management intervention in people aged 65+ years living at home who have functional dependency and repeated health care contacts?</p>	<p>RCT including 153 participants (66-94 years, mean age 81.5 [SD 6.39], 67% women). Intervention group (IG) n=80, control group (CG) n=73.</p> <p>Number of falls, injurious falls, falls resulting in medical care during a 1-year follow-up</p>	<p>There were no statistically significant differences between the IG and the CG in falls, injurious falls or falls resulting in medical care.</p>

# Original papers

- I Olsson Möller U, Midlöv P, Kristensson J, Ekdahl C, Berglund J, Jakobsson U. Prevalence and predictors of falls and dizziness in people 60 years and older: a longitudinal cohort study. *Archives of Gerontology and Geriatrics*. 2013; 56 (1):160–8.
- II Olsson Möller U, Ekvall Hansson E, Midlöv P, Ekdahl C, Jakobsson U, Kristensson J. Fighting for control in an unpredictable life - a qualitative study of older persons' experiences of living with chronic dizziness. [Re-submitted to *BMC Geriatrics* 2014 July 29].
- III Olsson Möller U, Kristensson J, Midlöv P, Ekdahl C, Jakobsson U. Predictive validity and cut-off scores in four diagnostic tests for falls – a study in frail older people at home. *Physical & Occupational Therapy in Geriatrics*. 2012; 30(3): 189–201.
- IV Olsson Möller U, Kristensson J, Midlöv P, Ekdahl C, Jakobsson U. Effects of a one-year home-based case management intervention on falls in older people: A randomized controlled trial. *Journal of Aging and Physical Activity* 2013 Oct 23. [Epub ahead of print].

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# Abbreviations and definitions

## Abbreviations

ADL	Activities of daily living
CG	Control group
CM	Case manager
DFRI	Downton Fall Risk Index
IADL	Instrumental activities of daily living
HRQoL	Health Related Quality of Life
ICF	International Classification of Functioning, Disability and Health
IG	Intervention group
ITT	Intention-to-treat
MRC	Medical Research Council
PADL	Personal activities of daily living
PT	Physiotherapist
RCT	Randomized controlled trial
RT	Romberg test
SF-12	Short Form – Health Survey
SNAC	Swedish National Study in Aging and Care
SRT	Semi tandem Romberg test
TRT	Tandem Romberg test
TUG	Timed Up & Go
WHO	World Health Organisation

## Definitions

Dizziness In Paper I dizziness is an umbrella term for various dizziness diagnosis and symptoms were the reason behind the perceived sensation of dizziness is unknown.

Fall	‘A fall is an unexpected event in which the participants come to rest on the ground, floor, or lower level’ Lamb et al. (2005)
Frail	In Study III-IV people with IADL dependency and repeated health care contacts.
Older people	In Study I aged 60 + years and in Study II-IV aged 65+ years.
Aging in place	The ability to live in one’s own home and community safely, independently, and comfortably, regardless of age, income, or ability level.



# Introduction

Preventing falls has in the last few decades been an important subject on the agenda for physiotherapists working with older people. Falls are no longer seen as an inevitable effect of the aging process, but instead as something that can to a great extent be prevented [1, 2]. Falls in older people affect the individual as well as society and a growing elderly population means that falls are a major public health concern. The risk of illness and functional decline increases with age and, as a consequence, so does the risk of falling [3]. Globally, approximately one third of older people fall each year [4] and Swedish studies have shown prevalences of 11.5% and 41% depending on sample characteristics and settings [5-7]. The number of falls increases with age and women are more prone to fall than men. Several risk factors for falls exist, such as a history of falls, dizziness, impaired balance and mobility, and medications [1, 3, 4]. Falling occurs when a person is incapable of maintaining postural and dynamic stability. Severe consequences of a fall can be fall-related injuries such as hip, pelvis or distal arm fractures and falls are associated with increased morbidity and mortality. Other consequences of a fall can be a fear of falling, leading to activity restriction and a reduced quality of life. The consequences of falls are also associated with high health care costs and preventing falls is beneficial for the individual as well as for society [3, 4, 8].

When I worked with fall prevention in my clinical work as a physiotherapist in municipal care for older people, I met many older people with dizziness. A common symptom in older people, dizziness is a strong risk factor for falls and is associated with functional disability, poor self-rated health and reduced quality of life [9-11]. The prevalence varies and Swedish studies have shown prevalence rates of 29-50% depending on sample characteristics, how data was collected and how dizziness was defined [12-14]. Dizziness increases with age and is more common in women than in men. Dizziness in older people may not be manifested in the same way as in young people and the multiple causes of dizziness in older people, such as cardiovascular diseases, neurological diseases or peripheral vestibular disorders, make treating older people with dizziness a challenge. Dizziness gives a feeling of unsteadiness that in turn might lead to inactivity and impaired physical function, further increasing the risk of falls [15-17].

Interventions to prevent falls in older people should be multifactorial, which means that several components should be included [1]. Exercise is one of the most important components and one which puts fall prevention on the physiotherapeutic agenda.

Exercise improves physical function and thereby reduces the risk of falls [18]. The exercise components of fall preventive interventions should include strength and balance exercises and group or home-based exercise significantly reduces the risk of falling and of fall-related fractures. Other factors that should be included in fall preventive interventions are medication review, home safety assessment and modification of environmental risk factors, or aids for personal mobility. It is recommended that fall preventive interventions be delivered by a multi-professional team [1, 3, 4, 8].

Fall preventive interventions in older people have been studied in different health care organizations: hospitals, primary health care centres as well as nursing homes. Recommendations for fall prevention interventions in community-dwelling older people mainly address fairly healthy and independent older adults [1]. Although older people today stay healthier for longer, more and more frail older people live at home instead of in nursing homes due the concept of “Aging in place” [19]. This means that people with a high risk of falls live at home, but there is no consensus on effective fall prevention interventions in this context. Thus, more knowledge is needed on how to prevent falls and dizziness and how to support frail older people living at home.

# Background

## Aging

The process of aging is individual due to genetic and contextual factors, and a person's level of functioning is not only related to their chronological age. The functional decline with age is affected by others factors such as disease or inactivity. In many Western countries the standard retirement age of 65 years is considered to be the chronological definition of old. However, because of the large heterogeneity in biological, social and psychological aspects people aged 65+ years have chronologically been divided into third and a fourth ages [20]. These ages are not tied to a specific age range but are dynamic and moving targets [20]. However, in developed countries the distinction between the third and fourth ages is usually around 80-85 years. Chronological as well as biological, psychological and social aspects are separate dimensions of the complex dimension that is aging. Biological aging is described in terms of complex cellular and molecular changes in the organism [21] and is divided into primary aging, i.e. irreversible changes in bodily systems (genetics), and secondary aging, i.e. external/environmental factors (lifestyle) [22]. In the psychological aging process the last phase in life is marked by integrity or despair. Integrity incorporates a feeling of a meaning in life while despair means a feeling of stagnation and a resistance towards the end of life [23]. Psychological aging has also been described from a social point of view as entering a new social role in old age [24].

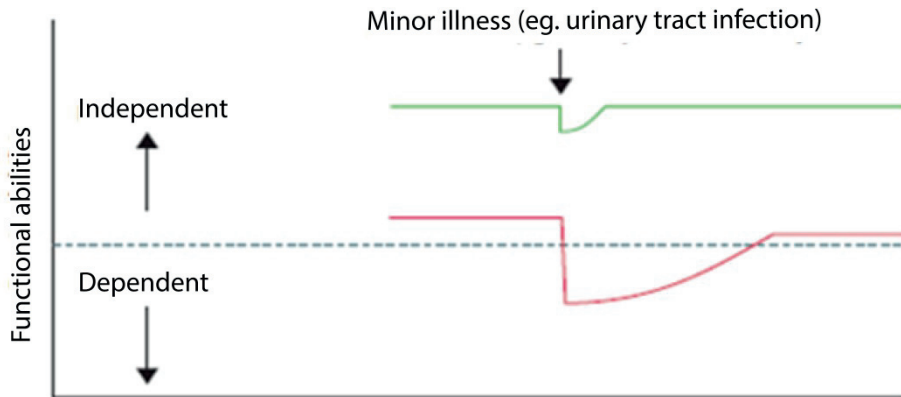
The number of older people is, in the developed world, expected to increase from 278 million in 2013 to 417 million by 2050 and 440 million in 2100 [25]. The population aged 80+ years is expected to increase from 8 million in 1950 to 214 million in 2050 [26]. Over the past 50 years the number of people in Sweden 65 years and older has more than doubled, from 700,000 to nearly 1.6 million, and in the coming decades this group will continue to grow. In 2030 a fifth of the Swedish population will be aged 65+ years [27]. During the lifespan some processes decline while others develop. In general, the older population is healthy, but the aging processes itself and the increase in the number of diseases and health complaints with age eventually generate a transition from functioning to disability. Disability is associated with morbidity and dependency [28] and increased health care costs due to this higher dependency [29]. As the aging population is increasing the number of people facing disability will increase.

Disability is a central concept in the International Classification of Functioning, Disability and Health (ICF), a classification system and framework to describe health and health-related states [30]. The ICF focuses not only on the cause of a disease, but also on the impact. Functioning refers to all body functions, activities and participation while disability similarly is an umbrella term for impairment, activity limitations and participation restrictions [30]. During the aging process, bodily impairments may lead to activity limitations and participation restrictions. However, since a person's level of functioning at old age is, not only affected by genetic factors and diseases, but also by life style factors, a person's functional decline can to a certain degree be prevented. Health promotion defined by the World health Organization (WHO) as "the process of enabling people to increase control over their health and its determinants, and thereby improve their health" [31], covers a wide range of strategies to promote health, where physical activity and exercise are main strategies. Physical activity and exercise have the ability to prevent diseases and disability, and postpone the negative effects of the aging in an ageing global society.

## Frailty

There are different explanations for why the body ages. The aging process has been described as a lifelong accumulation of molecular damage [32]. This process is regulated by genetic mechanisms for maintenance and repair. Deficits accumulate with age across the whole adult spectrum and even though the aging process is individual, the chances of complete recovery from illness decline with age [33]. As the accumulation continues, the effects on the body are finally revealed as age-related disability, disease and frailty [32]. Frailty has no clear definition, but usually relates to older people with multiple diseases and a vulnerability to sudden changes in health status after minor stressors. Frailty in older people is associated with a high risk of mortality, institutionalization, greater use of health care services and falls [33, 34]. Recently Clegg et al (2013) defined frailty as "a state of increased vulnerability to poor resolution of homeostasis after a stressor event, which increases the risk of adverse outcomes, including falls, delirium and disability" [35] (Figure 1). It is a consequence of age-related, cumulative declines in many physiological systems. Frail older people undergo a larger deterioration when struck by illness and are less likely to regain the same functional and physical ability as before the stressor event [35]. The complexity of frailty was shown when linking patterns of frailty to ICF [36]. The clinical manifestation of frailty was described as an unstable health condition with a decline in different levels such as impaired vision or hearing (impairments of the body's structure/function) or decreased mobility (activity limitations). Although frailty and disability frequently coexist, and may contribute to each other, they belong to different concepts [37]. Frailty indicates instability and decreased reserve capacity

in several organ systems, and disability indicates loss of function [38]. This indicates that interventions to frail older people may have the possibility to prevent or postpone disability.



**Figure 1.** Vulnerability of frail older people to a sudden change in health status after a minor injury. ©

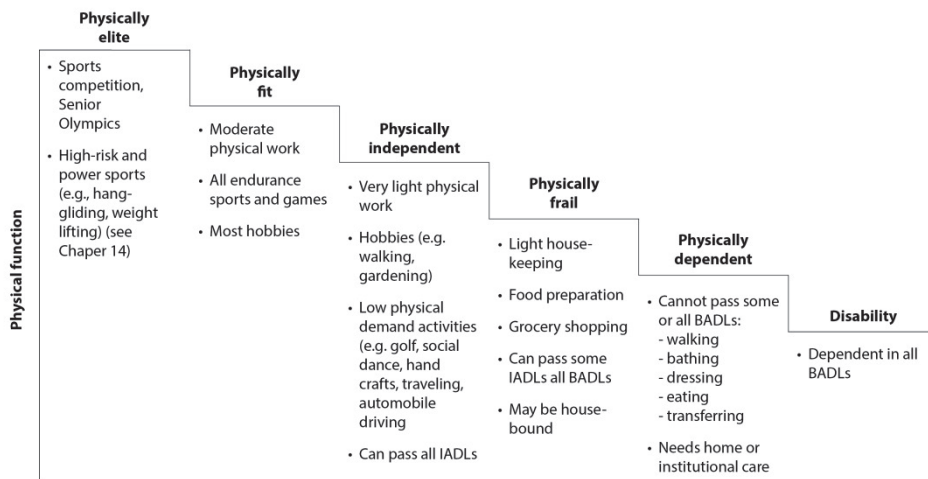
The non-frail individual (green line) has a small deterioration in function and returns to homeostasis after a minor stressor event. After a similar stressor event, the frail individual (red line) undergoes a larger deterioration and does not return to baseline homeostasis. This may manifest as functional dependency. Source: Clegg et al. [35].

Due to differences in the operationalization of frailty, prevalence rates vary greatly between different studies [39]. In a review that mainly included Western countries the prevalence rates ranged from 4.0% to 59.1%, with a weighted average prevalence of 9.9% [39]. A study [40] including 16,584 people aged 50+ years in ten European countries (Sweden included), showed a prevalence rate of 4.1% in people aged 50-64 years and 17.0% in those aged 65+years. Women were more frequently frail than men ( $p < 0.001$ ). In the 1,911 Swedish participants the prevalence rates were 1.9% and 8.6%, respectively. [40]. A study from the USA showed a prevalence of frailty of 7.2% in the total sample of people aged 65+ years ( $N=5,317$ ), with a prevalence of 3.2% in those aged 65-70 years, 9.5% in those aged 75-79 years and 27.7% in those aged 85-89 years [34]. Frailty was significantly more frequent in women than in men ( $p < 0.001$ ) [34].

Although the complex concept of frailty has been included in physical, physiological, cognitive and psychosocial characteristics and functions [35, 36, 41], a phenotype of physical frailty was described in one study as having three or more of the following five characteristics; unintentional weight loss, self-reported exhaustion, weak grip strength, slow walking speed and low physical activity [34]. The study included 5,317



persons 65 years and older of whom 7% (n=368) were considered to be frail. Frailty significantly increased the risk of falling [34]. Another definition of physical frailty included severely impaired strength, mobility, balance and endurance [42]. In the continuum of physical function among older people, being physically frail was described as managing light housekeeping, food preparation and grocery shopping, can pass some instrumental activities in daily life (IADLs) and all personal activities in daily life (PADLs), but may be homebound [43](Figure 2). Physically frail older people have a debilitating disease or condition that challenges them physically on a daily basis [38], meaning that they may have a reduced ability to manage daily living independently.



**Figure 2.** Continuum of physical function in older adults.

(Adapted with permission from Shumway-Cook A and Woollacott MH. Motor control. Translating research into clinical practice. 4th ed. Philadelphia PA: Lippincott Williams & Wilkins, 2012:225, Figure 9.1, originally from a figure in Spirduso W, Francis K, MacRae PG. Physical dimensions of aging. Champaign IL: Human Kinetics, 2005:265, Figure 11.1)

Being vulnerable to stressors indicate that even a minor illness leads to a transition in health state, from independent to dependent, mobile to immobile and postural stability to proneness to falling [35] (Figure 1). The change in level of functioning that leads to an increased risk of falls implies that falls are a clinical presentation of frailty. Balance and gait impairments are both risk factors for falls and features of frailty [35] showing that frailty and falls are closely connected: falls are predictors and risk factors for frailty and vice versa. Frailty in older people has also been associated with multiple falls and fractures [44] suggesting that fall prevention interventions in frail older people are essential.

## Health care and social service for older people

In Sweden, older people receive health care and social services from county councils, municipal care or private care. It is mainly funded by tax revenues [19]. The responsibility for health care and social services is regulated by two laws: the Health and Medical Service Act and the Social Service Act. The county councils are mainly responsible for providing health care through primary health care and acute care, and for medical services provided by doctors in all health care services [19]. The municipalities are responsible for health care and social services in special accommodation [19]. Most of the municipalities are also responsible for home care services. The county councils and municipalities share responsibility for rehabilitation and assistance technology [19]. The policy in Sweden aims to enable older persons to live independently and with a high quality of life [19]. "Aging in place" is the main care philosophy in the care for older people in Sweden today and means that older people should be able to continue living in their own homes for as long as possible [19]. Aging in place imply that the municipalities are mainly responsible for care and rehabilitation of older people at home by nurses, occupational therapists, physical therapists and nursing assistants. When the care and services cannot meet the older person's needs at home, care in special accommodation is provided. In Sweden in the 21st century a substantial reduction in the number of beds in special accommodation has occurred, and frail older people are to a greater extent receiving health care at home [45]. Swedish studies have shown that older people receiving community health care and services at home have more frequent contact with in- and outpatient care as well as a higher number of days in hospital compared with older people in special accommodation [46, 47]. Another Swedish study showed that the number of acute hospital admissions increase in the five months preceding decision about long-term municipal care [48]. This indicates the need for preventive interventions to prevent illness and promote health at a point in life where the older person gradually becomes dependent on others to manage their daily life. Through early identification and intervention acute illness or injury, such as falls and fall injuries may be prevented.

## Postural and dynamic stability

Postural and dynamic stability is required to maintain balance when standing and moving. Posture and balance control emerges from an interaction between the individual, the environment and the task and requires a complex interaction between several bodily systems such as neuromuscular synergies, musculoskeletal components, and individual sensory systems in a continuous process [49-53]. *Postural control* has been defined as controlling the body's position in space to maintain stability and orientation, where *postural and dynamic stability* is the ability to control the centre of

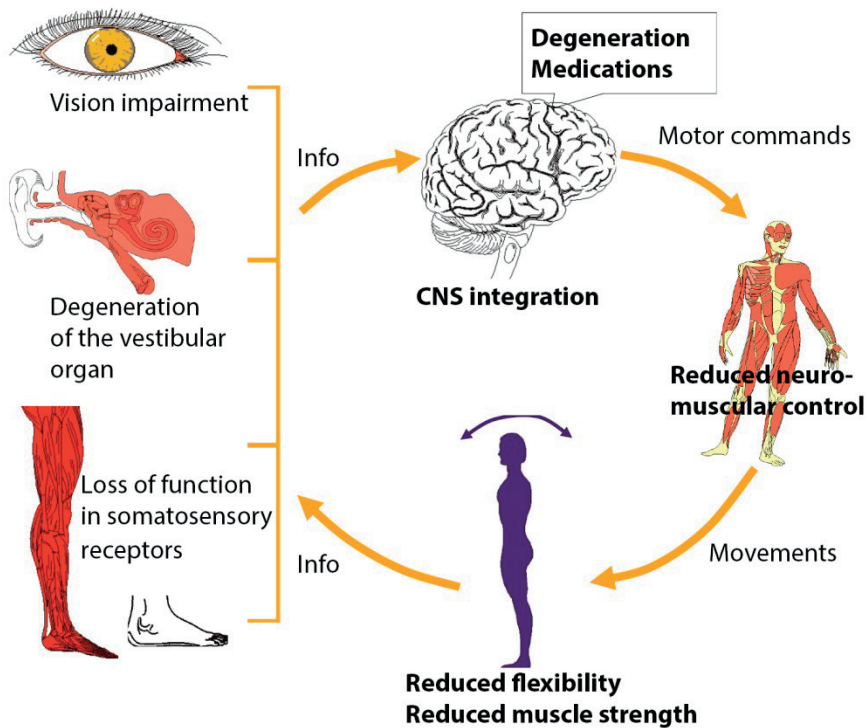
mass (COM) in relation to the base of support (BOS) in a quiet stance as well as while moving [50, 52, 54]. *Postural orientation* is the ability to maintain an appropriate relationship between the body segments and between the body and the environment [50]. Postural control have also been described as our ability to maintain an upright posture and adjust to gravity or environmental forces, also referred to as *postural equilibrium* [49] or *balance* [50]. Balance has been described as “a generic term describing the dynamics of body posture to prevent falling” [51]. Every task in daily life has an orientation component and a stability component, but the requirement varies with the task and environment. COM is a point that is at the centre of the total body of mass i.e. the weighted average of the COM of each body segment [50, 51]. This means that about two-thirds of our body mass is located in two-thirds of our body height which makes it an inherently unstable system [51]. Maintaining postural and dynamic stability requires input from three systems: the vestibular system, the somatosensory system and the visual system. It is a continuous process where input from sensory systems to the central nervous system (CNS) creates constant appropriate responses for postural adjustments and movements [49-51]. Since we have three different systems to control our postural and dynamic stability, a certain degree of redundancy exists where one system can compensate when another systems fails [51].

To maintain postural stability, the COM and centre of pressure (COP) need to be located over the BOS i.e. under and between our feet. The COP moves continuously around the COM to keep the COM within the BOS [50, 52]. Internal and external disturbances displace the COM and COP and without postural adjustments a fall occurs. Postural adjustment involves pro-active and re-active mechanisms triggered by muscle stretch or visual or vestibular input [52]. Three strategies to restore postural stability have been described: the ankle, hip and stepping strategies [49, 50, 55]. The ankle strategy is used when the perturbations are small and stability is restored by body movements primarily around the ankle joints; the hip strategy involves synergetic muscle activity around the trunk and hips in larger and faster perturbations, while the stepping strategy involves a step or reach when the ankle and hip strategies are insufficient [49, 50, 55]. The muscles required for postural stability are the knee and ankle flexors and extensors for forward and backward sway [50] and the hip abductors and adductors for lateral stability [56].

Systems important to postural control deteriorates with age and various pathologies (Figure 3). This dysfunction contributes to instability and an increased risk of falls [43, 49]. The changes affecting postural control are manifested in a variety of ways in older people, such as a changed posture [57], increased postural sway [58], reduced muscle strength [59] and reduced dynamic stability [60]. Lateral instability due to weak abductor and adductor muscles in the hip may increase the risk of a lateral fall, the type of falls that is most likely to result in a hip fracture [56]. The multi-sensory input from the vestibular system changes with age due to loss of function of somatosensory receptors [61], impaired vestibular organs [62] and vision [63]. Horak

(2006) [49] described six important resources required for postural stability. Disorders in any of them increase the risk of falls. *Biomechanical constraints* involve the BOS and the limits of stability, and *movement strategies* involve the ankle and hip strategies. *Sensory strategies* involve the ability to re-weight sensory information. *Orientation in space* is the ability to orient and control body parts with respect to gravity, the support surface, visual surroundings and internal references. *Control of dynamics* relates to control of balance when moving, and *cognitive processing* relates to reaction time and the difficulty of the postural task [49].

Even though older people may suffer from multiple impairments, one may not assume that impairments alone directly lead to disabilities because other systems can compensate depending on the type of impairment and the compensatory strategies [49]. However, the redundancy that underpins compensatory mechanisms in younger people may not be present in older people with multisensory deficits due to age or disease [43]. This explains the increased prevalence of falls with age.



**Figure 3.** Multisensory impairments in human postural control due to age and illness.

(Reproduced with permission from Professor M. Magnusson, Lund University, Sweden).

# Dizziness in older people

The deterioration in postural and dynamic stability with age implies that many older people perceive dizziness. However, this is not a natural and inevitable state of aging [64]. Dizziness is a general term and is not well-defined [11]. It represents a variety of sensations such as unsteadiness, and a lightheaded, floating, giddy or fuzzy feeling [11]. The four most common dizziness symptom categories are: *vertigo*., a feeling that the environment is moving or a feeling of falling or spinning; *presyncope*, a sensation of impending fainting or loss of consciousness; *disequilibrium*, a feeling that a fall is imminent characterized by unsteadiness or imbalance; and *non-specific dizziness*, a vague sensation of light-headedness, heavy-headedness or wooziness [65]. Presbyastasis is another term that describes disequilibrium due to age-related impairment in the vestibular system [17]. The term multisensory dizziness has been used to define dizziness attributed to age and deterioration in multiple systems [16, 17]. Input from the sensory systems may be affected by polyneuropathy, reduced vision or impaired vestibular function; the processing procedure in CNS may be affected by age, illness or side effects of drugs; and postural adjustments may be affected by muscle weakness or loss of flexibility [66] (Figure 3).

## Prevalence, causes and associated factors

Dizziness is one of the most frequent symptoms among the elderly [67]. Swedish studies have shown prevalences of dizziness in older people of 29% to 50% [12-14]. The large variation is probably due to differences in sample selection and how dizziness was reported. Large variation has also been shown in international studies [11, 68-70]. Dizziness increases with age [11, 69, 70]. One study showed a prevalence of 27% in participants aged 65-79 years, 38% in those aged 80-89 years and 54% in those aged 90 + years [11]. One study, however, showed a similar prevalence of dizziness in men and women aged 85 years and older [71]. For many older people dizziness is a chronic condition [10, 72, 73] and women are more frequently affected than men [70].

The causes of dizziness in older people depend on several interacting factors relating to aging and various diseases that are common in the elderly [16, 17, 67]. Causes such as peripheral vestibular disorders, cardiovascular disorders, brainstem cerebrovascular disease, central and primary neurologic disorders and psychiatric disorders, have been suggested [67, 74]. The cause of dizziness in older people can be difficult to establish since it may manifest differently (i.e. with less severe symptoms) in older people compared to younger people. Two frequent and probably underdiagnosed causes of dizziness in older people are benign paroxysmal positional vertigo (BPPV) and multisensory dizziness [75]. Dizziness is a known risk factor for falls [9, 11, 14] and

has in older persons also been associated with hospitalization in the past year, hypertensive medication use, antidepressant use, low self-rated health, reduced participation in social activities, reduced mental and physical quality of life, postural instability, low level of exercise, reduced mobility and activities in daily life (ADL) dependency [10, 13, 14, 76]. As an adverse consequence of dizziness [10], inactivity may lead to impaired physical function and impaired postural control, which in turn may worsen the experience of dizziness. Dizziness in older people has itself, irrespective of other potential causes of dizziness, independently been associated with hypertension, heart disease, neurological disease and diabetes [64].

Identifying and treating dizziness in older adults has been described as complicated and challenging [17, 67]. It includes diagnosis-specific treatments and general management strategies such as repositioning manoeuvres, pharmacologic treatment or vestibular rehabilitation [17, 65, 67]. Vestibular rehabilitation in older people with dizziness has shown positive effects on the intensity of perceived dizziness [77] and on balance performance [78].

The high prevalence of dizziness in older people along with its considerable impact on life necessitates the investigation of factors predicting dizziness. Factors triggering dizziness need to be identified in longitudinal studies. Studies investigating predictors of dizziness are, however, sparse. A study in 620 people aged 65+ years showed that the main predictors for dizziness were age, female gender, cardiovascular disease, osteoporosis, depression, sleep disorders, disturbance of memory, short-sightedness, incontinence, three or more medical conditions, four or more medications, poor health status, falls and mobility problems [11]. Since the prevalence increases with age, investigating predictors stratified by age may reveal age-specific predictors that are useful for identifying people at risk of developing dizziness and risk factors that it might be possible to eliminate.

Although quantitative studies have shown that dizziness has a large impact on life, few qualitative studies have explored daily life from the perspective of the individual. A few qualitative studies have been performed, in younger people with specific vestibular disorders [79-81]. These studies showed that dizziness caused severe limitations in life [79-81]. However, the perception of living with dizziness might differ between younger and older people due to different challenges at different stages of life and the impact of other diseases that older people might suffer from. A study in 20 people aged 65+ years with dizziness [82] revealed that important priorities for the participants were finding the cause or stabilizing the symptoms as well as preserving mobility and preventing falls. However, this study mainly focused on the participants' expectations and wishes when consulting their general practitioner (GP). Exploring the daily life situation in older people with chronic dizziness might give insights into aspects affecting daily life, which in turn might help efforts to develop health care for older people with dizziness.

## Falls in older people

Different definitions of a fall have been used over the years, but in 2007 a consensus group from Prevention of Falls Network Earth (ProFaNE) [83] suggested the following definition: “an unexpected event in which the participants come to rest on the ground, floor, or lower level” [68]. This definition is today widely recognized.

The risk of falls increases with age: one third of people aged 65+ years fall at least once a year [3, 4] and in people aged 80+ years as many as 50% fall each year [84]. Swedish studies in people aged 65+ years have shown prevalence rates of 11.5% in people aged 65+ years [7] and 41% in people aged 84 + years [5, 6]. Falls are reported more frequently among women than men [85] and the number of falls increases with increased frailty level [4, 86], probably because many of the indicators for frailty coincide with risk factors for falls [44]. A multinational study [87] in 48,636 women aged 55 + years divided into non-frail, pre-frail and frail women showed that greater frailty was associated with greater risks of falling, fracture and disability. The prevalence of  $\geq 1$  fall was 32% in non-frail, 37% in pre-frail and 51% in frail women ( $p < 0.001$ ). The risk of falls was three times higher in frail women compared to non-frail women (OR= 3.35, 95% CI = 3.13-3.58) [87].

Falls in older people are a major source of morbidity and mortality and may lead to injuries, disability, depression and loss of independence [3, 4, 88]. The consequences of a fall are usually more severe in older people due to a combination of high prevalences of diseases and age-related physiological changes, leading to high susceptibility to injury even in relatively mild falls [89], as in people with osteoporosis [90]. Of all falls in older adults, approximately 10-20% result in injury, hospitalization and/or death [89]. A fear of falling is frequent in people who have sustained a fall, but may also be prevalent in people who have never experienced a fall and may strongly affect daily life [91]. This fear may prevent a person from being physically active and could lead to a vicious circle with falls, decreased level of functioning, fear of falling and lower activity levels leading to further functional decline and an increased risk of falls [91].

International studies have shown that fall injury is a leading cause of death and disability among older adults [92, 93]. In Sweden, an average of 3 older people die each day due to a fall accident [8] and the number of fall accidents in Sweden has increased in the last two decades [94]. In the last 10 years, the number of people in Sweden aged 65+ years with injurious falls resulting in hospital care has increased by 31.9% in men and 8.2% in women [95]. Falls have a major impact on the overall health status and increase the risk of institutionalization [96]. Besides the personal suffering of the individual they also mean high costs for society. The National Board of Health and Welfare in Sweden has estimated the direct cost of fall injuries in 2006 in people aged 65+ years to be 4.8 billion SEK. Most of these costs concern fall

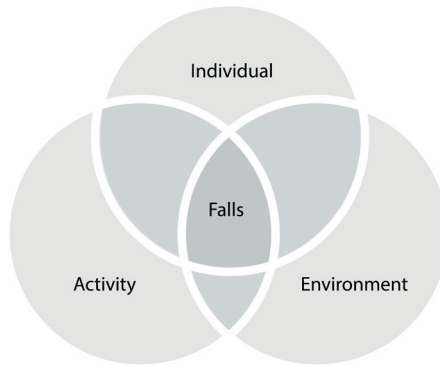


injuries in older people living at home, with or without community home health care [8]. In US adults in 2000 the direct medical costs for fall injuries were \$19.2 billion [97].

## Risk factors for falls in older people

Susceptibility to falls depends on the ability of the individual, the requirements of the activity and the environment in which the activity is performed (Figure 4). Risk factors for falls are inherent in all three areas. As many as 400 risk factors for falls have been identified in older people [3, 9, 89, 98]. Falls occur as a result of a complex interaction between risk factors [4] and the risk of falling increases with the number of risk factors present [99, 100]. Risk factors have sometimes been divided into intrinsic factors i.e. age- or disease-related changes in the older person and extrinsic factors, i.e. environmental hazards [38]. However, this distinction may be an oversimplification since many risk factors may be inter-related [98]. The WHO risk factor model for falls includes behavioural, biological, environmental and socioeconomic risk factors such as lack of exercise, chronic illness, slippery floors or stairs, and limited access to health and social services [4]. Lord et al. [98] divided risk factors for falls into: sensory and neuromuscular (impaired vestibular function or decreased vibration sense); psychological (attentional limitations or fear of falling); medical (cerebrovascular disease or depression); environmental (uneven pathways or insufficient lighting); and medications. A wide range of medications have been associated with an increased risk of falls [101, 102]. Reviews have shown that medication-related falls in older people are mainly due to psychotropic medications such as benzodiazepines, antidepressants, antipsychotics, neuroleptic, antiepileptics and sedatives/hypnotics [103-107] Other causative medications include cardiac medications e.g. antihypertensive, diuretics, digoxin and type IA antiarrhythmic agents [105, 106]. A recent review [106] showed that fall-risk-increasing drugs (FRIDs) caused impaired postural control and thereby increased the risk of falls. The risk of falls increases with an the number of medications [107]. It was also increased with higher age, higher daily doses, longer half-lives and administration for a longer period [106].





**Figure 4.** Interactions between the individual, the activity, the environment and falls. Reproduced with permission from Nordell E. Fall prevention. Riskfaktorer och åtgärder för att förhindra fallolyckor bland äldre. Nestor FoU-center, Stockholm: Liber 2009:13 Figur 2).

The strongest risk factors are previous falls, mobility impairment, gait disorders and balance deficits [3] and a systematic review and meta-analysis [9] showed that falls, fear of falling and walking aids were associated with a 3-fold increased odds of falling. Most falls in older people occur during walking or other movements [108]. In frail older people, severe impairments in postural control make safe navigation difficult even in undemanding environments [35] and falls usually occur within the home [108]. A recent study analysing real-life falls captured on video in older people in long-term facilities [109] showed that the most common causes of falls were incorrect transfer or shifting of bodyweight, and the most common activity was walking. It was concluded that people at risk of falls may be possible to identify by assessing those activities [109]. Identifying risk factors can be used to identify people at risk of falls or to find modifiable risk factors to decrease the risk of falls. Finding age- or disease-specific risk factors may increase the possibility of customizing fall prevention intervention and thereby increase the possibility of preventing falls.

## Fall risk assessments

By using fall risk assessment tools, health care providers can reliably identify at-risk populations and guide intervention by highlighting remediable risk factors [110] and targeting those who are most likely to benefit from preventive interventions. Easy, quick and reliable assessment tools facilitate the screening process. The predictive abilities of a variety of questionnaires and functional performance tests have been evaluated [110-112]. The tests should be evaluated in different contexts, care settings and populations. Published reviews describe and assess predictive validity for fall risk assessment tools in hospitals [113], primary health care centres [111] and long-term

care facilities [114]. In a systematic review from 2007 [110] the validity and reliability of tools used in community, home-support, long-term and acute care settings aimed to select the most appropriate fall-risk assessment tool for the risk profile of the intended population. A total of 38 tools, divided into functional mobility assessment tools and multifactorial assessment tools, were assessed in 34 studies. Twenty-three of the tools were tested on independently living older people, 10 in long-term care settings, 8 in acute care and 4 in supportive housing. The review's authors concluded that although many fall-risk assessment tools are available, few have been tested more than once and in more than one setting indicating that more research is needed [110]. Because older and frailer people often live at home, identifying people at risk of falling in this setting is essential.

A person identified as having an increased fall risk should be offered a comprehensive evaluation including an assessment of physical performance [3, 115, 116]. In-home assessments put special demands on functional assessment and physical performance tests as lack of space and equipment precludes many of them. Timed Up & Go (TUG) [117] and the Romberg Test (RT) [118] have been used in in-home assessments [119] and are commonly used in older people. Their predictive validity for falls has been investigated in older people with cognitive impairments in in-home assessments [119], but not in cognitively intact frail older people in this setting.

In Sweden, falls are an important indicator when reducing injuries in health care settings [116]. National [116] as well as international [4] guidelines have suggested that people aged 65+ years with a history of falls should be offered a fall risk assessment. In Sweden, Senior Alert [120], a national quality register aimed at developing systematic, preventive health care for older people, uses the Downton Fall Risk Index (DFRI) [121] to identify people at risk of falls. This easily administered questionnaire is today used in health care and municipal care in Sweden. Its predictive ability for falls was investigated in institutionalized older people, showing 81-100% sensitivity and 9-40% sensitivity [121-123]. However, its predictive ability has not been investigated in frail older people living at home.

## Fall prevention in older people

Preventing falls and fall injuries includes primary, secondary and tertiary prevention. Primary prevention aim to provide general information on how to prevent falls on a population basis. Secondary prevention aims to identify people at risk of falls before a fall occurs or to prevent further falls. Tertiary prevention aims to prevent fall injuries and other negative effects of falling at the individual level.

A substantial amount of research has shown that it is possible to prevent falls in older people and multifactorial assessments and interventions by multidisciplinary teams

are recommended [1-4]. The approach relates to the features of a complex intervention where several interacting components are needed to affect the outcome [124]. A Cochrane review from 2003 [88] recommended that fall prevention interventions for older people include assessment of risk factors and interventions, e.g. exercise programs; withdrawal of psychotropic medications; cardiac pacing for fallers with cardio inhibitory carotid sinus hypersensitivity; and tai chi. This review was updated in 2009 and 2012 to focus on interventions for preventing falls in older people living in the community [1, 125]. According to the 2009 and 2012 reviews, group- or home-based exercise programs and home safety interventions reduce the risk of falls. Fall prevention interventions should focus on eliminating as many risk factors as possible. However, eliminating risk factors may be difficult in frail older people. It may therefore be even more important to strengthen protective factors, such as physical function, to decrease the risk of falls.

The positive effects of exercise to prevent falls are the main reason that fall prevention is a natural and evident part on the physiotherapeutic agenda. Exercise has been shown to improve postural stability and various components such as leg muscle strength, balance and gait should be included in exercises to prevent falls [3, 115, 126, 127]. Several exercise interventions in older people at home [18, 128-130] or in frail older people in special accommodations [18, 131] have shown positive effects in reducing falls. The programs in fall preventive interventions should be regular, individually tailored and progressive [126, 127]. Exercise also plays an important role in slowing down the physiological effects of aging and thereby the progression of disability [132]. Vestibular rehabilitation [133, 134] and physical activity [14] have also shown positive effects in older people with dizziness, and the treatment should be multifactorial once dizziness has become a chronic complaint [15, 16, 65].

It has also been argued that to reduce falls more research on the effectiveness of different intervention designs is needed [125]. The 2012 Cochrane review [1] included few home-based intervention studies. Of the 159 trials included in this review only 12 offered home-based exercises as an intervention or as a part of an intervention [129, 130, 135-143], of which 8 showed significant positive effects on falls [129, 130, 135-137, 141-143]. Other home-based studies including participants' or subsamples classified as or considered to be frail have been conducted [129, 130, 135-138, 140, 141, 144-147]. However, the effects on falls in the studies differed. Eight studies [129, 130, 135-137, 141, 146, 147] showed positive effects on falls and four studies [138, 140, 144, 145] showed no effect. The participants' health status and level of functioning differed, but all of them had experienced a previous fall or were classified as being at high risk of falls. However, the complexity in defining the frailty concept and the different designs of complex interventions preclude direct comparisons of the results. In some studies frailty was not defined [130, 135, 138, 147]; the number of home visits differed [44, 130, 135, 140, 141, 144, 147]; and the locations of the assessments differed [130, 135, 138, 140, 145, 146]. None of the studies were, however, designed to be conducted in the participants' homes.

Interventions that derive from the participants' homes put special demands on the design of the intervention and the instruments being used.

## Case management

To meet the complex health care needs of frail older people, complex interventions focusing on a variety of aspects are needed. Complex interventions are also needed to prevent falls in frail older people. Case management might meet these requirements. It has its roots in psychiatric and social work aimed at maintaining quality of care while controlling the cost of health care through coordination and management of care [148]. Case management has today moved into different arenas of health care aimed at helping people with complex and long-term health care needs to navigate through a complex health care system [148, 149]. The Case Management Society of America (CMSA) [150] defines case management as “a collaborative process of assessment, planning, facilitation, care coordination, evaluation, and advocacy for options and services to meet individual's and family's comprehensive health needs through communication and available resources to promote quality cost-effective outcomes”. Since case management is not recognized as a profession and is not governed by legislation and regulation [149] various health professionals can take the role as case manager (CM), depending of the needs of the individual. In most studies, however, the CMs are usually nurses and social workers. In a Swedish study investigating the effects of a home rehabilitation program for acute stroke patients [151] one professional in a team of physical, occupational and speech therapists was selected to be the CM, using the other therapists on a consultant basis. In this study the CM was responsible for a) most of the therapy at home, b) coordination between therapists at the hospital and c) contacts with relatives and home service assistants.

To provide comprehensive service for community-based frail elderly people, many developed countries are attempting to integrate case management approaches into their elderly care systems [152]. Distinguishing features of case management in community elderly care may include [152]:

- providing a broad range of case-managed community care and medical services for those with chronic, ongoing and complex medical conditions, and age-related disabilities, including dementia;
- providing services long-term or in intense short periods before placement in residential elderly care;
- a collaborative process with the family carer;

- employing a planned approach to achieve client outcomes with cost-efficiency; and
- being based in the community elderly care sector.

Case management in community elderly care interventions has been shown to improve psychological health or well-being and unmet service needs in the older people, but the effects on other outcomes such as functional status are less conclusive [152]. Several systematic reviews and meta-analyses have investigated the effects of case management or multidimensional home visits on community-dwelling older [153-155] and frail older [156-159] people. The reviews investigated the effects on outcomes such as functional status, nursing home admission, mortality [153-155, 159], health care costs and consumption, quality of care, health and ADL [156-159]. Even though most of the studies showed positive effects, some did not, and the lack of a uniform terminology precludes direct comparisons of the results [154, 160]. A systematic review by van Haastregt et al. (2000) [155] investigated the effects on different outcomes of preventive home visits, designed as case management interventions, to elderly people living in the community. Six studies [147, 161-165] investigated falls as an outcome and two studies [147, 161] showed favourable effects. However, these studies, from the early and mid- 1990s, mainly included independently living older people with no disability [161-164] and the two studies that included people with disabilities showed divergent results [147, 165]. Therefore, more knowledge is needed on the effect on falls of case management for frail older people at home.

## Rationale for the thesis

Falls are common in older people and have negative effects on the individual and on society. Being older and frail implies having several risk factors for falls and a high risk of falling. Frailty indicates a larger deterioration after stressor events, such as a fall, and a higher risk of not returning to the previous level of functioning, emphasizing the need to prevent falls in frail older people. Dizziness and unsteadiness are strong risk factors for falls and are common, and often chronic, health complaints in older adults. Managing older people with chronic dizziness is complicated and challenging. Dizziness in older people has been associated with reduced quality of life, postural instability, low level of exercise and reduced mobility. Few studies have, however, explored how daily life is affected from the perspective of the individual. Knowledge on this subject could highlight important factors for improving health care for this group.

Today many frail older people at high risk of falls live and receive health care at home. Most costs for fall injuries in Sweden concern older people living at home. Professionals need easy, quick and reliable fall risk assessment tools to identify people at risk of falls. However, there is limited knowledge about the predictive validity for falls of tools that can be used in in-home assessments. This knowledge could guide professionals in how to identify fall risk in older people living at home.

Early identification of people at risk of falling allows fall prevention interventions to be introduced. By identifying age-specific risk factors for falls and dizziness it may be possible to customize fall prevention interventions in various samples. Multifactorial interventions have shown positive effects in preventing falls in older people. They should include an assessment of risk factors, and components such as exercise programs, measures to increase home safety and a medication optimization. However, limited knowledge exists about in-home fall prevention interventions in frail older people. Case management interventions for frail older people living at home have shown positive effects in reducing functional decline and disability. However, few studies have investigated falls as an outcome and those that have been conducted show inconclusive results. Investigating the effects on falls in a case management intervention may add to the knowledge in how to prevent falls in frail older people living at home.



# Aims

## Overall aim

The overall aim of this thesis was to investigate risk factors for falls or dizziness and to explore experiences of living with dizziness in older people. Furthermore, the aim was to evaluate the effects of a home-based case management intervention on falls in frail older people.

## Specific aims

- I To investigate the prevalence of and predictors of falls and dizziness among people aged 60-80 years and 80+ years.
- II To explore older people's experiences of living with chronic dizziness.
- II To investigate the predictive validity for falls of the Downton Fall Risk Index (DFRI), Timed Up & Go (TUG) and Romberg test (RT) when used in in-home assessments in frail older people (aged 65+ years).
- IV To evaluate the effects of a home-based one-year case management intervention in frail older people (aged 65+ years) on self-reported falls, injurious falls and falls resulting in medical care





# Methods

## Design

To explore falls and dizziness in frail older people, various methodological approaches were used. This thesis includes data from three studies (Studies I-III) resulting in four papers: Study I had a longitudinal cohort design (Paper I), Study II had a qualitative explorative design (Paper II), and Study III had a randomized controlled trial (RCT) with repeated follow-up (Paper III and IV). An overview is given in Table 1.

**Table 1.** Overview of the design, population, data collection and data analyses in this thesis.

	<b>Paper I</b>	<b>Paper II</b>	<b>Paper III</b>	<b>Paper IV</b>
Study design	Longitudinal cohort design	Qualitative explorative design	Prospective design	Randomized Controlled Trial
Study population	N=1402, 10 age cohorts, 60-96 years	N=13, 73-87 years with chronic dizziness (> 3 months)	N=153, 66-94 years, mean age 81.5 (SD 6.3), 67% women	N=153, 66-94 years, mean age 81.5 (SD 6.3), 7% women
Data collection	Medical examination. Structured interviews.	Semi-structured interviews	Structured interviews. Physical performance tests	Structured interviews. Physical performance tests
Data analyses	Pearson's chi-square test. Mann-Whitney U-test. Student's <i>t</i> -test. Multiple logistic regression analyses	Qualitative content analysis	Sensitivity Specificity LR+ LR- Youden's index	Pearson's chi-square test. Mann-Whitney U-test. Student's <i>t</i> -test

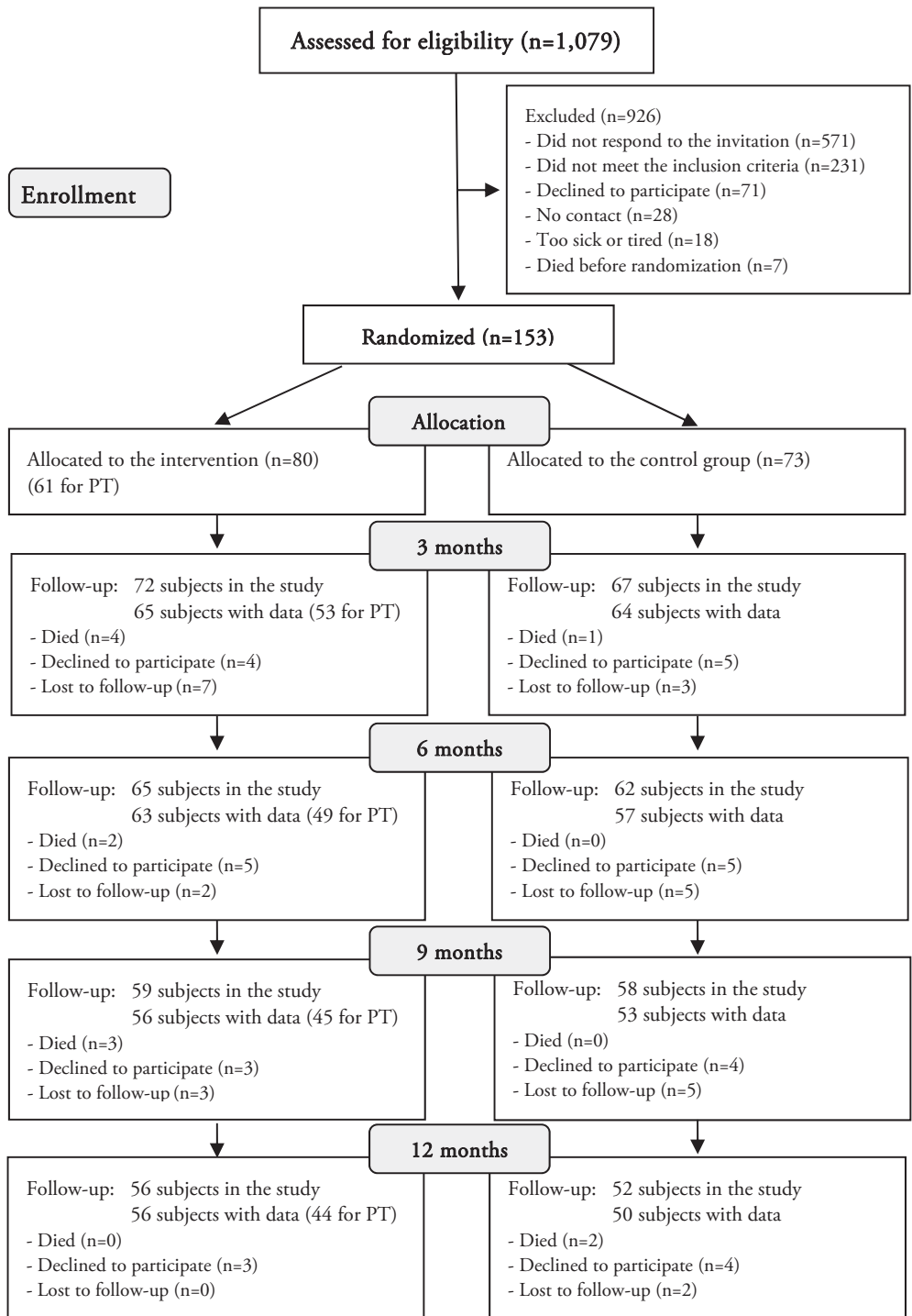
## Study populations

The sample in Paper I was drawn from a national, longitudinal population study in Sweden – the Swedish National Study on Aging and Care (SNAC) [166]. This study involved four research centres and consists of two parts: a population part and a care and service part. The population part aimed to record and describe different aspects of the aging process and the care and service part to collect data on the provision of care and services, functional ability, specific health care problems and living conditions [166]. Data from the population part from a sub-study of the county of Blekinge (SNAC-B) were used. This sub-study is performed in one municipality in the south-east of Sweden with approximately 60, 000 inhabitants living in both urban and rural areas, with the intention to represent the ageing population in Sweden. The study included 10 age cohorts where the four youngest ones (aged 60, 66, 72 and 78 years) were selected from the Swedish Total Population Register by computer-based randomization within a 3-month period from their birthday. For the six older age cohorts (aged 80, 84, 87, 90, 93 and 96 years) all inhabitants of the specified ages were included. In all, 1,402 (62%) of the people who were approached agreed to participate and were included in the baseline data collection, which was carried out in 2001-2003. The most common reasons for not taking part were not wanting to (83%) or feeling too ill (11%) [167]. The age distribution of the participants was as follows: 28.4% aged 60-69 years, 24.6 % aged 70-79 years, 38% aged 80-89 years and 9% aged 90-96 years [168]. The selected subjects were invited by mail to visit the research center and to take part in the study. Those who didn't respond to the invitation letter received a second invitation by telephone. For those who declined to participate the reason was registered. The enrolled participants who were unable to come to the research centre were given the opportunity of being examined at their home [169]. In Paper I 973 and 1,273 participants were interviewed at baseline about self-reported falls and dizziness, respectively, in the past year. The participants in each group (falls or dizziness) were then grouped into participants in the younger (aged 60-78 years) or older (aged 81-96 years) age cohorts. The high drop-out rate in falls at baseline was due to the fact that this question was not included in the first data collection period but was added at a protocol revision 6 months after the study had started. Two follow-up assessments were made. The first follow-up was 3 years after inclusion in the study and was performed on participants in the older age group at baseline. This sample comprised 237 and 224 participants with valid baseline data on falls and dizziness, respectively. The second follow-up was after 6 years and included all participants with baseline data. This sample comprised 616 participants with valid data on falls (441 in the younger age cohort and 175 in the older) and 677 participants with valid data on dizziness (531 in the younger age cohort and 146 in the older).

In Paper II a qualitative design was considered suitable as the aim of qualitative methodology is to get a deeper understanding of a phenomenon based on participants' own beliefs and experiences about human interaction, behaviour and culture [170]. The study included interviews with seven women and six men suffering from chronic dizziness. They were recruited at a primary health care centre in Malmö, a city with approximately 280,000 inhabitants in the south of Sweden. At this primary health care centre a PT specialized in vestibular diseases recruited participants to the present study when making a follow-up call to persons who had received vestibular rehabilitation due to dizziness. They were informed about the study and asked if they were willing to participate. Sixteen persons gave a positive response and their names and phone numbers were given to the interviewer, who then contacted them by phone to give them further information about the study and to inform them that they could withdraw at any time without giving any reason. During these phone calls three respondents dropped out or were excluded: two due to a lack of time and one because of not wanting to record the interview. For the remaining 13 participants an appointment was made for the interview and a letter with information about the study, and informed consent, contact information and the time of the interview was sent. The inclusion criteria were: age  $65 \pm$  years, dizziness of any cause for at least 3 months and ability to communicate in Swedish. Purposeful selection [171] was done to ensure variability in terms of age, gender, living arrangements, diagnosis and duration of dizziness.

Papers III and IV used data from an RCT designed according to the framework of the Medical Research Council (MRC) that provides guidance when designing complex interventions to improve health [172]. The RCT in addition had a quasi-experimental cross-over design [173] where the participants in the control group (CG) after 12 months had the opportunity to be included in the intervention group (IG). The papers in this thesis, however, only include data from the main study. The RCT aimed to evaluate the effects of a healthcare model using case managers in community-dwelling older people with functional dependency and repeated health care contacts [174]. The study was a collaboration between Lund University, a local hospital (Skåne University Hospital in Lund) and primary care and municipal home care and services in Eslöv. The sample included 153 participants (IG=80, CG=73) who were recruited from October 2006 to April 2010, and was carried out in Eslöv, a municipality with approximately 30,000 inhabitants in the southern part of Sweden. Inclusion criteria for the study were: aged  $65 \pm$  years, residence in the community where the study was conducted, need of help with at least two ADL and at least two hospital admissions or four visits to outpatient or primary care in the 12 months prior to inclusion in the study. The participants had to be able to communicate verbally and with no severe cognitive impairment. The Mini Mental State Examination (MMSE) [175] was used to assess cognition and a value of  $\geq 25$  was required for participation. The sample was consecutively recruited from three clinics at the hospital by the nursing working as case managers, through a screening process, by the

health care staff at the primary care centres or the municipal home care organization. It was also possible for interested people to contact the research group themselves [176]. In the screening process, all 65 ± years with four or more visits the last year in two primary health care centres in Eslöv were contacted by mail. They were given information about the study and a reply form where they were asked if they agreed to allow the research team to contact them in order to give them additional information. This procedure made it possible to recruit participants by phone. The randomization procedure involved sealed envelopes with information about group allocation which were drawn by a research team member. This procedure gave all participants an equal chance of being assigned to each group. The randomization was done after enrolment and prior to baseline data collection. The RCT underwent pilot testing and a description of the study design and intervention has been published [174]. During the pilot testing, falling and low physical activity were identified as important and problematic areas for the participants. Therefore, PT's were included in the intervention after the pilot testing. Papers III and IV in this thesis include the entire sample, i.e. also the participants from the pilot study. Between 2006 and 2011 1,079 persons were approached, of whom 926 were excluded due to death (n=7), not meeting the inclusion criteria (n=231) or non-randomization (n=688) (Figure 5). Reasons for non-randomization were not responding to the invitation during screening (n=571), unwillingness to participate (n=71), inability to contact the participant (n=28) or the participant feeling too tired or ill (n=18). During the 12-month study, 45 participants died or declined further participation, leaving 108 participants who completed the study [177].



**Figure 5.** CONSORT flow diagram for Papers III and IV.

## The case management intervention

The intervention included home visits at least once a month for 12 months and the first visit was performed after baseline measurement. In the pilot study (n=35), the intervention only included nurses as case managers. After the pilot study PTs, were also included in the intervention as CMs. Of the 80 participants in the intervention group (IG) (pilot study included), 61 received home-visits by both nurses and PTs. The nurses and PT's performed the home visits together or separately depending on the participants' preferences which meant that some participants received home visit twice per month. The intervention was performed by six CMs: four nurses and two PTs who worked on a part-time basis. They had experience of working with older people in geriatric wards at a university hospital or in municipal care and services for older people.

The intervention started with an assessment of the participants' health status. The nurse CMs made an initial assessment with the Minimum Data Set for Home Care (MDS-HC) [178], a comprehensive geriatric assessment tool. The PT CMs added questions about functional and physical abilities such as ADL, mobility aids and physical activities. According to "Taxonomy to describe and conceptualize fall preventive interventions"[179] all gait, balance and functional training should be based on an assessment of the persons abilities prior to starting, the intervention should be tailored to the individuals abilities and progressed should occur as the person's ability improves. To obtain an estimate of general physical ability, the PT assessment included the Berg Balance Scale (BBS)[180], General Motor Function assessment scale (GMF) [181], Fukuda Stepping Test [182] and an assessment of vibration perception in the lower limbs [183]. The BBS is a widely used tool for assessing functional balance [180, 184] and consists of 14 items graded from 0 to 4 (maximum score 56 points) [184]. The scale showed good internal consistency (0.77), good inter-rater reliability (0.87) and moderate correlation with TUG score and gait speed in independently living people aged 65+ years [185], and high intra-rater reliability (0.97) in older people in residential care facilities [186]. BBS predictive ability for falls has been investigated but there is no consensus on the optimal cut-off score [187-189]. In this study we used 40 as cut-off score to identify persons at risk of falls [189]. The GMF is a performance-based tool for measuring function-related dependency, pain and insecurity that was developed for use in geriatric rehabilitation [181]. It has shown high inter-rater reliability (0.99-1.00), acceptable test-retest reliability (0.83-1.00), high content, concurrent and criterion-related validity and adequate clinical sensitivity [181, 190, 191] and has been recommended for use in home environment [191]. The Fukuda Stepping Test[182] is a gait test that assesses vestibular dysfunction. It is performed with the person standing upright, with both arms stretched straight forward and eyes closed, and stepping in place at normal walking speed [182, 192]. In the present study, 50 steps

were used and a minimum deviation of 45° towards the affected side was considered a positive test [182, 192]. The test showed good inter-rater reliability (0.91-0.99) and moderate test-retest reliability (< 0.70) when tested on adults [192], but its diagnostic ability has been questioned [193]. Vibration perception was tested with a tuning fork at the base of the first metatarsal bone, the medial malleolus and the medial surface of the tibia level with the tibial tuberosity in both legs [183]. The instruments we used were partly chosen because of their ability to be used in in-home assessments. A self-reported schedule of physical activities (type and duration) during one month was filled out by each participant.

The intervention, based on the needs of the participants, comprised four different parts: traditional case management tasks, general information, specific information, and safety and continuity [174]. Traditional case management tasks included assessment, care planning and care coordination, implementation, monitoring, evaluation and reassessment. The aim was not to treat the participant but rather to guide the participant to receive help at the right time and the right place. General information was given in a folder to each participant (after the pilot study) and included information brochures from the primary care and municipal home care and service in Eslöv, and information on safety aspects of daily life and mobility aids and training equipment. The folder also included three sheets of papers; one describing the bodily effects of exercise, one where the participants could write down questions for the CMs and one describing plans or goals for the next visit. Specific information included information specifically related to the individual such as information about specific diseases, medications or technical or mobility aids. Safety and continuity included informing the participants that the CMs could be contacted to solve upcoming problems or answer questions on a mobile phone during office hours. Regarding continuity, the intention was that the participants should meet the same CMs during the entire intervention.

Based on the assessments, an individual care plan and an individual non-supervised home exercise program were developed together with the participant. Because of the variability in the participants' physical ability, the programs varied in type, duration and degree of difficulty. For some participants they involved stair walking or Nordic walking, but for others they included rising from a chair without using their hands or standing with their eyes closed. All exercise programs did, however, include leg-muscle strength and balance components and were recommended to be performed three times per week. Safety aspects when performing the programs were always taken in consideration. Continuous re-assessments, where the program was modified or intensified, were made when needed and efforts were made to motivate the participant to be physically active.

The information brochure about fall prevention was discussed together with the participants and a home-safety checklist was used to assess environmental risk factors for falls, fires and poisoning. It also included questions about general well-being.



Corrections were made if needed. The participants were advised to contact the PT by phone if they fell. The fall was documented by phone or at a home-visit in terms of reason for falling, time, place, activity when falling, symptoms before falling, environmental factors, consequences and action plans. Actions were taken to reduce the consequences of the fall and recommendations were given to avoid future falls.

All CMs worked according to the four different parts of the intervention and collaborated closely regarding interventions such as pain management, contacts with health care settings or with relatives, or social activities. However, due to their different professional abilities, PT CMs focused on aspects in mainly four areas:

- Physical training: an individualized home-exercise program that could include physical balance, muscle strength, and/or aerobic exercise.
- Physical activity: walks, Nordic walking, dancing, boule
- Fall prevention: information, checklist, corrections if needed
- Household and mobility aids: walker, crutches, stool in the shower, pincers

Referrals to physicians, PTs or occupational therapists in primary health care settings or in municipal health care and services were made when needed, e.g. for PT treatment, to receive technical or mobility aids. The assessments and interventions were documented. The experiences of working as CMs of the nurses and PTs included in this study are described elsewhere [160]. The CMs had the ability to contact physicians in the project group if needed. The participants in the CG had access to the ordinary range of health care and social services from the county council, the municipality or private care [19].

## Data collection

In Paper I the participants were examined on two occasions, each lasting about 3 hours, by a research team that included physicians and nurses who were accessible during office hours and who assisted with filling in the questionnaire when needed. The participants also filled in a questionnaire between the two sessions. At the first session, informed consent and a release form for their medical records were obtained [169]. The same data collection procedure was used at the follow-up at 3 and 6 years ( $\pm 3$  months) after inclusion in the study. Data used in the present study were for socio-demographic variables, physical function, self-reported health complaints, cognition, health-related quality of life (HRQoL) and medications.

The 13 interviews in Paper II were conducted between February and October 2012. The participants were able to choose where the interview should take place. Eleven interviews were conducted at the participants' homes and two at the primary health care centre. At the beginning of the study, the first and last authors of the manuscript

together conducted one interview to enhance the interview technique; the other interviews were conducted by the first author. A semi-structured interview-guide was first tested by the first author within the framework of a course in qualitative methodology and was then further developed together with the last author. To focus on living with dizziness the guide comprised some predefined questions and special topics [171]. The guide was constructed with four themes: describing dizziness symptoms, the impact on daily life, strategies for managing daily life, and health care and support. The interviews started with the question “Please tell me about how your dizziness started?” and probing questions were added for clarification. The interviews lasted between 37 and 72 minutes (mean 54 minutes), were recorded digitally and were transcribed verbatim by the first author. Directly after the interviews, notes containing impressions and thoughts about the interview were written down by the first author.

In Papers III and IV data were collected through home visits by a member of the research team (which comprised six people) and included an extensive structured questionnaire and examinations [174]. The questionnaire contained five areas: background, social aspects, health status, HRQoL and life satisfaction and care and services. They were selected by standardized instruments or single-item questions. The physical examination included a battery of function and balance tests and was added when PTs were included in the intervention. Therefore, only 85 participants (IG= 46, CG=39) performed the physical tests battery. Criteria for choosing the test battery were that the instruments should measure different aspects of function and balance relevant to frail older people, that they should be able to be used in in-home assessments, that no equipment was needed to perform the tests, and that that they could be used by research assistants (nurses and psychologists). The research assistants were educated in how to perform the physical tests and inter-rater reliability was assessed in 13 persons. Data were collected before the intervention started (baseline) and after 3, 6, 9 and 12 months, except for the physical test battery, which was collected at baseline, 6 and 12 months. If the follow-up was delayed by more than 5 weeks it was not carried out [174].

## Measurements

An overview of the measures and instruments used in Papers I, II and IV is shown in Table 2. Different background variables were used to describe the samples at baseline. Age and sex were used in all studies. In Paper I living arrangements were measured as living in ordinary housing (community-dwelling) or in special accommodation (nursing homes, modified facilities with staff on call or present at all times). In Paper IV data on the use of municipal care were collected in the structured interviews.

**Table 2.** Measurements used in Papers I, III and IV.

Measurements	Paper I	Paper III	Paper IV
<b>Socio-demographic variables</b>			
Age	X	X	X
Gender	X	X	X
Community-dwelling	X		
Community elderly care			X
<b>Functional ability</b>			
ADL staircase	X	X	X
Grip strength	X		
Romberg test, eyes open	X		
Romberg test, eyes closed	X	X	
Semitandem Romberg test		X	
Tandem Romberg test		X	
Downton Fall Risk Index		X	X
Timed Up & Go		X	X
Walking aids (self-reported)		X	X
<b>Self-reported health complaints</b>			
History of falls	X	X	X
Number of falls	X	X	X
Injurious falls		X	X
Falls resulting in medical care		X	X
Type of injury			X
Dizziness	X		X
Fear of falling	X	X	X
Fatigue	X		X
Sleeping problems	X		
Self-reported balance-impairment	X		
Poor appetite	X		
Feeling nervous	X		
Hearing impairment	X		
Vision impairment	X		X
Number of health complaints			X
<b>Cognition</b>			
Mini Mental State Examination (MMSE)	X	X	X
<b>Health Related Quality of Life (HRQoL)</b>			
SF-12	X		
<b>Medications</b>			
Neuroleptics	X		
Sedatives	X		
Hypnotics	X		
Benzodiazepines	X		
Medium- and long- acting benzodiazepines	X		

## Physical function

This section described physical performance tests (TUG, RT and grip strength) and physical ability (ADL staircase and walking aids).

### *Timed Up & Go (TUG)*

TUG scores [117] was used to assess the scale's predictive validity for falls (Paper III) and as an additional outcome measure in the case management study (Paper IV). TUG is a modified, timed version of the "Get-Up and Go" Test [194] that was developed an easily administered instrument to assess basic functional mobility as a part of a geriatric assessment [117]. TUG has shown high test-retest and intra-/inter-rater reliability (intraclass correlation [ICC]=0.98-0.99) and moderate associations with reduced mobility, balance impairment and reduced ADL in elderly populations [42, 117, 195].

In Papers III and IV a 44-46 cm arm-chair was used and a line was taped 3 metres from the front chair leg. The participant was instructed to rise, walk across the line, turn around, return to the armchair and sit down again[117]. This was done as quickly as possible, but safely, and the participant was reassured about receiving help from the researcher if they lost their balance. The participant was given a practical trial before being timed and was able to use any walking aid they normally used during the test. Efforts were made to enabling using a walking aid at the test procedure for example by having enough space to turn around with a walker. The timing was started when the participant's back left the backrest of the chair and was stopped when they were seated again.

### *Romberg Test (RT)*

RT is often used as a part of a neurological examination to detect static balance impairment derived from a pathology in the proprioceptive pathways [196]. It has the ability to discriminate between fallers and non-fallers [197, 198] and has shown good test-retest reliability (eyes open [EO], ICC=0.86, eyes closed [EC] ICC=0.84) [199]. To test balance, the test can be performed with EO or EC and with feet in different positions. In semi-tandem Romberg Test (SRT) you stand with one foot in front of the other and in the tandem Romberg Test (TRT) you stand with your feet in a tandem (heel-to-toe) position [118]. The TRT has shown moderate test-retest reliability (EO, ICC=0.70, EC, ICC=0.91)[199].

In Paper I the RT was performed with EO and EC. In Paper III an RT test battery with three foot positions was used [118]: a. Feet together; b. One foot in front of the other; and c. Tandem stance. The tests were performed with EC and arms crossed over the chest. Participants who were able to perform the test in the first position for 30 seconds continued with the second position. If this position could be held for 60 seconds the third position was tested. The time in seconds was measured from closing of the eyes until test failure (opening of the eyes, loss of balance or compensatory arm

movements). After a pre-test practice run, the best time from three attempts was recorded.

### *Grip strength*

Grip strength was measured using the Grippit® [200]. This electronic grip force instrument measures the maximum isometric grip strength and sustained isometric grip strength with very high precision [201]. It has shown good reliability [200, 201]. In Paper I maximum isometric grip strength in the right hand was used.

### *ADL staircase*

The ADL staircase [202] is a hierarchical, cumulative scale that measures functional performance in PADL and IADL and is an expanded version of the Katz ADL index [202]. PADLs include bathing, dressing, going to the toilet, transfer, and feeding; IADLs includes cleaning, shopping, transportation and cooking. Each activity is graded as being performed independently, partly independently or dependently. This 10-item scale has shown acceptable psychometric properties in terms of content, criterion and construct validity, reproducibility and reliability in terms of internal consistency and inter-rater reliability [203, 204]. When validated in different age groups the scale generally showed acceptable construct validity and internal consistency but worked best in the older age cohorts and is therefore more suitable for older people [205]. The ADL staircase has also been shown to predict mortality in frail older people [206].

In Papers I and IV the activities were self-reported. In Paper I the response alternatives were dichotomized [204] and the summary score was dichotomized as 0=Independent and 1=Dependent. In Paper I a summary score of 0-9 was used and was divided into PADLs (scores 0-5) and IADLs (0-4) where a higher score indicates a higher degree of dependency. In Papers III and IV the scale was reported in median quartiles in ADL, IADL and PADL.

### *Walking aids*

In Papers III and IV the use of walking aids was self-reported and type of aid was recorded.

## Fall risk assessment

### *Downton Fall Risk Index (DFRI)*

The DFRI is a questionnaire that was developed to assess fall risk in older people [121]. It comprises 11 fall risk items: history of falls in the preceding 12 months; use of tranquilizers or sedatives; diuretics; antihypertensive drugs; anti-parkinsonian drugs; antidepressants; visual impairment; hearing impairment; limb impairment;

cognitive impairment; and walking ability. Each item is scored as 0 or 1 giving a summary score of 0-11, where  $\geq 3$  indicates an increased fall risk. In patients with stroke (N=135), the DFRI was able to differentiate between fallers and non-fallers ( $p=0.009$ ) with 91% sensitivity and 27% specificity [123]. In a study by Rosendahl et al. (2003) [122] in 78 persons living in a residential care facility, the predictive validity was assessed at 3, 6 and 12 months. The sensitivity ranged from 81% to 95% and the specificity from 35% to 40%. Today this instrument is frequently used in municipal care as it is a part of Senior Alert, a national quality register that aims to develop systematic, preventive health care for older people [120].

In Papers III and IV data on falls and medications was self-reported in DFRI. Impairments were assessed by the researcher together with the participant: visual and hearing impairments were classified as “moderate to severe impairment or blindness/deafness”, and “need of glasses/hearing aid on a daily basis”; limb impairment was defined as signs of extremity paresis/muscle weakness, and walking unsafely with or without a walking aid, with an MMSE score  $\geq 25$  (an inclusion scores for the studies).

## Self-reported health complaints

### *Falls*

In Paper I falls were measured using a single item: “Have you fallen in the last 12 months? How many times?” 0, 1, 2, 3, 4 or  $>4$  falls were the response alternatives. In Papers III and IV falls were measured with the initial question “Have you fallen in the last 3 months?” “Yes” and “No” were the response alternatives. If the answer was “Yes” answers to questions on frequency, location (Indoors/Outdoors/Both), injury (Yes/No) and type of injury were recorded, as well as on whether the fall/injury resulted in medical care (Yes/No).

### *Self-reported health complaints*

Other self-reported health complaints common in older people were, in Papers I and IV assessed using a questionnaire inspired by Tibblin et al. (1990) [207] with questions of the type “Have you during the last three months suffered from...?” “Yes” and “No” were the response alternatives. Balance impairment (Paper I) was measured with the question “Do you feel that your balance has got worse?” (Yes/No). Vision and hearing in Paper I were measured with a single item with the response alternatives “Yes”, “No” and “Don’t know”. Fear of falling was measured with the question “Are you afraid of falling when being outdoors?” in Paper I and “Are you afraid of falling?” in Paper IV. Paper IV used a summary score of the total number of health complaints.

## Cognitive impairment

### *Mini Mental State Examination (MMSE)*

The MMSE [175] is an indicator of cognitive status and measures cognitive functions such as memory, attention and orientation. The test gives a score of 0-30 where a higher score indicates a better cognitive status. In the original article by Folstein et al. [175],  $> 24$  was suggested as the cut-off. However, different cut-offs have been suggested [208] due to the fact that the test may be influenced by age, culture and education [209, 210].

In Paper I a cut-off of  $\leq 24$  was used; in Papers III and IV a score of  $\geq 25$  was used as an inclusion criterion.

## Health related quality of life (HRQoL)

### *Short-form Health Survey (SF-12)*

The SF-12 [211] assesses HRQoL and is a short version of the SF-36 [212]. The questionnaire consists of two subscales: the Physical Component Summary Scale (PCS), which includes questions on physical function, physical role, bodily pain and general health; and the Mental Component Summary Scale (MCS), which includes vitality, social functioning, emotional role and mental health. The questionnaire gives a summary score of 0-100, where a higher score indicates greater wellbeing. The SF-12 has shown acceptable reliability and validity, but its two-dimensional structure has been questioned when it is used on older people [211, 213, 214]. In Paper I both sub-scales were used.

## Medications

The medications include in Paper I were neuroleptics (N05A), sedatives (N05B), hypnotics (N05C) and SSRIs (N06AB). Benzodiazepines (N05BA, N05CD) included subgroups of medium-acting (N05CD0, N05CD03) long-acting (N05BA01) substances. The response alternatives were “Yes, taking the medication” or “No, not taking the medication”.

# Analysis methods

## Statistical analysis

In Papers I, III and IV both descriptive and analytical statistics were used. Comparisons between groups were performed using the Pearson's chi-square test for nominal data, the Mann-Whitney U-test for ordinal data and Students *t*-test for interval and ratio data. A *p*-value of  $\leq 0.05$  was considered statistically significant [215, 216]. The statistical analyses were performed using SPSS 17.0, 18.0 and 19.0.

In Paper I the sample was first divided into those aged 60-78 years and those aged 81-96 years. These age cohorts were then divided in subsamples of those who had reported at least one fall in the past year and those who had not. In the same way the sample was divided into those who had reported dizziness in the last 3 month and those who had not. Prevalence of falls and dizziness in the subsamples was described. The subsamples at the 3- and 6-year follow-ups were compared according to their baseline data. To identify predictors of falls and dizziness, variables significantly associated with falls and dizziness at baseline in the subsamples were entered into a multiple logistic regression analysis (manual backward) with falls or dizziness as the independent variable (0-1). Tests of multicollinearity (variance inflation factor [VIF]) and tolerance were performed to rule out high correlation between the independent variables. The highest Pearson correlation values were for grip strength and gender (0.642) and for PADLs and being community-dwelling (0.608). To test the quality of the regression models in terms of prediction accuracy the Hosmer and Lemeshow goodness-of-fit test was used. Nagelkerke  $R^2$  (was used as an indication of how much of the variation in the dependent variable was explained by the model. In this study, the test of goodness-of-fit showed acceptable values and  $R^2$  varied between 13.8% and 40.4%.

In Paper III the ability of DFRI, TUG and RT to predict the outcome (falls) correctly was assessed, as was the value that should be used to discriminate between people at risk of falls and those not at risk [217, 218]. The entire sample was included since no significant differences in fall rate between was found the intervention and control groups at the 6-month ( $p=0.641$ ) and 12-month ( $p=0.174$ ) follow-ups. Sensitivity, specificity, positive likelihood ratio (LR+), negative likelihood ratio (LR-) and percentage of cases classified correctly were calculated to assess the discriminant ability of the tests. Sensitivity identifies true positives (i.e. the number of fallers correctly classified by the test) and specificity identifies true negatives (i.e. the number of non-fallers) [217]. LR+ is the ratio of the probability of a positive test result if the outcome is positive to the probability of a positive test result if the outcome is negative (i.e. sensitivity/[1-specificity]). LR- is the probability of a negative test result if the outcome is positive to the probability of a negative test result if the outcome is



negative (i.e.  $[1-\text{sensitivity}]/\text{specificity}$ ) [217]. If  $\text{LR}^+$  is  $>10$  the test is highly accurate at identifying people at risk of falls; an  $\text{LR}^-$  value of  $<0.1$  can rule out the risk of falls [218]. To investigate the optimal cut-off score, Youden's Index was used [217]. The value of this index ranges from -1 to +1, where  $J=+1$  indicates the cut-off value for which sensitivity and specificity are maximized [217].

Paper IV investigated the effects of an RCT by summarizing the number of participants with falls, injurious falls, and needing medical care after an injurious fall, as well as number of falls, injurious falls and falls resulting in medical care from data collected at 3, 6, 9 and 12 months. The effect of the intervention was also measured by comparing the number of falls reported in the IG and the CG at each data collection point, i.e. 3, 6, 9 and 12 months. A complete cases analysis and an analysis with imputed values according to the intention-to-treat (ITT) principle [219] were done. Dropout analyses were done to confirm that the dropouts were missing completely at random (MCAR) [220] and that there were no significant differences between dropouts and participants in gender ( $p=0.215$ ), age ( $p=0.135$ ), falls ( $p=0.177$ ), DFRI ( $p=0.558$ ), ADLs ( $p=0.582$ ) or TUG ( $p=0.441$ ). Last observation carried forward (LOCF) was used as the imputation technique [220], where the last observed value from baseline, 3,6, and 9 months was imputed for falls, DFRI, ADLs and TUG. To test the robustness of the analyses imputation was also made according to the best-case scenario (no value= no fall) and worst-case scenario (no value= a fall) [221].

In the case management study a power analysis was performed in the pilot study on health care consumption, depressive symptoms and life satisfaction [174] but not on the outcome measure used in this thesis. Health care consumption usually demands quite a large sample due to skewed data [48, 222]. The power analysis showed that sample size needed to be 42 -95 participants per group, depending on various differences in mean values for different instruments [174].

## Content analysis

In Paper II content analysis was used to analyse the text derived from the interviews. Content analysis may include a manifest level which describes the visible, obvious components and a latent level that comprises an interpretation of the underlying meaning [171]. According to Graneheim and Lundman [223] manifest and latent content both deal with interpretation but vary in depth and level of abstraction. Hsieh and Shannon [224] describe three approaches to content analysis: a summative approach involving counting or comparing keywords or content followed by interpretation of the underlying context; a directed approach, where the analysis starts with a theory or relevant research findings as guidance for initial codes; and a conventional approach, where categories are derived directly from the text data. In Paper II we used a conventional approach. This approach is usually appropriate when

existing theory or research literature on a phenomenon is limited. No preconceived categories are used; instead, categories are allowed to flow from the text [224].

The analysis process was performed according to Graneheim and Lundman [223] and was conducted in several steps. The categories were labelled subthemes, themes and overall theme according to Morse (2008) [225]. We read the texts and listened to the audio recordings several times to become familiar with the content and general understanding of the text was confirmed by two of the co-authors. Meaning units relating to the aim of the study were highlighted and further condensed into codes in the form of shorter phrases or words. At this point the first and last authors each categorized sub-themes in the same two interviews independently of each other and met and discussed the content until a consensus was reached. The first author then categorized sub-themes in the remaining interviews and labelled them with preliminary themes. After that, all the authors met and discussed the themes until a consensus was reached. Research triangulation was used during the analysis since the co-authors represented PTs, nurses and a GP. We continued the analysis by going a back and forth through the text, meaning units, sub-themes and themes which finally lead to an overall theme. The final thematic overview of the results was confirmed by all authors.



# Ethical considerations

The studies were conducted in accordance with the Declaration of Helsinki [226] and the Swedish Act concerning the Ethical Review of Research Involving Humans [227] (SFS 2003:460 and SFS 2008:192), and followed the ethical principles of autonomy, nonmaleficence, beneficence and justice [228]. The Regional Ethical Review Board in Lund approved the studies (Study I: nos. LU 650-00 and LU 744-00; Study II: nos. 402/10 and 659/11; and Study III: nos. 342/06 and 499/08).

Respect for the principle of *autonomy* obligates professionals in health care and research involving human subjects to disclose information, to probe for and ensure understanding and voluntariness, and to foster adequate decision making [228]. Written consent was obtained in all the studies of this thesis. Participants were repeatedly informed that the participation was voluntarily and that they could withdraw at any time without any consequences. In Paper I an invitation with information about the study was sent by mail. Written consent was obtained from the participant or, if the participant was cognitively impaired from next of kin, at the first data collection session by the research team. In Paper II the respondents were informed about the study orally on two occasions and then received written information. The respondents could choose the location of the interview and before the interview started the interviewer asked the respondents if they had understood the written information and if they had any question. Then written consent was obtained. In Papers III and IIV written and/or oral information was given to the eligible participants prior to randomization and before the baseline measure. Written consent was obtained and it was emphasized that the participants could withdraw at any time during the study without explanation. The different parts of the intervention were voluntary, and the participants had the possibility to change their CM if they so desired.

The principle of *nonmaleficence* asserts an obligation not to harm, impose risk of harm or set back the interests of participants [228]. The aim of the case management intervention in Papers III and IV was to benefit the participants by protecting and defending their rights and preventing harm by removing conditions that risked causing harm to them. In all studies the confidentiality was ensured by coding each respondent with a number. The coded research data in all studies were only available to the research team and the coded list and the questionnaires were stored separately in locked cabinets. To further ensure anonymity, the results from Papers I, III and IV are presented at the group level. In Paper II information that had the potential to

jeopardize anonymity or confidentiality was excluded. A data collection process may provoke thoughts, feelings or emotions in the participant. In Paper I the respondents were offered help to complete the questionnaire if needed and the research team was available by phone for questions. In Paper II the respondents were able to contact the interviewer by phone after the interviews. In Papers III and IV all data were collected in face-to-face interviews with the possibility of meet upcoming issues, and the research team was available by phone. Since all of the studies included older and sometimes frail people, efforts were made to ensure that this process wasn't too tiresome for the participant, e.g. by taking short breaks. The case management intervention in Papers III and IV included a component to increase physical activity might have increased the risk of a fall or an injury. Safety issues were, however, always the main priority and efforts were made to minimize the risk of injury e.g. by using aids for personal mobility or performing the exercise in a safe way. Another aspect of nonmaleficence is withdrawal of the intervention after 1 year. The close relationship between the CM and the participant may have led to the respondent feeling abandoned at the end of the study. However, efforts were made at the end of the intervention to make sure the participant had sufficient human contact and activities.

The principle of *beneficence* comprises doing good and acting for the benefit of others [228]. The benefit of the results in all studies in this thesis might be recognized in terms of the contribution of new knowledge about a group of people in need of a considerable health care and social service resources and about improvements in health care for older people. In Papers III and IV if during the interview session the research assistant discovered a need for help the CM, next of kin, the participant's GP, or the GPs in the research team was contacted. The IG and the CG also had a pharmaceutical review by a GP in the research team. In Papers II, III and IV the personal interviews gave the respondents an opportunity to reflect on their situation and to discuss issues arising during the interview, which potentially gave new insights.

The principle of *justice* includes an equal chance of having access to various kinds of resources [228]. In Papers III and IV an equal chance of receiving the intervention was ensured through the randomization process. The cross-over design gave the participants an opportunity to receive the intervention after being included in the CG. However, since those studies included frail older people there was the risk that the participants' mental health would decline when in the CG, leading to their exclusion before they had the possibility to be enrolled in the IG. No participant in either study was excluded due to age, gender, sexuality, nationality, political ideology or social status. In Paper IV, although the intervention was individualized, all the participants had the same opportunity to receive the different parts of the intervention, i.e. traditional case management tasks, general and specific information, and safety and continuity. They were also able to receive a minimum of one visit per month for 1 year.

# Results

## Predicting dizziness

In Paper I 23.6% of the sample (n=973) reported dizziness at baseline, 17.8% in the younger age cohort and 31.0% in the older age cohort (Table 3). Of those who reported dizziness (n=80) in the *3-year follow-up* 56.3% also reported dizziness at baseline. Splitting the sample at the 3-year follow-up into people with and without dizziness and investigating differences between the age cohorts in baseline variables showed significant differences in gender, IADLs, grip strength, falls, dizziness, fear of falling, self-reported balance impairment, fatigue and physical HRQoL. Predictors of dizziness in the 3-year follow-up were history of dizziness and history of falling (Table 4).

In the *6-year follow-up* of those who reported dizziness in the younger age cohort (n=114) 40.4% also reported dizziness at baseline. Splitting the sample at the 6-year follow-up into people with and without dizziness and investigating differences between the age cohorts in baseline variables showed significant differences in age, gender, grip strength, falls, dizziness, fear of falling, self-reported balance impairment, fatigue, sleep, appetite, nervousness, vision, HRQoL, hypnotics, all benzodiazepines, and medium- and long-acting benzodiazepines. In the 6-year follow-up in the younger age cohort the predictors of dizziness were history of dizziness, nervousness and reduced grip strength (Table 4).

In the older age cohort with dizziness at the *6-year follow-up* (n=58) 43.1% reported dizziness at baseline. Splitting the sample at the 6-year follow-up into people with and without dizziness and investigating differences between the age cohorts in baseline variables showed significant differences in IADLs, falls, dizziness, self-reported balance impairment, fatigue, nervousness and HRQoL. History of dizziness and history of falling were predictors of dizziness (Table 4).

**Table 3.** Baseline characteristics in the younger (aged 60-78 years) and older age cohorts (aged 80-96 years) in Paper I.

	Younger age cohort (n=740)	Older age cohort (n=662)	p-value
<b>Socio-demographic variables</b>			
Age (years), mean (SD)	68.6 (6.6)	85.7 (3.9)	p<0.001 <sup>d</sup>
Female, n (%)	401 (54.1)	416 (62.8)	p=0.001 <sup>c</sup>
Community-dwelling, n (%)	707 (98.6) <sup>a</sup>	519 (87.1) <sup>b</sup>	p<0.001 <sup>c</sup>
<b>Functional capacity</b>			
PADL dependency, n (%)	28 (3.8) <sup>a</sup>	156 (24.0) <sup>a</sup>	p<0.001 <sup>d</sup>
IADL dependency, n (%)	63 (8.5) <sup>a</sup>	360 (55.0) <sup>a</sup>	p<0.001 <sup>d</sup>
Romberg test, EO pos, n (%)	11 (1.6) <sup>a</sup>	77 (15.7) <sup>c</sup>	p<0.001 <sup>d</sup>
Romberg test, EC pos, n (%)	64 (9.5) <sup>a</sup>	184 (38.3) <sup>c</sup>	p<0.001 <sup>d</sup>
Grip strength (right) mean (SD)	281 (120) <sup>a</sup>	193 (92) <sup>c</sup>	p<0.001 <sup>c</sup>
<b>Self-reported health complaints</b>			
History of falling, n (%)	90 (16.5) <sup>c</sup>	136 (31.7) <sup>c</sup>	p<0.001 <sup>d</sup>
Dizziness, n (%)	127 (17.8) <sup>a</sup>	174 (31.0) <sup>b</sup>	p<0.001 <sup>d</sup>
Fear of falling, n (%)	97 (13.7) <sup>a</sup>	204 (37.4) <sup>b</sup>	p<0.001 <sup>d</sup>
Self-reported balance impairment, n (%)	117 (16.7) <sup>a</sup>	256 (47.0) <sup>b</sup>	p<0.001 <sup>d</sup>
Fatigue, n (%)	313 (44.1) <sup>a</sup>	311 (55.3) <sup>b</sup>	p<0.001 <sup>d</sup>
Sleeping problems, n (%)	206 (29.0) <sup>a</sup>	208 (36.9) <sup>b</sup>	p=0.003 <sup>d</sup>
Poor appetite, n (%)	44 (6.2) <sup>a</sup>	98 (17.6) <sup>b</sup>	p<0.001 <sup>d</sup>
Feeling nervous, n (%)	110 (15.6) <sup>a</sup>	112 (20.2) <sup>b</sup>	p=0.035 <sup>d</sup>
Hearing impairment, n (%)	239 (32.3) <sup>a</sup>	344 (52.4) <sup>a</sup>	p<0.001 <sup>d</sup>
Vision impairment, n (%)	198 (26.8) <sup>a</sup>	339 (51.4) <sup>a</sup>	p<0.001 <sup>d</sup>
<b>Cognition and HRQoL</b>			
MMSE ≤ 24, n (%)	65 (8.8) <sup>a</sup>	258 (41.1) <sup>a</sup>	p<0.001 <sup>d</sup>
SF 12 (PCS), mean (SD)	45.6 (10.4) <sup>a</sup>	37.6 (11.8) <sup>c</sup>	p<0.001 <sup>c</sup>
SF 12 (MCS), mean (SD)	55.3 (8.1) <sup>a</sup>	52.5 (9.4) <sup>c</sup>	p<0.001 <sup>c</sup>
<b>Medications</b>			
Neuroleptics, n (%)	11 (1.5)	34 (5.1)	p<0.001 <sup>d</sup>
Sedatives, n (%)	34 (4.6)	88 (13.3)	p<0.001 <sup>d</sup>
Hypnotics, n (%)	62 (8.4)	146 (22.1)	p<0.001 <sup>d</sup>
Benzodiazepines, n (%)	47 (6.4)	131 (19.8)	p<0.001 <sup>d</sup>
Medium- and long-acting benzodiazepines, n (%)	35 (4.7)	88 (13.3)	p<0.001 <sup>d</sup>
SSRI, n (%)	30 (4.1)	55 (8.3)	p=0.001 <sup>d</sup>

Missing values: <sup>a</sup>0.1-8.8 %, <sup>b</sup>10-17.7 %, <sup>c</sup>26.1-35.2 %.

<sup>d</sup>Chi-square test, <sup>e</sup>Student's *t*-test

**Table 4.** Predictors of dizziness at follow-up at 3- and 6 years in subjects the younger (aged 60-78 years) and older (aged 80-96 years) age cohorts.

Final model	OR <sup>a,b,c</sup>	95% CI for OR	p-value	Crude OR	95% CI for crude OR	p-value for crude OR
<b>Younger age cohort</b>						
<i>6-year follow-up (n=513)</i>						
History of dizziness	4.74	2.76-8.14	<0.001	6.38	3.88-10.47	<0.001
Feeling nervous	2.41	1.37-4.25	0.002	2.96	1.77-4.93	<0.001
Reduced grip strength	0.99	0.99-1.00	<0.001	0.99	0.99-1.00	<0.001
<b>Older age cohort</b>						
<i>3 year follow-up (n=164)</i>						
History of dizziness	18.15	6.88-47.90	<0.001	14.14	6.76-29.58	<0.001
History of falling	3.74	1.55-9.03	0.003	3.67	1.74-7.71	0.001
<i>6-year follow-up (n=107)</i>						
History of dizziness	5.42	1.90-15.47	0.002	5.91	2.55-13.67	<0.001
History of falling	4.40	1.50-12.92	0.007	4.13	1.48-11.50	0.007

The dependent variable (dizziness) coded as no = 0 and yes = 1.

<sup>a</sup>Hosmer and Lemeshow goodness-of-fit test: 3-year: 0.414; 6-year: younger age cohort: p=0.927; older age cohort: p=0.814.

<sup>b</sup>Nagelkerke R<sup>2</sup>: 3-year: 0.404; 6-year: younger age cohort: 0.231; older age cohort: 0.217.

<sup>c</sup>Variables at baseline entered into the regression analysis (manual backward): 3-year: gender, IADLs, grip strength, history of falling, dizziness, fear of falling, self-reported balance impairment, and fatigue; 6-year: younger age cohort: age, gender, grip strength, history of falling, dizziness, fear of falling, self-reported balance impairment, fatigue, sleeping problems, poor appetite, feeling nervous, vision, and hypnotics; older age cohort: IADLs, history of falling, dizziness, self-reported balance impairment, fatigue, and feeling nervous.

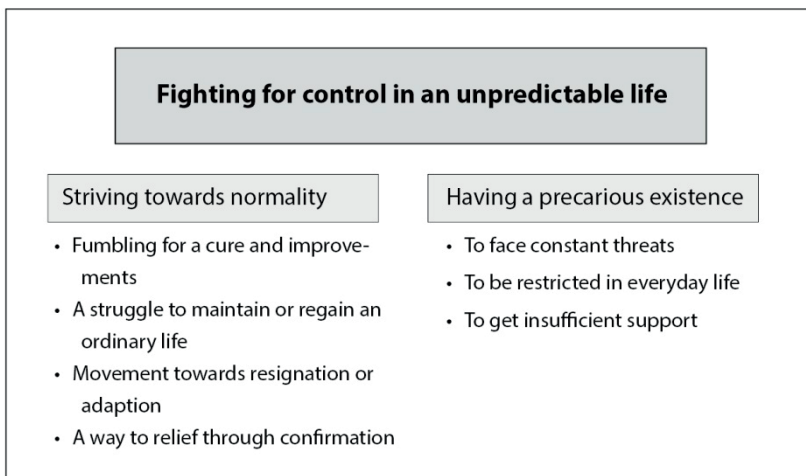
The drop-out analyses showed that those with no data on dizziness at baseline (n=129) were significantly older (p<0.001) but with no gender difference (p=0.596). When investigating dizziness at the *3-year follow-up* the drop-outs included more women (p=0.009), were older (p<0.001) and more frequently reported dizziness (p=0.012). At the *6-year follow-up* the drop-outs showed no significant difference in gender (p=0.362), but they were older (p<0.001) and more frequently reported dizziness (p<0.001).



## Living with chronic dizziness at old age

Paper II explored daily life from the perspective of older people with chronic dizziness. The respondents were between 73 and 87 years old (mean age 80 years). They were diagnosed with Meniere's disease, multisensory impairment, acoustic neuroma and vestibular neuritis by their GP or otolaryngologist, and they had lived with dizziness for between 1.5 and 20 years (median 7.5 years). Most participants described multiple diseases including heart diseases, polyneuropathy, asthma, cancer, arthritis, diabetes, osteoporosis or depression. They lived in both urban and rural areas, five were cohabiting and eight lived alone. Four had home help (cleaning) or help from relatives. None of them had help in PADL.

The interpretation of the interviews formed the overall theme *fighting for control in an unpredictable life* with two subordinate themes. The theme *striving towards normality* included four sub-themes: *fumbling for a cure and improvements*, *a struggle to maintain or regain an ordinary life*, *movement towards resignation or adaption*, and *a way to relief through confirmation*. The theme *having a precarious existence* included three sub-themes: *to face constant threats*, *to be restricted in everyday life*, and *to get insufficient support* (Figure 6)



**Figure 6.** Thematic overview of the results.

The overall theme revealed that daily life when older and suffering from chronic dizziness was a constant fight to live in and take control of an unpredictable existence. Some of the respondents had developed coping strategies which gave them a feeling of being in control of their situation. Others expressed the inability to maintain or regain the way of life they wanted and that they didn't get the support they felt they were in need of.

*Striving towards normality* meant trying to hold on to a previous lifestyle to be able to "feel normal". This was expressed as a constant search for a cure and improvement, even in respondents who had lived with their dizziness for more than 10 years and had frequent health care contacts. This search included trying out various treatments or seeking new information. How living with dizziness was perceived was strongly affected by whether the inevitable changes in daily life were thought of as voluntary or involuntary. Some expressed motivation to keep on searching and not give in to their dizziness symptoms but instead be determined and go through with planned activities, in spite of the great effort involved. Self-help strategies were used to find new solutions to incorporating the effects of chronic dizziness into daily life. The respondents had adapted to a life with dizziness and felt confident in controlling their daily life. Others expressed feelings of resignation and that suffering from dizziness strongly affected their lives in a negative way. They had been forced to give up activities, were not able to maintain their standard of living, and had lost confidence in their ability to control their situation. To stay independent was a commonly mentioned wish and was facilitated by receiving formal as well as informal support. This support was perceived as enhancing physical as well as psychological aspects of living with chronic dizziness. Getting support meant that the participants' concerns were taken seriously and it also gave them hope for the future.

*Having a precarious existence* was interpreted as having an insecure daily life with ever-present risks. This insecurity evolved from having experienced or being at risk of getting into dangerous or unpleasant situations such as a vertigo attack or a fall. It included being forced to consciously expose oneself to dangerous situations to manage daily life. The consequence of this insecure daily life was the need for constant awareness about daily activities. This included everyday adjustments and immediate revaluations, which meant that the respondents suddenly had to change or restrict their daily activities. They expressed that it was difficult to find the most appropriate activity level and to make the right priorities. Having a precarious existence also included living with a physically narrow security zone due to not being able to move around without an mobility aids. This had consequences in terms of inaccessibility of public buildings and transport or other hazardous environments and led to avoidance of activities. Another aspect of an insecure daily life was that it meant having concerns about the present and future life situation. This was expressed as a fear of being dependent on others without access to the amount of help and support that was felt to be necessary. Being dependent on others raised feelings of frustration at being forced to adapt to others or unwillingly having to lower one's demands. The feelings

of insecurity also emerged from a lack of information about the disease in terms of the cause and prognosis, and the respondents sometimes felt that their dizziness symptoms were not taken seriously. This in turn led to feelings of abandonment and dashed expectations of recovery. This was expressed in spite of the fact that all the respondents had frequent health care contacts. The respondents also experienced that the treatment they received didn't help, although objective measures had improved after the treatment.

## Predicting falls

### Fall risk-increasing factors

In Paper I 23.2% of the sample (n=1273) reported falls at baseline. The prevalence differed when the sample was split according to age; 16.5% in the younger age cohort and 31.7% in the older age cohort. Other variables investigated in this study also showed significant associations between the age cohorts at baseline (Table 3).

Of those who reported a fall at the *3-year follow-up* (n=88) 32 people (36.4%) also reported a fall at baseline. Splitting the sample at the 3-year follow-up into people with and without falls and investigating differences between the age cohorts in baseline variables showed significant differences in age, IADLs, Romberg test (EC), falls, fear of falling, self-reported balance impairment, fatigue, hearing, vision, HRQoL, hypnotics, all benzodiazepines, and medium- and long acting benzodiazepines. Predictors of falls at the 3- year follow-up were history of falls, fatigue and higher age (Table 5).

In the *6-year follow-up* in the younger age cohort, those who reported a fall (n=81), 23 people (28.4%) also reported a fall at baseline. Splitting the sample at the 6-year follow-up into the younger age cohort with falls and no falls and investigate differences between the age cohorts in baseline variables showed significant differences in age, ADLs, grip strength, falls, dizziness, fear of falling, self-reported balance impairment, hearing, vision, physical HRQoL, use of neuroleptics and sedatives. The predictors for falls in the younger age cohort were: use of neuroleptics, PADL dependency, history of falling, vision impairment and higher age (Table 5).

In the older age cohort at the *6-year follow-up*, 75 people reported a fall; 30 of them (40.0%) also reported a fall at baseline. Splitting this sample in the older age cohort in people with or without falls showed significantly differences in IADLs, falls, self-reported balance impairment, fatigue and physical HRQoL. The predictors of falls were history of falling and IADL dependency (Table 5).

**Table 5.** Predictors of falls at follow-up at 3 and 6-years in the younger (60-78 years) and older (80-96 years) age cohorts.

Final model	OR <sup>a,b,c</sup>	95% CI for OR	p-value	Crude OR	95% CI for crude OR	p-value for crude OR
<b>Younger age cohort</b>						
<i>6-year follow-up (n=438)</i>						
Neuroleptics	10.82	1.62-72.15	<b>0.014</b>	6.88	1.13-41.90	<b>0.036</b>
PADL dependency	6.58	1.00-43.18	<b>0.050</b>	9.37	1.68-52.08	<b>0.011</b>
History of falling	2.63	1.42-4.89	<b>0.002</b>	3.08	1.72-5.52	<b>&lt;0.001</b>
Vision impairment	2.29	1.28-4.09	<b>0.005</b>	2.86	1.67-4.91	<b>&lt;0.001</b>
Higher age	1.05	1.01-1.09	<b>0.022</b>	1.07	1.03-1.11	<b>&lt;0.001</b>
<b>Older age cohort</b>						
<i>3 year follow-up (n=233)</i>						
History of falling	2.05	1.10-3.82	<b>0.024</b>	2.09	1.16-3.75	<b>0.013</b>
Fatigue	2.00	1.12-3.58	<b>0.019</b>	0.44	0.25-0.76	<b>0.004</b>
Higher age	1.16	1.07-1.26	<b>&lt;0.001</b>	1.16	1.07-1.26	<b>&lt;0.001</b>
<i>6-year follow-up (n=174)</i>						
History of falling	3.18	1.49-6.80	<b>0.003</b>	4.10	1.97-8.50	<b>&lt;0.001</b>
History of falling	2.72	1.35-5.47	<b>0.005</b>	3.50	1.80-6.82	<b>&lt;0.001</b>

The dependent variable (falls) was coded as 0 = no falls and 1 = falls

<sup>a</sup>Hosmer and Lemeshow goodness-of-fit test: younger age cohort:  $p = 0.886$ ; older age cohort: 3-years:  $p=0.420$ ; 6-years:  $p = 0.406$ .

<sup>b</sup>Nagelkerke  $R^2$ : younger age cohort: 0.138; older age cohort: 3-years: 0.153; 6-years: 0.167.

<sup>c</sup>Variables at baseline entered into the regression analysis (manual backward): 3-year: age, IADLs, Romberg (EC), history of falling, fear of falling, self-reported balance impairment, fatigue, hearing, vision, and hypnotics; 6-year: younger age cohort: age, IADLs, grip strength, history of falling, dizziness, fear of falling, self-reported balance impairment, hearing, vision, use of neuroleptics, and sedatives; older age cohort: IADLs, history of falling, self-reported balance impairment, and fatigue.

The drop-out analyses showed that those with no data on falls at baseline ( $n=429$ ) were significantly older ( $p<0.001$ ) and more of them were women ( $p=0.009$ ). The participants who dropped out before follow-up were older ( $p<0.001$ ) but with no gender difference. When investigating falls at the *3-year follow-up* the drop-outs showed no significant difference in gender ( $p=0.357$ ), but they were older ( $p<0.001$ ) and more frequently reported falls ( $p=0.020$ ). At the *6-year follow-up* the drop-outs showed no significant difference in gender ( $p=0.813$ ), but they were older ( $p<0.001$ ) and to a higher degree reported falls ( $p<0.001$ ).

## Fall risk in-home assessments

Baseline characteristics in the participants in Paper III are shown in Table 6. In the total sample ( $N = 153$ ) the mean age was 81.5 years (Standard deviation [SD] 6.3, range 66–94 years) and 67% of the participants were women. At baseline 38 participants (24.8%) reported at least one fall in the past 3 months of whom 26 (68.4%) sustained an injury. Of them, almost half required medical care. Most falls occurred inside and fear of falling was reported by ~63% of the participants. The median score for the ADL staircase was 2 and ~75% of the participants were using a walking aid. Seventy-eight percent had, according to the DFRI, an increased risk of falling (DFRI score  $\geq 3$ ). In the 85 participants that performed the physical performance tests, the mean TUG time was 15.6 seconds (SD 6.0, range 5.6-36.4 seconds). The RT was executed for 30 seconds by 79% of the. The SRT was executed for 30 seconds by 66% of the sample and only 5% of the participants were able to execute the TRT for 30 seconds.

Analysis of complete cases at the 6- and 12-month follow-ups showed no significant differences in TUG, RT, SRT, TRT or DFRI between those reporting a fall and those with no fall. For *DFRI* at the 6-month follow-up a cut-off of  $\geq 2$  showed the highest Youden's index with 100% sensitivity, 8% specificity and 34% of the participants were correctly classified. For the 12 month-follow-up a value of  $\geq 3$  showed the highest index, with 79% sensitivity, 24% specificity and 39% of the participants were correctly classified. For *TUG* at the 6-month follow-up the Youden's index revealed the highest value with a cut-off of  $\geq 13$  seconds which gave 67% sensitivity, 50% specificity and 54% of the participants were correctly classified. In the 12 month-follow-up a value of  $\geq 12$  seconds showed the highest index, with 78% sensitivity, 37% specificity and 50% of the participants were correctly classified. For the *RT* the highest Youden's index in the 6-month follow-up was  $\geq 30$  seconds with 20% sensitivity, 82% specificity and 68% of the participants were correctly classified and in the 12 month-follow-up a value of  $\geq 15$  seconds showed the highest index with 22% sensitivity, 91% specificity and 70% of the participants were correctly classified. For the *SRT* the highest index in the 6-month follow-up was  $\geq 15$  seconds with 20% sensitivity, 72% specificity and 61% of the participants were correctly classified and in the 12 month-follow-up a value of  $\geq 60$  seconds showed the highest index with 39% sensitivity, 67% specificity and 59% of the participants were correctly classified. For the *TRT* the highest index in the 6-month follow-up was 0 seconds (i.e. not able to perform the test) with 73% sensitivity, 32% specificity and 41% of the participants were correctly classified and in the 12 month-follow-up a value of  $\geq 15$  seconds showed the highest index with 94% sensitivity, 12% specificity and 36% of the participants were correctly classified.

**Table 6.** Baseline characteristics in the participants in the case management intervention (Papers III-IV).

Variables	Total sample (n=153)	IG (n=80)	CG (n=73)	p-value
Age (years), mean (SD)	81.5 (6.3)	81.4 (5.9)	81.6 (6.8)	0.795 <sup>g</sup>
Women, n (%)	102 (66.7)	52 (65.0)	50 (68.5)	0.647 <sup>h</sup>
Married or cohabiting, n (%)	54 (35.3)	24 (30.0)	30 (41.1)	0.151 <sup>h</sup>
Municipal elderly care, n (%)	54 (35.3)	30 (37.5)	24 (32.9)	0.550 <sup>h</sup>
Falls in the past 3 months, n (%)	38 (24.8)	16 (20.0)	22 (30.1)	0.147 <sup>h</sup>
1 fall <sup>a</sup> , n (%)	20 (55.6)	9 (11.2)	11 (15.1)	0.484 <sup>h</sup>
2 falls, n (%)	10 (27.8)	3 (3.8)	7 (9.6)	0.195 <sup>h</sup>
≥ 3 falls, n (%)	6 (16.6)	3 (3.8)	3 (4.1)	1.000 <sup>h</sup>
Inside <sup>b</sup> , n (%)	26 (70.3)	10 (13.8)	16 (23.3)	0.728 <sup>h</sup>
Outside, n (%)	9 (23.7)	4 (6.2)	5 (8.2)	1.000 <sup>h</sup>
Both inside and outside, n (%)	2 (5.3)	1 (6.2)	1 (4.5)	1.000 <sup>h</sup>
Fall related injury in the past 3 months, n (%)	26 (68.4)	11 (13.8)	15 (20.5)	0.263 <sup>h</sup>
Fall related injury resulting in medical care in the past 3 months, n (%)	12 (31.6)	7 (8.8)	5 (6.8)	0.662 <sup>h</sup>
ADL staircase score, median (q1-q3)	2 (1-3)	2 (1-3)	2 (1-3)	0.831 <sup>i</sup>
IADLs, median (q1-q3)	2 (1-3)	2 (1-3)	2 (1-3)	0.651 <sup>i</sup>
PADLs, median (q1-q3)	0 (0-0.5)	0 (0-0.8)	0 (0-0.5)	0.881 <sup>i</sup>
DFRI <sup>c</sup> ≥ 3, n (%)	114 (78.0)	61 (76.6)	63 (84.9)	0.198 <sup>h</sup>
TUG <sup>c</sup> , seconds, mean (SD)	15.6 (6.0)	15.4 (6.8)	16.3 (5.5)	0.468 <sup>g</sup>
RT <sup>c</sup> , < 30 seconds, n (%)	18 (21.2)	10 (21.7)	8 (19.5)	0.890 <sup>h</sup>
SRT <sup>c</sup> , < 30 seconds, n (%)	29 (34.1)	13 (28.3)	16 (41.0)	0.216 <sup>h</sup>
TRT <sup>c</sup> , < 30 sec, n (%)	81 (95.3)	42 (91.3)	39 (100.0)	0.121 <sup>h</sup>
Number of self-reported health complaints, median (q1-q3)	11 (8-15)	11 (7-15)	11 (8-15)	0.655 <sup>i</sup>
Dizziness, n (%)	79 (51.6)	38 (47.5)	41 (56.2)	0.284 <sup>h</sup>
Fear of falling <sup>e</sup> , n (%)	94 (62.7)	47 (60.3)	47 (65.3)	0.525 <sup>h</sup>
Fatigue, n (%)	86 (56.2)	45 (56.3)	41 (56.2)	0.991 <sup>h</sup>
Hearing impairment, n (%)	54 (35.3)	31 (38.8)	23 (31.5)	0.208 <sup>h</sup>
Unsteadiness <sup>f</sup> , n (%)	62 (69.7)	32 (66.7)	30 (73.2)	0.506 <sup>h</sup>
Pain in the musculoskeletal system, n (%)	107 (66.9)	55 (68.8)	52 (71.2)	0.738 <sup>h</sup>
Walking difficulties, n (%)	111 (71.4)	55 (68.8)	55 (75.3)	0.365 <sup>h</sup>
Impaired mobility, n (%)	77 (50.3)	40 (50.0)	37 (50.7)	0.933 <sup>h</sup>
Vision impairment, n (%)	43 (28.1)	24 (30.0)	19 (26.0)	0.585 <sup>h</sup>
Walking aids, n (%)	111 (72.5)	57 (71.2)	54 (74.0)	0.492 <sup>h</sup>

Missing data <sup>a</sup>n=2, <sup>b</sup>n=1, <sup>c</sup>n=4, <sup>d</sup>n=3, <sup>e</sup>n= 85, <sup>f</sup>n=89,

<sup>g</sup>Student's *t*-test, <sup>h</sup>Pearson's chi-square test, <sup>i</sup>Mann-Whitney U-test.

## Preventing falls – the case management intervention

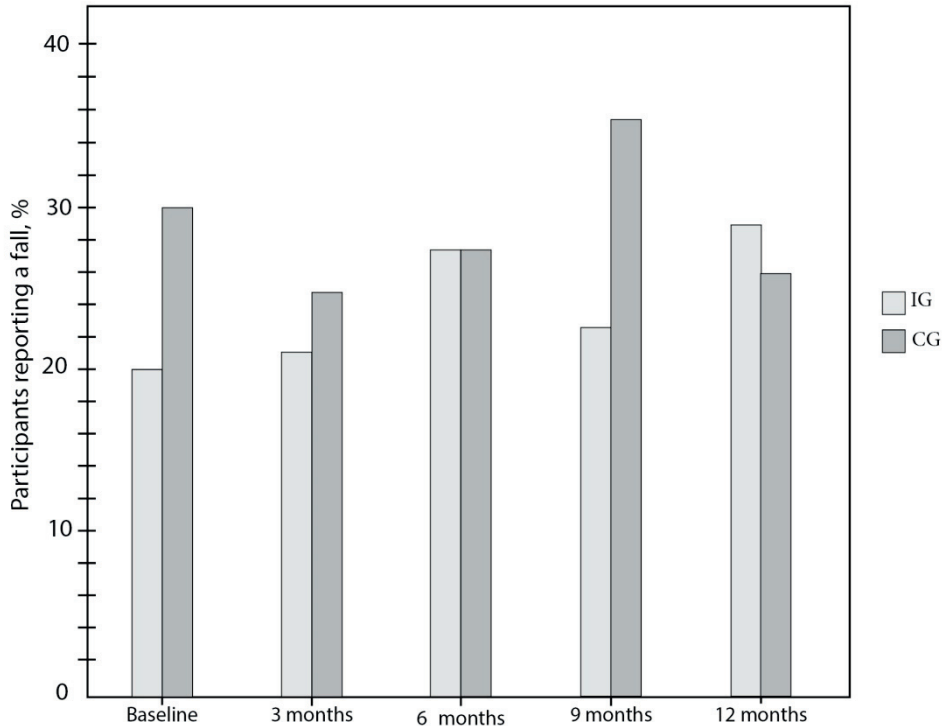
In Paper IV the effects of a fall prevention intervention were investigated. Baseline characteristics are shown in Table 6. No significant differences between the IG and CG were reported at baseline. In the IG, mean age was 81.4 years (SD 5.9) and 65% were women. Twenty percent had suffered a fall in the past 3 months, 77% had a risk of falling (score of  $\geq 3$  on the DFRI) and the mean TUG result was 15.4 seconds. In the CG, mean age was 81.6 years (SD 6.8) and 68.5% were women. Thirty percent of participants had suffered a fall in the past 3 months, 85% had a risk of falling and the mean TUG result was 16.3 seconds. Both groups scored a median of two points on the ADL staircase and had a median of 11 health complaints; about a third of participants in both groups used municipal elderly care (Table 6).

The participants who dropped out during the 12-month follow-up period did not show any statistically significant differences with those who remained in the study in the following baseline characteristics: age ( $p=0.892$ ), gender ( $p=0.172$ ), falls in the past 3 months ( $p=0.680$ ) and risk of future falls (DFRI) ( $p=0.936$ ).

For those participants who completed the intervention, the PT CMs made a mean of 10.4 home visits and 0.8 telephone calls, nurse CMs a mean of 11.1 home visits and 1.9 telephone calls. For drop-outs the mean number of PT CMs visits and telephone calls were 2.5 and 1.0, respectively, and the mean number of nurse CMs visits and telephone calls were 3.7 and 1.0, respectively.

The participants in the IG reported 1-10 falls; those in the CG reported 1-11 falls. In IG 30% ( $n=24$ ) reported 1 fall, 7.5% ( $n=6$ ) 2 falls, 4% ( $n=3$ ) 3 falls and 12.5% ( $n=10$ )  $\geq 4$  falls. In CG 16.5% ( $n=12$ ) reported 1 fall, 16.5% ( $n=12$ ) 2 falls, 7% ( $n=5$ ) 3 falls and 8% ( $n=6$ )  $\geq 4$  falls.

Analysis of participants who reported a fall in each group at each data collection time point (3, 6, 9, and 12 months) showed 14 (21.5%), 19 (30.2%), 14 (25.0%) and 19 (33.9%) falls, respectively, in the IG and 13 (20.3%), 15 (26.3%), 19 (35.8%) and 11 (22.0%) falls, respectively, in the CG (Figure 7). When we analysed complete cases we found no statistically significant differences between the groups at any time point (3 months,  $p=0.864$ ; 6 months,  $p=0.641$ ; 9 months,  $p=0.218$ ; and 12 months,  $p=0.174$ ). This pattern remained after imputation (3 months,  $p=0.616$ ; 6 months,  $p=0.989$ ; 9 months,  $p=0.073$ ; and 12 months,  $p=0.706$ ).



**Figure 7.** Participants (%) reporting a fall in the past 3 months in the intervention group (IG) and control group (CG) at baseline, 3, 6, 9 and 12-month follow-ups.

Number of participants with falls and the number of falls during the study in the IG and CG is shown in Table 7. In the IG, 44 participants (55.0%) reported a fall and of whom 30 participants (68.2%) reported a fall injury and 15 (50.0%) reported a fall injury resulting in medical care. In the CG 35 participants (49.7%) reported a fall of whom 27 participants (77.1%) reported an injurious fall and 9 (33.3%) reported a fall injury resulting in medical care. Ninety-six falls were reported in the IG and 85 in the CG ( $p=0.248$ ). In the IG, 40 falls (41.7%) resulted in an injury and 19 (47.5%) required medical care. In the CG, 38 falls (44.7%) resulted in an injury and 15 (39.5%) required medical care. The injuries consisted mainly of wounds, bruises and pain. Of the 181 reported falls only six (3%) resulted in fractures: five in the IG (facial, wrist, rib, hip and toes) and one in the CG (pelvis plus rib).



**Table 7.** Numbers of participants with falls, rates of falls, injurious falls and falls resulting in medical care in the intervention group (IG) and control group (CG) during the 12-month follow-up period.

	IG (n=80)	CG (n=73)	p-value
Participants with falls, n (%)	44 (55.0) <sup>a</sup>	35 (47.9) <sup>a</sup>	0.248 <sup>b</sup>
Participants with fall injuries, n (%)	30 (68.2)	27 (77.1)	0.338 <sup>b</sup>
Participants with fall injuries resulting in medical care, n (%)	15 (50.0) <sup>a</sup>	9 (33.3) <sup>a</sup>	0.402 <sup>b</sup>
Number of falls (falls per person)	96 (1.20)	85 (1.16)	0.900 <sup>c</sup>
Number of fall injuries, n (%)	40 (41.7)	38 (44.7)	0.669 <sup>c</sup>
Number of fall injuries resulting in medical care, n (%)	19 (47.5)	15 (39.5)	0.151 <sup>c</sup>

<sup>a</sup>Item response rate: 88.8-91.8%. <sup>b</sup>Pearson's chi-square test. <sup>c</sup>Student's *t*-test

In the 12-month follow-up assessment (IG=56, CG=50) no statistically significant differences in DFRI ( $\geq 3$  points: IG = 90.7%, CG= 88.0%,  $p=0.650$ ) or ADL (median [q1-q3]: IG = 2[1-3], CG = 2[1-3.35],  $p=0.297$ ) were observed. TUG (mean [SD]: IG = 18.1 [9.3], CG = 13.8 [3.8],  $p=0.009$ ) showed a significant difference, with a slower time in the IG. However, there were no significant results after imputation for DFRI ( $\geq 3$  points: IG = 85.7%, CG = 86.3%,  $p=0.918$ ), ADL (median [q1-q3]: IG = 2 [1-3.35], CG = 2 [1-3.5],  $p=0.423$ ) or TUG (mean [SD]: IG = 17.5 seconds [9.0], CG = 15.1 seconds [4.6],  $p=0.096$ ).

Analysis of the sub-sample containing those participants (n=61 in the IG) (Figure 5) who received the expanded intervention with PTs, showed no significant differences between the groups in number of participants reporting a fall (n [%]: IG = 33 [55] CG= 27 [45],  $p=0.289$ ), fall-related injuries (n [%]: IG = 24 [72.7] CG=22 [81.5],  $p= 0.425$ ), or fall-related injuries resulting in medical care (n [%]: IG=12 [50.0] CG=8 (36.4%),  $p= 0.472$ ). There were no differences in number of falls (IG = 76, CG = 69,  $p=0.653$ ), fall-related injuries (IG = 32, CG = 30,  $p=0.990$ ), or fall-related injuries resulting in medical care (IG = 14, CG = 13,  $p=0.138$ ). No statistically significant differences were shown between the IG and the CG in DFRI and ADL, neither in the analysis of complete cases, nor after imputation. TUG showed a statistically significant difference in the analysis of complete cases ( $p=0.009$ ), with shorter TUG time in the CG, but the difference was not shown after imputation ( $p=0.096$ ).

## Case descriptions

The two case descriptions presented below show examples of how the case management intervention was performed. They show positive effects of the intervention but also the difficulties in fulfilling the needs of the individual. The descriptions are derived from the CMs patient records and interviews with the CMs.

### *Case 1. Limited resources to prevent falls*

A 79-year-old woman was living alone in her apartment. She got help from the municipality with showering, laundry, and shopping, but prepared her own food. She also had alarms and a transportation service. Her sons did not live nearby but came and helped her sometimes. She had had cancer 10 years previously, had been diagnosed with osteoporosis, and was under investigation for Parkinson's disease. She was troubled by pain, reduced mobility after a fall the previous year, dizziness, and rarely went out. She had a home training program which she did while lying in bed. She had a desire to be more physically active and get out and meet people.

The initial tests in the intervention showed that she had a high risk of falling. The CM PT judged that she was in need of balance training, but that she couldn't safely manage it at home by herself. During each home visit, she and the CM PT went out for a walk or walked to the grocery store. She was given information about the possibility of physiotherapy at her primary health care centre or through the municipality. Because she really wanted to get out, she was not interested in physiotherapy at home and she declined all help from the municipality with taking walks. She contacted a physiotherapist and an occupational therapist at her primary health care centre for training. During the intervention she met the physiotherapist at the primary health care centre a few times but often cancelled visits because she didn't have the energy. The occupational therapist at the primary health care centre helped her with hand rails, forceps, and stockings. The CM PT helped her to contact an occupational therapist in the municipality to arrange the installation of automatic elevator doors. At the end of the intervention, she was put on Parkinson's disease medication, which had a good effect on her mobility.

During the intervention, she reported three falls. The household aids and medication she received probably reduced her risk of falling. However, the efforts to help her be more physically active failed. Despite encouragement, she only attended a few training sessions at her primary health care centre. She felt that her daily life used up much of her energy. Group training appropriate for her level was not available in primary care or her municipality. Her physical status at the end of the intervention was the same as it had been before the intervention. However, she expressed positive effects of the intervention, as having someone to talk to and being able to get out.

### *Case 2. Preventing further falls*

An 86-year-old woman was living in a ground-floor apartment with her spouse. They had no help from the municipality but their daughters supported them a lot. The woman suffered from several diseases, such as hypertension, polymyalgia rheumatica, cataracts, depression, and sciatica. She walked with a stick indoors and used a walker outdoors. Sometimes she went on short walks with her spouse. She experienced unsteadiness when walking.

The initial tests in the intervention showed that she had a high risk of falling. The intervention began with recommendations for various aids and initiation of a home training program which she, with physical support from her spouse, would do at home. During the fifth home visit, she reported that she had fallen in the bedroom at the weekend, but had not injured herself. The incident was reviewed and measures to prevent further falls were taken with the nurse CM. Before the next visit, however, she fell again, this time outdoors when she bent down to pick up something. She had hit her back and had not been able to train since. At the same time, she and her spouse reported that they found it hard to cope with the home training. The CM PT contacted a physiotherapist in the municipality who provided home training 3 times a week for 4 weeks. The participant subsequently continued to train with the physiotherapist in a training group run by the municipality. The participant, her spouse, and their daughters were all given additional information on preventing falls and fall injuries by the CM PT. The participant did not fall again during the intervention and had improved balance when the intervention ended.

# Discussion

## Methodological considerations

To evaluate the quality of the research methods in term of threats that may interfere with the results and conclusions, the terms validity and reliability must be addressed. In this thesis both quantitative and qualitative methods have been used to answer the specific and main aims. Four different designs were used. Paper I has a longitudinal cohort design. A longitudinal cohort design refers to strategies to follow a group or groups over time with the possibility to establish the relations between antecedent events and outcomes [229]. The aim of the qualitative design used in Paper II was to get a deeper understanding of a specific phenomenon. The design can be assessed by means of trustworthiness, which comprises credibility, transferability, conformability and dependability [230]. In Paper IV a prospective experimental design was used to study casual relationships when using manipulation [173]. This design also enabled the predictive validity of fall risk assessment tools to be investigated in Paper III. Quantitative designs can be assessed in terms of internal, external, construct and statistical conclusion validity [229].

### Internal validity

Internal validity refers to the extent to which the outcome is explained by the independent variable and the extent to which alternative factors affected the outcome [229]. Threats to internal validity include history (events occurring inside or outside the experiment), maturation (processes within the individual changing over time), testing (effects of repeated testing), instrumentation (changes in measuring instruments or measurement procedures over time), statistical regression (a tendency for measures to regress towards the mean), selection bias (systematic differences between groups before any experimental manipulation) and attrition (loss of individuals over time) [229]. RCTs have the great advantage of reducing many of the threats to validity [173, 229]. Such threats are therefore considered to be quite small in Papers III and IV, where history, maturation, testing, instrumentation, statistical regression and selection bias had the same opportunity to appear in both groups. Some of the issues are, however, discussed below.

In Paper I history and maturation may be seen as threats to internal validity. Follow-up after 3 and 6 years may have affected the results since a participant reporting falls or dizziness at the follow-ups may not have the same health status as they had at baseline and thus other risk factors may be present that weren't measured at baseline. It is, however, impossible to capture all risk factors. Nonetheless, the most common risk factors in previous research were used in this study in an attempt to capture the most relevant risk factors in the data that was collected.

The collection of fall data may have affected the outcome in Papers I, III and IV. The definition of a fall as “an unexpected event in which the participants come to rest on the ground, floor, or lower level”, suggested in 2005 is widely recognized [231]. It is also recommended that the participant be asked “In the past month, have you had any fall including a slip or trip in which you lost your balance and landed on the floor or ground or lower level?” when one collects fall data [231]. In Paper I fall data were collected with the question “Have you fallen during the last 12 months?” and in Papers III and IV the question “Have you fallen sometime during the last 3 months?” was used. This may mean that the numbers of falls are biased, with the possibility of both over- and underestimation. Underestimation is probably more likely because a fall without serious consequences may be forgotten, but there is also a risk that the same fall is reported several times when a long time span (3 or 12 months) is used. To increase the validity, another method and time interval to report falls should have been used [232]. This might have produced a more accurate prevalence of falls.

Instrumentation as a threat to internal validity was reduced by the use of standardized protocols and well established measurements in Papers I, III and IV. A threat may be that several persons collected the data; however, all research assistants were educated in how to use the standardized instruments and questionnaires. The data collection procedures and the instruments used are described in detail elsewhere [166, 174].

Attrition is one of the main threats in longitudinal studies, especially when including older people since the drop-outs may have specific characteristics that affect the outcome i.e. they may be sicker or more tired or have higher cognitive impairment compared to those participants still in the study. In Paper I the drop-outs during the study showed significant differences in age, falls and dizziness indicating that those who remained in the study were healthier. Attrition may also be a threat in Paper IV, where the characteristics of the drop-outs may differ between the IG and the CG groups, making the similarities between the groups at baseline invalid (selection bias). However, the data collection procedure, with personal testing in the participants' own homes, probably reduced the attrition rate in this old, frail sample. The ITT principle was adopted and imputation was done to reduce the threat of attrition. The dropout analyses showed no differences compared to participants who continued the study in any of the outcomes used in Paper IV, which suggests that the drop-outs were missing completely at random (MCAR), an assumption for imputing missing values [220].

The fact that the ITT analyses and the complete cases analyses showed the same results reduced the threat to internal validity and the risk of false-positive results.

## Construct validity

Construct validity refers to the presumed causal relationship between the content of an intervention and the outcome, i.e. why the intervention produced an effect and the possibility of confounders [229]. Threats to construct validity can be exemplified by attention and contact with the participants in a study, single operations or narrow stimulus sampling, researchers' expectancies and cues from the experimental situation [229].

To meet the needs of frail older people the study in Paper IV was designed as a complex intervention [172], which enhanced the construct validity. However, including several mediating components and dimensions that may have acted independently or interdependently [220] makes the intervention difficult to replicate. It is also difficult to point out the "active ingredients" in the intervention. Various threats to construct validity may be difficult to find and factors such as the personal relationships between the CMs and participants as well as the expectations of the CMs might be seen as contributing factors, among many others. The fact that several CMs were involved might have affected the outcome due to differences in work experience and education. However, newly employed CMs were carefully introduced and initially made home visits together with CMs who had already worked in the study. Interaction between people is a threat to construct validity due to characteristics of the CMs such as skills, levels of education or enthusiasm, the personal relationship between the CM and the participant, and the expectations of the CMs and the participants. The special attention given to the participants might be seen as a placebo effect. This threat was somewhat reduced by the fact that several research assistants and CMs were engaged in the study and also by the use of standardized instruments. Therefore, the impact of the CMs could be distinguished from the impact of treatment. However, the close relationships between the CMs and the participants should not be ignored.

One threat to construct validity was that the research assistants were not blinded. Blinding was not possible since the participants often revealed to the research assistants if they belonged to the IG or the CG group during the data collection. The standardized testing procedure may, however, have reduced this risk. Another threat is diffusion of the intervention since the study was performed in a quite small community where older people may have known each other because they may attend the same activities or be members of the same organizations. It is therefore possible that information about different topics, such as fall prevention, may have diffused to participants in the CG and this might have affected the outcome.

A study investigating the CMs' and participants' experiences of the intervention showed that the intervention was mostly performed as intended, albeit with some exceptions [160]. To increase the construct validity of this study a process evaluation investigating the CMs' documentation and reflective diaries may be necessary.

## Statistical conclusion validity

Statistical conclusion validity refers to the statistical methods and their influence on the conclusions we reach about the experimental conditions and their effects [229]. It can also be described as type I and type II errors [229]. Type I error is the risk of rejecting the null hypothesis when the null hypothesis is in fact true (false positive). Selecting an appropriate probability level reduces this risk and 0.05 (5%), a commonly used limit, was used in Papers I, III and IV. Type II error is the risk of not rejecting the null hypothesis when the null hypothesis is false (false negative) and is determined by sample size and power. The large sample in Paper I reduced the risk of type II errors; however, the sub-samples were sometimes quite small. The statistically significant differences that were found indicate that type II errors were not an issue. In Paper IV no power analysis was done for the outcomes in this thesis. Small differences in the outcomes between the IG and CG a statistically non-significant result were expected. The significant differences in TUG in the complete case analysis indicate that the study had sufficient power.

A possible threat to statistical conclusion validity is the variability in the test procedures in Papers I, III and IV. Such variability cannot be eliminated in research involving humans (as researchers and participants) but every effort should be made to minimize it. A strict data collection procedure, with standardized, valid and reliable instruments and trained research assistants, was performed in Papers I, III and IV to minimize the variability. However, in studies including older people and using broad inclusion criteria heterogeneity among subjects is unavoidable and reduces the chance of detecting differences.

## External validity

External validity refers to the extent to which the result can be generalized to another population, setting or set of circumstances [229]. Threats to external validity concern inferences about the extent to which a causal relationship hold over variations in sample characteristics, settings, multi-treatment interference, novelty effects or timing of measurements [173, 229][173]. Paper I is part of a large, national, population-based study in different areas in Sweden giving a representative sample of the Swedish population [166]. According to Rennemark et al. [169] the participants in SNAC-B had slightly better health and slightly less functional disability than the general

population in Sweden; nonetheless, data collected in SNAC-B still had the potential of being generalized to people 60 years and older in Sweden. However, since significant differences in age, falls and dizziness were seen in the drop-out analysis in Paper I it is reasonable to assume that the sample included in this paper included a younger and healthier sample compared to the general Swedish population.

A possible threat to external validity in Paper IV is that the follow-up time of 1 year might have been too short to detect changes. In frail, older people, adapting to a new situation or showing signs of improvement may take time, resulting in underestimation of the effects of the intervention. A longer follow-up period might have changed the outcome. Another threat to external validity is the setting in which the physical performance tests were performed. Even though the functional tests were performed in the participants' homes, efforts were made to standardize the tests as much as possible. However, though the circumstances were the same for both groups, the outcome (time in seconds) may not be generalized to another sample with the same characteristics tested in more standardized environments. External validity in the tests in this setting should be confirmed in other studies in older people with tests performed in their own home. How falls were reported, i.e. every third month instead of through a fall calendar may have affected the prevalence of falls in this study and may be a threat to external validity. To what extent the intervention can produce positive effects in other people (i.e. with better or worse health) and settings (primary health care, special accommodation or hospitals) should be investigated in future studies.

## Reliability

The procedure used to test physical ability in Papers III and IV could be a threat to reliability. Performing tests in the participants' own homes puts great demands on the reliability of the tests, since a standardized environment is impossible. The tests were chosen with this in mind and the threat to reliability might be considered smaller in the RT than in the TUG due to the way the tests were performed. Efforts were made to reduce the threat to reliability by educating the research assistant and pointing out the importance of performing TUG under similar conditions at each data collection session, such as performing the test in the same room, using the same walking aid and wearing the same foot wear. This probably reduced the threat when comparing test results at baseline and follow-up in each individual, but must be taken into consideration when interpreting the results at the group level.



## Trustworthiness

Trustworthiness in studies with a qualitative design (Paper II) can be assessed by means of credibility, transferability, confirmability and dependability [230].

*Credibility* relates to the truth value of the study and the ability to capture realities [170]. It relates to confidence in data collection and the analysis process, and several issues, such as the focus of the study, selection of context, participants and approach to gathering data must be taken in consideration [223, 230]. Techniques to increase credibility are prolonged engagement, triangulation, peer debriefing and member checking [170]. In Paper II, credibility through prolonged engagement was assured as the researchers had long experience of caring for older people in general; moreover, some of the researchers had long experience of treating older people with dizziness. Triangulation was achieved by having co-authors with several professional backgrounds (PTs, nurses, a GP). Peer debriefing was achieved when the study was presented at a seminar with doctoral students and senior researchers. Credibility can also be assured by choosing participants with various experiences of the phenomena, to get an appropriate amount of data, and to illuminate the analysis process [223]. The purposeful selection in Paper II enhanced the chance of variability in terms of age, gender, living arrangements, and cause and duration of dizziness. Seven women and six men aged 73-87 years were included and to further enhance variability living arrangements such as living alone or co-habiting and living in urban and rural areas were taken in consideration. However, the respondents had all received vestibular rehabilitation and had in most cases been extensively investigated due to their dizziness symptoms. Including older people with dizziness from other organizational levels, such as municipal care, might have changed the results since many older people with dizziness are undiagnosed and untreated. To get an appropriate amount of data the interviews should continue until no new knowledge emerges [171]. However, in practice this usually means 10-15 interviews. In Paper II the 13 interviews lasted between 37 and 72 minutes (mean 54 minutes) and the semi-structured interview included open questions to obtain rich and extensive data. All interviews started with the request "Please tell me about how your dizziness started". The respondents were able to choose the location for the interview to foster a feeling of security, to help them to speak freely. The analysis involved a back-and-forth process where the first and last authors in Paper II worked closely together and the co-authors confirmed the meaning units, sub-themes, themes and the overall theme. The analysis process is illustrated in Paper II where quotations from the interviews are shown to allow similarities within and differences between the themes to be judged.

*Transferability* relates to the possibility to transfer the result to other settings or groups [223] but, unlike for quantitative studies, it should be judged by the reader and not the researcher. It is, however, the researcher's obligation to provide a clear description of the context, participants, data collection and analysis process to make

transferability judgments possible [223, 230]. In Paper II efforts were made to give as comprehensive a description as possible to facilitate transferability. The study included older people with chronic dizziness recruited from a primary health care centre and the results might thereby be transferable to older people receiving health care for chronic dizziness at this organizational level.

*Dependability* relates to changes in the data over time [170, 223]. It includes changes in the researchers' perceptions and experiences during data collection and in the researchers' interpretation of the data during the analysis process, and is closely linked to credibility [230]. The interviews were performed between February and October 2012. The semi-structured guide increased dependability by ensuring that different aspects were covered in all interviews, which used the same opening question [223]. Involvement of the co-authors several times during the analysis process also increased the chance of discovering and discussing similarities and differences over time.

*Confirmability* refers to the researchers' objectivity and neutrality regarding their data [170, 230]. The concept of pre-understanding was taken into consideration by the first author to establish confirmability. The close collaboration between the first author and the co-authors (i.e. researcher triangulation) also increased confirmability, especially because the first and last authors conducted one interview together and two of the interviews were independently analysed by the first and last authors. Another aspect relates to the results being well-grounded in the data, which was enhanced by the illustration of the analytical process and by the use of quotations.

## General discussion of the results

### Falls, dizziness and related factors – a complex interaction

The results from this thesis showed that falls and dizziness are common in older people and complexly related to each other and to other related factors. Prevalence rates for falls and dizziness in Paper I were in line with previous studies [12, 14, 69, 70], with an almost doubled prevalence of both falls and dizziness in the older age cohort. Paper I showed factors associated with falls or dizziness in a number of areas, such as ADL dependency, various health complaints and reduced quality of life, in line with other studies [3, 9, 11, 233], implying that daily life is strongly affected. The paper also showed that falls and dizziness shared certain risk factors in both age cohorts: IADL dependency, self-reported balance impairment, fatigue and lower HRQoL (physical component). These are all common problems in older adults and relate to impairments due to age and illness. Our data show the significance of these risk factors in relation to falls or dizziness in old age. IADL dependency may be related to gait disturbances seen in older people at high risk of falls and dizziness [11,

234] as a consequence of reduced postural and dynamic stability (due to age and illness). The reduced stability was confirmed by the high prevalence of self-reported balance impairment in people with a history of falls or dizziness and may explain falls being a predictor for dizziness, as shown in Paper I. One study [11] showed that other risk factors that co-occurred with falls and dizziness in older people were poor self-rated health status and gait disturbances. A systematic review and meta-analysis [235] showed that balance deficits in community-dwelling people aged 60+ years had a 2-fold increase in odds of falling.

Fatigue showed high prevalence rates in Papers I and III-IV, in line with previous studies [236, 237]. Fatigue is multidimensional, with several facets, i.e. physical, emotional, cognitive and social [238]. The papers of this thesis used fatigue as a broad term without the possibility of identifying the underlying cause. It has also been showed that functional consequences of fatigue in older people are poorer handgrip strength, lower SPPB score, slower walking speed, inability to walk 400 m, and ADL dependency [236], factors known to increase the risk of falls. Fatigue has also been associated with dizziness in older people [239] and with falls in people with Parkinson's disease [238]. Physical fatigue has been associated with changes in gait characteristics such as a broader BOS and increased step width [240] and impaired balance and functional ability [241]. However, the relationship between fatigue, as a broad term common in older adults, and falls is not fully understood and more research is needed, especially on the ability to reduce falls by decreasing fatigue.

Papers III and IV did not use frailty as an inclusion criterion. Instead common consequences of frailty were used for inclusion: functional disability and repeated health care contacts [33-36]. However, different characteristics to define frailty such as fatigue/exhaustion, IADL dependency, impaired mobility and balance, and an increased risk of falls [34, 42, 43], were found in the participants at baseline (Table 6, Framework). The baseline data indicate that the majority of the sample may be described as frail. Frailty further adds to the complex interaction between falls, dizziness and related factors. Frailty also indicates vulnerability to situational changes [15, 35], which means that small stressors can imply a transition from having no risk of falls to having a high risk of falls. It is important to be aware of this sometimes sudden transition, when caring for frail older people.

The complexity in assessing and treating diseases in old age has resulted in falls and dizziness being described as geriatric syndromes, with frailty as an overarching term [15, 16, 242]. Other geriatric syndromes are pressure ulcers, delirium, urinary incontinence and syncope [242]. Geriatric syndromes highlight unique features such as being highly prevalent, substantially affecting quality of life and disability and not fitting in to discrete disease categories, in common health conditions in older people [242]. The syndromes include the involvement of multiple risk factors and multiple organ systems [242]. Classifying a condition as a geriatric syndrome implies that the focus should be moved from merely finding and treating a single cause to using a

multifactorial strategy including the assessment and treatment of related factors [15, 16, 243]. Preventive strategies such as exercise, balance training, and mobilization to reduce functional impairment and impaired mobility have been suggested. [243]. Schwab (2008) argue that the majority of the frail and chronically ill are treated successfully, but that those who are unsuccessfully treated consume an ever increasing amount of resources, not because of the severity of the illness itself but rather the breakdown of the bio-psychosocial construct in which the illness occurs [244]. This was seen in Paper II, where the respondents reported frequent health care contacts but their needs were not met. Geriatric syndromes cross organ systems and discipline-based boundaries and challenge traditional ways of viewing clinical care and research [242]. More research is needed to improve healthcare and social service for frail and chronically ill older people.

The complex interactions of several factors related to falls and dizziness in older people have a strong influence on the daily lives of those affected, illustrated in Paper I as reduced HRQoL. The complexity was also shown in Paper II, which explored older people's experiences of living with chronic dizziness. Living with dizziness implied having an unpredictable daily life that may not only be explained by the dizziness itself, but also factors associated with dizziness, such as balance impairment and fear of falling [11, 79, 245]. The unpredictability implied losing control in daily life and the respondents described a fear of being unable to control or influence their situation, with risk of great discomfort, pain or injury. This resulted in restrictions in daily activities. The respondents expressed that they were unable to live life the way they wanted to, and they wished to preserve mobility and stay independent, which is in congruence with an earlier study in older people with chronic dizziness [82]. Self-learned strategies were for some of the respondents expressed as a way to gain control over their situation. Other respondents did, however, not have the ability to develop strategies to control their situation. They all, however, had a powerful desire to be improved and not to deteriorate, and an unwillingness to give up.

## Identifying and assessing older people at risk of falls

To prevent falls, people at risk of falls needs to be identified. Baseline characteristics differed between the age cohorts (Table 6, Framework). Compared to the younger age cohort, the older age cohort had a reduced functional capacity; reported health complaints more frequently; cognitive impairments; had lower HRQoL; and more frequently reported taking various medications. Different factors predicted falls in the younger and older age cohorts. History of falls, known as the strongest risk factor for falls in older people [76], was a predictor in both age cohorts. In the younger age cohort two variables showed higher odds for falling than history of falls: participants taking neuroleptics had a 10-fold increased odds of falls and those with PADL dependency a 7-fold increased odds, albeit with great variation (95% CI for OR:

1.62-71.15 and 1.00-43.18, respectively). Subjects with vision impairment showed a 2-fold increased odds (95% CI for OR: 1.28-4.09). Other studies have shown use of neuroleptics (OR: 1.5 [1.25-1.79]) [101], ADL dependency (OR: 2.3 [1.5-3.1])[3] and vision impairment (OR: 1.35 [1.18-1.54] ) [9] are known risk factors for falls. Paper I indicated that people aged 60-80 years with PADL dependency or vision impairment should benefit from fall prevention interventions. The increased risk of falling should be taken into consideration when prescribing neuroleptics. A recent study [246] showed that fall risk-increasing drugs (FRIDs) i.e. psychotropic medications and some cardiac drugs, caused impaired postural control and should only be prescribed at the lowest effective dose and for a limited period of time in older people. Improving postural control by physical exercise may be important in people where withdrawal of the drugs is impossible, but this has to be investigated in future studies.

In the older age cohort, participants with history of falls had a 3-fold increased odds of falls. Other predictors were fatigue and IADL, with 2- and 3-fold increased odds, respectively. As discussed earlier in this thesis, the interaction between fatigue and falls need to be investigated in future studies. One study [247] showed that fatigue increased the odds of falls (OR: 1.13 [1.02-1.20]) in 550 people (aged 18-88 years) with rheumatoid arthritis. ADL dependency is a risk factor for falls as it represents impaired mobility [3]. IADL dependency being a predictor for falls indicates that in the transition from independence to dependency, a person's physical function is impaired to a degree where the risk of falls is increased. IADL dependency means needing help with cooking, cleaning, shopping or public transport. This suggests that it is important to introduce and prioritize fall prevention when the older person needs support from family, friends or municipal care.

In Paper I history of dizziness was the strongest predictor for dizziness in the 3- as well as 6-year follow-up. This indicates that dizziness is a chronic condition for many older people and is difficult to treat, as has been shown earlier [10, 17], implying that postponing dizziness in older people is important. History of falls was associated with a 4-fold increased odds of dizziness and, as described earlier in this thesis, the explanation may be the close relationships between falls, dizziness, gait disturbances, and balance impairment [11]. By increasing physical function it is possible to reduce the fall risk and the feeling of dizziness. Feeling nervous was a predictor for dizziness in the younger age cohort and this health complaint should be addressed and the underlying cause explored.

Another way to identify people at risk of falls is to use a fall risk assessment tool. In a systematic review and meta-analysis [9] several tools were investigated, but no universal tool that can be used in populations in different health states and care settings was recommended. It is, however, not to be expected. Instead, different fall risk assessment tools have to be used, and their psychometric properties have to be investigated in different settings. Paper III investigated the predictive validity for falls

of the DFRI, TUG and the RT. The DFRI and other questionnaires can be used in many settings. However, the usefulness of various tests of physical function to predict falls in in-home assessments precludes many of the tests used in other settings [110] because of the lack of space and equipment. "Aging in place" implies that it is common for older people with high health care and social service needs to receive municipal or private care at home. For professionals working in municipal or private care (nurses, physical and occupational therapists) their only opportunity to assess a person's risk of falls is in the person's own home. This shows the significance of evaluating the ability of various instruments to assess physical function and fall risk in home settings. Paper III showed that the predictive validity for falls was the same for the DFRI (cut-off 3 points) and TUG (cut-off  $\geq 12$  seconds), with acceptable sensitivity but low specificity. This means that neither of them showed strong predictive validity. The results are, however, in congruence with other studies of the DFRI [122] and TUG [195]. The low sensitivity of the RT and SRT and the low number of participants that were able to perform the TRT means that they cannot be recommended to be used to assess risk of falls in frail older people.

There are several possible explanations for the weak predictive validity. Considering the large number of risk factors for falls, it is impossible to include them all of them in a questionnaire. Of maximum 11 points in the DFRI, five of them relate to medications. Even if the medications included are known to increase the risk of falls [103, 105, 106] they are also commonly prescribed to older people. Taking three or more of these medications is associated with a high risk of falls i.e. a lot of older people score  $\geq 3$  points. Paper III showed that TUG had the same predictive validity as the DFRI, implying that functional mobility, irrespective of specific risk factors for falls, can predict falls. A meta-analysis [195] investigated the usefulness of TUG as a clinical screening instrument for falls. Cut-off points for falls varied between 8.1 and 16 seconds for independent-living samples and between 13 and 36.6 seconds in people in institutional settings. No recommendation regarding threshold values could be made. The study showed that mean TUG time differed significantly between fallers and non-fallers. There were small differences in healthy older people and larger ones in frailer and less-mobile groups. The authors concluded that TUG may be useful in less healthy, lower functioning populations [248]. However, more research is needed to determine TUG's and DFRI's abilities to predict falls.

Exploring risk factors for falls in Paper IV were performed in the participants' homes which precluded including all parts of a comprehensive assessment [3] such as neurological, cardiovascular or respiratory measures. This may imply that important fall risk factors were not identified. It is, however, not just the number of risk factors that determines the risk of falls, but also how the individual handles living with an increased risk of falls. Impaired postural and dynamic stability increases the risk of falls, but if you move in a safe way the risk may be eliminated. In-home assessments make it possible to make accurate judgments of important resources required for postural stability in everyday life [49]. By assessing different movements at home it

may be possible to predict the risk of falls. The reliability and validity of tests of physical function that can be used in in-home assessments need to be evaluated in future studies.

Papers III and IV showed that 78 % of the participants had an increased fall risk (DFRI  $\geq 3$ ), in congruence with Swedish study in older people living in special accommodation [122], indicating that frail older people at home are as prone to falls as older people in special accommodations. Rosendahl et al. [122] recommended screening for fall risk in older people in special accommodation every third month. The health status of frail older people is complex and changes rapidly and this screening interval may also be recommended for frail older people at home.

## Fall prevention in frail older people living at home

After identifying a person at risk of falls, a fall prevention intervention should be offered. Other home-based studies to frail older people have included fall risk assessments, information in fall prevention, medication reviews, home safety assessment and exercise programs [130, 137, 141, 144-147]. However, the effects on falls in these studies differed. Paper IV investigated the effects of a case management intervention on falls, injurious falls and falls resulting in medical care. No differences were seen between the IG and CG in any of the outcomes and the lack of effects may have several explanations. First, this study was not designed as a specific fall prevention intervention; fall prevention was one aspect among (many) others. Therefore, the people interested in taking part in this intervention may not have had fall prevention as their main issue. As this complex intervention focused on individual aspects relevant to the participant, other issues may have been prioritized. However, the fall prevention part of the intervention was given to all participants, albeit at different times during the intervention. Another aspect relates to the inclusion criteria. For preventive interventions to be effective it is important to choose the right target [155]. In fall prevention interventions this means people who have sustained a fall during the past year, i.e. at-risk individuals [249]. In Paper IV baseline characteristics showed that only one quarter of the participants (20% in the IG and 30% in the CG) had fallen during the past year. This might be one of the reasons for the lack of effects. However, according to Ferruci et al. (2004) [250] people most likely to benefit from interventions to prevent or delay disability are frail individuals who are not yet disabled and those with early disability who are at high risk of progression. Baseline characteristics showed that the participants in Paper IV were well suited to efforts to prevent disability and thereby reduce the risk of falls.

The design in Paper IV meant that the intervention partly consisted of assessment, information and referral. Other home-based studies in older people with similar designs did not show any effect on falls [144, 145, 251]. However, the fall prevention intervention in Paper IV included active and passive parts. The passive part included



information about fall prevention, a home safety checklist (that the participant and the PT CM went through together), and a medication review by the nurse CM. This part of the intervention was accomplished in all participants. The active part included a non-supervised home-training program or other physical activities performed by the participants themselves. To increase physical function and ADL performance and decrease fall risk in frail older people, supervised high-intensity training is needed [127, 252-254]. However, in Papers III and IV 70% of the participants reported unsteadiness, walking difficulties and use of a walking aid, and it may be difficult for frail older people to perform high-intensity self-training on their own that is challenging enough without risking injuries.

For those participants who found it difficult to perform the self-training exercise program it was difficult to find an appropriate level of exercise. Some of the participants exercised with a PT at a primary health care center or from municipal care (usually once a week for 8-10 weeks). However, group exercise with human support during exercise was only available from municipal care during the first 6 months of the case management intervention, after which it was terminated. This made it difficult to refer participants, who were not able to exercise on their own, to group exercise.

Several studies in older people with increased fall risks have shown that center-based group training was more effective at improving physical function and HRQoL and reducing falls than home-based training [255, 256]. However, in one study [255] several participants declined participation in the center-based group training as they preferred to have the program delivered at home. The most appropriate location for fall prevention interventions might therefore be difficult to establish. Instead, a variety of programs available at different organizational levels should be offered. In recent years several exercise concepts, such as the High Intensity Functional Exercise (HIFE) program [257], the Lifestyle approach to reducing Falls through Exercise (LIFE) program [137] and the Otago Exercise program [129, 130, 258], have been developed to reduce falls in frail older people and have shown positive effects. Although exercise in older people has shown positive effects on falls [259, 260], the role of physical exercise in improving health and physical function in frail older people has been debated [18, 41, 261, 262]. It has been stated that to address the common patterns of frailty exercise appears to be the most applicable treatment [18, 41]; however, more research is needed according to the kind of exercise performed [261, 262]. The effects of structured exercise programs in frail older people at home need to be established in future studies.

A limitation in Paper IV was that the frequency, duration and intensity of the exercise performed were not documented by the participants. If the exercise performed had been documented, for example using an exercise diary [3, 130], compliance with the exercise program could have been evaluated. This would have increased our knowledge of the impact of exercise on the outcome of the intervention. In future studies, the exercise performed should be documented. However, for self-reported



outcomes there is a risk of under- or overestimation. Another limitation is that no structured instrument/model was used to motivate the participant to adhere to the fall prevention and exercise part of the intervention. Studies of fall prevention interventions showed that frail older people have the most difficulty in starting and sustaining home-base exercise training [129, 141]. Some have suggested that behavioural change theories be used to overcome barriers to exercise in older people [263, 264]. For instance, according to the self-efficacy theory, a person needs a strong belief in their abilities to take action make changes to e.g. increase their health [265]. Falls-efficacy is defined as “low perceived self-efficacy at avoiding falls during essential, nonhazardous ADLs” [266] and should be acknowledged in fall prevention interventions. Older people’s strategies to prevent falls may not always be productive [267] and they should be helped to adhere to appropriate coping strategies after a fall. Helping them to regain control of their body and of hazardous situations in daily life may improve their self-efficacy in taking control of their situation. The executors of interventions, for example case managers, should be educated in behavioural change models and should be used as a conceptual framework when designing future (fall) prevention interventions.

The need of support to regain control and cope with daily life when suffering from a chronic illness was shown in Paper II. Older people with chronic dizziness have needs that are unmet by health care. Studies have shown that living with dizziness interferes with daily life [79, 81, 82]. Paper II showed that even after many years with dizziness, sufferers were still fighting to regain the life they used to live before the dizziness started. Several respondents did not have appropriate coping strategies to manage daily life, in spite of frequent health care contacts. Difficulties in managing threats to control in daily life have been shown in older people suffering from other chronic diseases such as Parkinson’s disease or diabetes [268, 269] and treating older people with chronic diseases should go beyond merely treating a specific diagnosis. Older people with dizziness, falls and frailty need continuous support to be able to manage everyday situations and to adapt to a new life situation.

Given the multifactorial nature of chronic dizziness and falls in old age, one study used ICF categories to examine predictive validity for falls of clinical assessment tools used in people with stroke [270]. The study showed that assessment tools on body function showed weak associations with fall history; measures of disability and contextual factors showed the strongest associations with fall history. ICF core sets, i.e. sets of ICF categories that are relevant to specific health conditions or care settings [271], were recently identified for fall-related risk factors in acute rehabilitation settings in one study [272]. The study’s authors concluded that risk factors for falls could be comprehensively organized in the ICF, and could thereby facilitate clinical practice of fall prevention. An investigation of core sets in people with chronic vertigo [79] showed that the ICF is a useful tool for comprehensively describing functioning, the burden of disease and treatment effects. These studies showed promising results, suggesting that the ICF can be used to assess fall risk or develop fall risk assessment

tools with strong predictive validity. The ICF can also be used to assess the burden in the individual and guide treatments and assess treatment effects. Use of the ICF in frail older people at home should be investigated in future studies.

Preventing falls in older people is complex for a variety of reasons and deserves attention. The complex situation demands a careful and thorough approach when working with fall prevention interventions in frail older people. The identification of risk factors is always essential in fall prevention, but in the older, frailer population interventions aimed at helping people to live with an increased risk of falls may be effective. One approach might be to combat risk factors for falls and add supervised high-intensity exercise. Another approach may be to focus on aspects of daily living to improve safety and introduce appropriate coping strategies. The most appropriate approach might be to link the two approaches. This approach, however, necessitates collaboration between health care organizations.

# Conclusions and clinical implications

Falls and dizziness are common, serious health complaints in frail older people and deserve attention. The complex interactions of falls and dizziness with related factors such as IADL dependency, self-reported balance impairment, fatigue and lower HRQoL imply that falls and dizziness should not be treated in isolation. Treating balance impairment and fatigue may decrease the fall risk, reduce the feeling of dizziness and increase quality of life. However, this complexity also implies that fall prevention interventions should be individualized.

Using the DFRI and TUG in frail older people at home did not correctly identify people with and without a high risk of falling, indicating that the assessment tools should not be used to identify potential recipients of fall prevention interventions in home settings. The assessment tools may, however, be used to screen people for fall risk. Prior to the intervention a comprehensive assessment of fall risk factors should be performed.

In spite of frequent health care contacts, older people with chronic dizziness experience needs that were unmet. However, they had a powerful desire to be improved and not to deteriorate, and an unwillingness to give up. Besides identifying and treating the underlying cause of dizziness, managing older people with dizziness should also focus on appropriate coping strategies in daily life. Support should not end until the affected individual has regained control of their situation. Enhancing safety aspects of daily life, such as preventing falls, should be prioritized.

Preventing falls in frail older people is challenging. The home-based case management intervention did not show any effect on falls, injurious falls and falls resulting in medical care. Thus, other interventions are needed to prevent falls in frail older people at home. Frailty further adds to the complexity of falls and related factors, and may limit the possibility to combat fall risk factors. This implies that finding other ways to reduce fall risk, for example through physical exercise, is important. Alternative evidence-based fall prevention strategies that create opportunities for frail older people living at home to perform physical exercise, safely and with high intensity, should be developed.

# Further research

The results from the studies in this thesis indicate that preventing falls in frail older people is complex. Fall prevention interventions should be evidence-based and there is a need to further explore how falls in frail older people living at home can be prevented. To make fall prevention interventions effective, different intervention designs need to be evaluated. Further research may focus on how to correctly identify frail older people at risk of falls and risk factors that are important to acknowledge (and act upon?). More research is needed on the accessibility and effectiveness of various exercise concepts in home settings. In-home instruments for assessing physical function that are useful, reliable and valid are needed. The home setting as a workplace for physiotherapists ought to be further evaluated in future studies.

In older people the risk of falls increases in the transition from being independent to becoming dependent in ADL. Further research is needed to evaluate the effects of introducing fall prevention interventions in older people in the phase where the older individual no longer manages daily life independently. The relationship between fatigue and falls is not fully understood and more research is needed, especially on the ability to reduce falls by decreasing fatigue.

To improve the quality of care for frail older people, interventions should be individualized and multifactorial, and should not merely focus on specific diseases. A comprehensive investigation is necessary to identify risk factors in the individual and their surroundings. Evaluating the effects of a fall prevention intervention in a close collaboration between primary health care and municipal care is called for. The intervention may include a comprehensive assessment of risk factors for falls, provide supervised high-intensity training and focus on enhancing safety aspects of daily life.



# Svensk sammanfattning

Fallolyckor inträffar i alla åldrar, men är betydligt vanligare hos äldre personer och kan få allvarliga konsekvenser i form av frakturer och mjukdelsskador. Det kan även leda till en rädsla för att falla igen. Dessa konsekvenser kan leda till en sämre funktionsförmåga än före fallet eller till inaktivitet, vilket leder till försämrad balans och muskelstyrka som ytterligare ökar risken för fall. Denna nedåtgående spiral kan vara svår att ta sig ur. Eftersom fallskador också innebär stora kostnader för samhället finns det all anledning att försöka förhindra fall bland äldre personer.

Det finns många faktorer som ökar risken för att en person ska falla. Risken ökar ju äldre man är och kvinnor har en ökad risk jämfört med män. Exempel på riskfaktorer hos individen är nedsatt funktionsförmåga, försämrad syn och bieffekter av läkemedel. Riskfaktorer i omgivningen kan vara halt underlag, dålig belysning och ojämna trottoarer. Vissa, men inte alla, av dessa riskfaktorer går att ta bort. Att ha fallit tidigare är en av de största riskfaktorerna för att falla igen. En annan stark riskfaktor är yrsel. Yrsel, eller ostadighet, är förknippat med nedsatt funktionsförmåga, lägre aktivitetsgrad och sämre livskvalité. Personer med yrsel är också i riskzonen för att hamna i en nedåtgående spiral med inaktivitet och en ökad risk för fall. Eftersom yrsel är ett vanligt och ofta svårbehandlat symtom hos äldre är det viktigt att öka kunskapen om adekvat hälso- och sjukvård utifrån deras behov.

Att falla är inte en naturlig konsekvens av att åldras, utan forskning visar att fall i hög grad kan förhindras. Bra tester behövs för att identifiera vilka personer som är i riskzonen för att falla och erbjuda dem fallförebyggande åtgärder. Fallprevention ska innehålla flera komponenter. Initialt ska en individuell riskbedömning göras och riskfaktorer ska elimineras i den mån det är möjligt. Åtgärder som minskat antalet fall är översyn och ändring av läkemedel och att se över risker i personens närmiljö. En annan viktig komponent i fallprevention är fysisk träning. Genom att träna upp balans och muskelstyrka ökar säkerheten vid förflyttningar och ger en bättre beredskap för att kunna parera när man tappar balansen. Detta är framförallt viktigt hos sköra äldre personer med flera riskfaktorer som kan vara svåra att eliminera. Genom träning går det att kompensera för de faktorer som ger en ökad fallrisk.

Forskning om fallprevention har framförallt inriktat sig på friska äldre personer som har varit oberoende av hjälp från andra, men det finns studier som visat att fallpreventiva insatser haft positiva effekter även för personer på äldreboenden. Däremot finns det mindre forskning på sköra, äldre personer som bor kvar hemma (ordinärt

boende). Inom äldreomsorgen i Sverige idag gäller kvarboendepincipen, vilket innebär att äldre personer kan bo kvar i sitt eget hem så länge det finns möjlighet. Eftersom en allt större andel av befolkningen är äldre och antalet platser på äldreboenden har minskat, så bor fler sköra äldre i ordinärt boende idag än förr. Detta innebär att många äldre som bor hemma idag har en hög risk för att falla, och därför är i behov av fallprevention. Ett sätt att arbeta med fallprevention kan vara att inom hälso- och sjukvården erbjuda hembesök. Dessa hembesök kan innehålla att informera om fallprevention, bedöma risker för fall hos individen och i miljön, och erbjuda fysisk träning och aktivitet för att förbättra den äldres fysiska funktionsförmåga. Ett sätt att arbeta med förebyggande hembesök är genom "case management"-modellen. En "case manager" (CM) hjälper till att planera, koordinera, övervaka och utvärdera den äldre personens vård och omsorg. Genom kontinuerliga hembesök finns det möjlighet att tidigt upptäcka och möta den äldre personens behov.

Denna avhandling består av fyra delstudier där det övergripande syftet var att undersöka riskfaktorer för fall och yrsel samt att belysa hur äldre personer med långvarig yrsel upplever att det dagliga livet påverkas. Ett annat syfte var att utvärdera effekterna på fall och fallskador av en "case management"-intervention till sköra äldre i ordinärt boende.

Den första delstudien var en epidemiologisk studie som undersökte förekomst och riskfaktorer för fall eller yrsel i olika åldersgrupper. Delstudien baserades på data från ett studieområde (Karlskrona kommun, Blekinge) i det nationella, fleråriga forskningsprojektet Swedish National Study on Aging and Care (SNAC). Projektet inkluderade 10 åldersgrupper mellan 60 och 96 år och vid studiens start 2001-2003 ingick 1402 personer. Personer mellan 60 och 78 år följdes upp vart 6:e år och de som var äldre vart 3:e år. Vid baslinjemätningen besvarade 973 personer frågan om de fallit senaste året och 1273 personer svarade på frågan om de upplevde yrsel. Dessa personer ingick i denna delstudie. De grupperades i åldersgrupperna 60-78 år eller 81-96 år. Data från 3- och 6- årsuppföljningarna användes också. Data från baslinjemätningen visade att ca 25 procent uppgav att de hade fallit det senaste året och lika många rapporterade att de besvärades av yrsel. Förekomsten var dubbelt så hög i den äldre åldersgruppen jämfört med den yngre gruppen. Riskfaktorerna för fall i den yngre gruppen var: neuroleptika, behov av hjälp från andra i personliga aktiviteter i dagligt liv (beroende i PADL) (t.ex. vid förflyttning, på- och avklädning, eller dusch/bad), tidigare fall eller nedsatt syn. I den äldre gruppen var riskfaktorerna för fall: tidigare fall, behov av hjälp från andra i instrumentella aktiviteter i dagligt liv (beroende i IADL) (t.ex. städning och inhandling) eller trötthet. I båda åldersgrupperna var den största riskfaktorn för att utveckla yrsel att man hade besvärats av yrsel tidigare. I den yngre gruppen var även nervositet en riskfaktor för yrsel och i den äldre gruppen var tidigare fall en riskfaktor för yrsel. Denna delstudie visade att förekomsten av både fall och yrsel ökade med åren och att riskfaktorerna till viss del skiljde sig åt mellan åldersgrupperna. Rekommendationerna, baserade på resultatet i denna delstudie, var att personer som fallit tidigare bör erbjudas fallprevention. Hos

personer 60-80 år bör man ta hänsyn till en ökad fallrisk när man förskriver neuroleptika. Personer beroende i PADL eller med nedsatt syn i denna åldersgrupp bör erbjudas fallprevention. Fallprevention bör också erbjudas till personer över 80 år som är beroende av andra i IADL eller uppger trötthet. Delstudien visade också att för många äldre är yrsel ett långvarigt symtom, vilket indikerar att yrsel är svårbehandlat. Nervositet var en riskfaktor för yrsel, och även om delstudien inte visade den bakomliggande orsaken till nervositeten, så är det ett hälsobesvär som bör beaktas hos äldre personer (60-80 år) med långvarig yrsel. Att tidigare fall var en riskfaktor för att uppleva yrsel kan bero på att en nedsatt funktions- och balansförmåga (vilket ger en ökad risk för fall) kan upplevas som ostadighet och yrsel. Med tanke på att yrsel är vanligt hos äldre och innebär en risk för fall och inaktivitet, behövs mer kunskap om hur hälso- och sjukvården till äldre personer med långvarig yrsel ska utvecklas.

Den andra delstudien var en intervjustudie med syfte att undersöka äldre personers erfarenheter av hur det dagliga livet påverkas av att leva med långvarig yrsel. I delstudien ingick sju kvinnor och sex män mellan 73 och 87 år som besvärats av yrsel mellan 1,5 till 20 år. Deras diagnoser, relaterade till deras yrsel, var Ménière's sjukdom, multisensorisk yrsel, vestibularisneurit och akustikusneurinom. De beskrev även andra diagnoser som t.ex. hjärtsjukdom, astma, artros, osteoporos eller depression. Intervjuerna analyserades med kvalitativ innehållsanalys. Resultatet visade att de levde i en osäker tillvaro som de kämpade för att ta kontroll över. Olika aspekter på hur det var att leva i en osäker tillvaro angavs: en rädsla för att hamna i farliga situationer (t ex. att falla och skada sig) eller en osäkerhet i att inte veta hur länge man kunde vara oberoende av hjälp från andra. De beskrev att de levde i en begränsad och oflexibel tillvaro. Kampen för kontroll innebar att de ständigt letade efter ny information eller nya behandlingsformer. De kämpade också för att behålla eller återfå sin tidigare livsstil, t ex. att fortsätta med en aktivitet, trots att det ibland kunde vara mycket påfrestande. De ville att deras liv skulle bli normalt igen. Delstudien visade att de hade frekventa sjukvårdskontakter, men vården svarade inte upp till deras behov och önskemål. Att symtomen inte togs på allvar eller att behandlingseffekter uteblev ledde till frustration. Samtidigt beskrevs också en tillfredsställelse över att ha snabb tillgång till specialistvård, lyckade behandlingsmetoder och att få hjälp med praktiska saker. Att få stöd innebar att deras yrselbesvär togs på allvar. Genom att fokusera på att ge stöd för att minimera risken för skador och oberoende, kan den äldre personen med långvarig yrsel få en ökad kontroll över sitt dagliga liv.

De tredje och fjärde delstudierna baserades på data från en randomiserad kontrollerad studie med syfte att undersöka effekterna av en "case management"-intervention till sköra hemmaboende äldre personer – Projekt Närsjukskötarska. Projektet genomfördes i en mellanstor kommun i södra Sverige och startade 2006. Inklusionskriterierna var: a) 65 år eller äldre, b) vistats på sjukhus minst två gånger, eller varit på läkarbesök minst fyra gånger det senaste året, c) bo i ordinärt boende och d) hjälp med minst två aktiviteter i dagligt liv (ADL) (t.ex. på- och avklädning, städning,



matinköp) av anhöriga eller kommunen. Sammanlagt 153 personer deltog i studien och blev lottade till en interventionsgrupp (80 personer) eller en kontrollgrupp (73 personer). Interventionen innebar hembesök av sjuksköterska och fysioterapeut minst en gång i månaden under ett år och bestod av fyra delar: 1) "traditionell" case management (t.ex. bedöma och utvärdera vårdbehov, koordinera vårdkontakter), 2) ge allmän information (t.ex. om sjukvård, säkerhet i hemmet, aktiviteter i kommunen), 3) ge specifik information inriktat mot personens behov och 4) säkerhet och tillgänglighet (sjuksköterska och fysioterapeut var tillgängliga på telefon under kontorstid mån-fre). Fysioterapeuten inriktade sig specifikt på fallprevention, fysisk aktivitet och träning. Denna del av interventionen innehöll exempelvis ett individuellt anpassat hemträningsprogram, information om träning utanför hemmet, och en genomgång av säkerhet i hemmet. Data samlades in i deltagarnas hem vid studiens start och efter 3, 6, 9 och 12 månader med hjälp av standardiserade frågeformulär och tester av fysisk funktionsförmåga.

Den tredje delstudien var en prospektiv studie som undersökte hur väl olika bedömningsinstrument kunde förutse (prediktera) vilka personer som hade en ökad risk för fall. Instrumenten som ingick var Downton's fallriskindex (DFRI), Timed Up & Go (TUG) och Rombergs test (RT), semi-tandem RT (SRT) och tandem RT (TRT). Delstudien visade att inget av testerna hade en hög prediktiv förmåga och endast 40-50 % av deltagarna blev korrekt klassificerade. RT, SRT hade låg sensitivitet och få deltagare kunde genomföra TRT. Högst prediktiv förmåga hade DFRI (gränsvärde 3 poäng) och TUG (gränsvärden 12 sekunder) med ca 80 % sensitivitet och 30 % specificitet. Rekommendationerna i denna delstudie var att DFRI och TUG kan användas för att identifiera personer med hög fallrisk, men bör inte användas som ett incitament för att introducera fallprevention. Andra mer omfattande och djupgående instrument behövs för att bedöma fallrisk på sköra äldre personer i ordinärt boende innan fallprevention erbjuds.

Den fjärde delstudien undersökte effekterna av Projekt Närsjuksköterska avseende självrapporterade fall, fallskador och behov av sjukvård på grund av fallskada. I interventionsgruppen rapporterades 96 fall mot 85 i kontrollgruppen. Fyrtio respektive 38 fallskador rapporterades i grupperna. I interventionsgruppen var 19 fallskador i behov av sjukvård mot 15 i kontrollgruppen. Inga statistiskt signifikanta skillnader sågs alltså mellan grupperna och slutsatsen var att interventionen inte kunde påvisa någon effekt på dessa utfall.

Sammanfattningsvis visar delstudierna i denna avhandling att många äldre besväras av fall och yrsel och förekomsten ökar ju äldre man blir. Riskfaktorerna för fall i olika åldersgrupper skiljde sig åt, vilket indikerar att insatser för att förhindra fall behöver vara individuellt utformade. DFRI and TUG visade låg prediktiv förmåga och mer forskning behövs för att med utvecklade tester som med hög precision kan identifiera vilka personer som är i behov av fallprevention. Att leva med långvarig yrsel innebär att leva i en osäker tillvaro med en ständig kamp för att bli trodd, för att bli frisk eller

för att kunna behålla sin nuvarande livsstil. De intervjuade gav uttryck för en önskan om att förbättras och hade en stark vilja att inte ge upp. Hälso- och sjukvården möter idag inte upp till deras behov utan behöver vidareutvecklas. Projekt Närsjuksköterska lyckades inte förhindra fall, fallskador eller sjukvård på grund av fallrelaterade skador. Andra modeller för att förhindra fall hos sköra äldre i ordinärt boende behöver utvärderas i framtida studier.



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