Falls in older community-dwelling women and men: risk factors and safety strategies

Fall risk awareness, fear of falling, and preferred exercise properties from a gender perspective

Petra Pohl

Department of Community Medicine and Rehabilitation, Physiotherapy
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In loving memory
Christine Pohl

It takes a child one year to acquire
independent movement and ten years to
acquire independent mobility.
An old person can lose both in one day.

Bernard Isaacs,
The Challenge of Geriatric Medicine, 1992

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Abstract

Background Falls are the leading cause for non-fatal injuries in older community-dwelling people. Compared to men, women fall more often, experience more fall-related injuries, and report fear of falling (FoF) more often. Falls may be prevented with specific exercises, but adherence is often low in long-term. One aim of the thesis was to gain a deeper understanding of the risk factors previous falls, FoF, and gender. Another aim was to explore safety strategies in older community-dwelling people in terms of fall risk awareness and actions taken to protect from falls, and to identify motives for exercising and preferred exercise properties. A gender perspective was used throughout the thesis.

Methods To determine the impact of the risk factors on future falls and injurious falls, a cross-sectional design was used combined with longitudinal data. Baseline data from 230 community-dwelling people over 75 years were collected with questionnaires and performance-based tests. FoF was measured with the single item question "Are you afraid of falling?". Monthly fall calendars were collected for one year (monitoring year). Based on status on falls, participants were classified as those with i) no falls (n=119), ii) 1 non-injurious fall (n=51), iii) ≥2 non-injurious falls (n=40), and iv) ≥1 injurious fall (n=20). These data were linked to data from an injury database (IDB) with respect to registered injurious falls for a period of about 5 years (long-term follow-up). Andersen-Gill method of Cox regression for multiple events was used to estimate the risk of future injurious fall events. To find relationships between FoF, gender, and falls (defined as two or more falls), a general log-linear analysis was performed. Associations between FoF and the components of the International Classification of Functioning (ICF) were explored with a structural equation model. To explore fall risk awareness and safety strategies, and to identify motives and preferred exercise properties, qualitative study design was used. Multistage focus groups were held with 18 community-dwelling people (10 women and 8 men) between 70 and 80 years. Transcriptions were analysed with qualitative content analysis.

Results Fourty-eight per cent of the 230 participants fell at least once during the monitoring year, and 23% experienced recurrent falls. Compared to men, women reported FoF more often, but did not experience more recurrent falls, and no more injurious falls. FoF was significantly associated with the ICF components *Activity/Participation* and *Personal Factors* in women and men both; but in opposite directions for women and men on *Personal Factors*. During the long-term follow-up, 91 injurious falls were registered in 70 participants (30%). Those with injurious falls during the monitoring year were at significant risk of experiencing new injurious falls in long-term

(HR 2.78; 95% CI 1.40-5.50), compared to those with no falls. Women experienced a higher rate of fractures than did men. Analyses from the multistage focus groups resulted in three categories: Facing various feelings; Recognizing one's fall risk; and Taking precautions. A comprehensive theme tied them together: *Safety precautions through fall risk awareness*. Analyses also resulted in six categories identifying preferred exercise properties in the context of falls prevention: Motives to start exercise; Barriers to start exercise; Exercise characteristics; Confirmation; Spirit lifters; and Maintenance tricks. All categories included sub-categories. Both studies revealed greater variations among women and among men than between women and men.

Conclusion Community-dwelling people over 75 years who have experienced an injurious fall are at high risk of sustaining new injurious falls the forthcoming five years, and should be offered multifactorial fall risk assessments with targeted interventions to optimize the prevention of future falls. The single item question "Are you afraid of falling?" has no predictive value for future falls, and the answer may be strongly gendered. The questions should therefore be avoided in clinical practice and research in community settings. The participants of the qualitative studies implicity and explicitly described how they had become aware of fall risks in everyday life, and both women and men took precautionary actions. Raised fall risk awareness was achieved by several channels including the media, and by meeting with peers and professionals with expertise in falls prevention. A wide variety of preferred exercise properties in the context of falls prevention were identified among the older community-dwelling people. The variations of the requests were greater among women and among men than between women and men. The results should be taken into consideration when offering exercise-based falls prevention interventions to older people. The results from this thesis indicated that measures can be taken on a broad front in order to reduce the damage from injurious falls in older community-dwelling people. A gender perspective is warranted for in clinical practice and future research. Adopting a gender perspective may broaden the understanding of gender differences and similarities when implementing falls prevention activities.

Svensk populärvetenskaplig sammanfattning

En fallhändelse – att oavsiktligt hamna på golvet eller marken – är den vanligaste orsaken till att äldre kvinnor och män skadar sig. Äldre personer i Västerbottens län är särskilt drabbade av skadefall. Det är vanligare att kvinnor skadar sig, men män avlider oftare än kvinnor av sviterna efter ett fall. Det finns indikationer på att äldre som faller ofta, med eller utan skador som följd, är mer drabbade av skadefall än de som inte faller, men det saknas idag specifika kunskaper om detta. Förutom skador kan fall också leda till fallrädsla. En viss grad av försiktighet skyddar mot fall, men en överdriven rädsla kan leda till att normala vardagsaktiviteter undviks. Man riskerar då att bli fysiskt inaktiv, vilket på sikt kan leda till muskelsvaghet, försämrad livskvalitet och ökad fallrisk. Tidigare studier har visat att kvinnor både faller och rapporterar fallrädsla oftare än män. Dessa samband ses ofta som normala och blir sällan ifrågasatta eller betraktade utifrån ett genusperspektiv. Det är oklart varför kvinnor är särskilt drabbade av fallrädsla och fall. Det övergripande syftet med denna avhandling var att få en fördjupad kunskap om fallriskfaktorer och säkerhetsstrategier hos äldre kvinnor och män i ordinärt boende, med särskilt fokus på tidigare fall, fallrädsla, fallriskmedvetenhet, och träningspreferenser. Avhandlingen genomsyras av ett genusperspektiv.

Att vara medveten om fallrisk i vardagen kan skydda mot många fallhändelser genom att förebyggande åtgärder vidtas. Många äldre saknar dock kunskaper om fallriskfaktorer. Många upplever inte heller själva att de löper risk att falla. För att finna kanaler till att öka fallriskmedvetenheten hos äldre personer är det viktigt att identifiera hur äldre personer kan bli medvetna om fallrisk i sin vardag, och vilka åtgärder de vidtar för att undvika att falla. Det finns idag också ett starkt vetenskapligt stöd för att många fallhändelser kan förebyggas genom skräddarsydd balans- och styrketräning under förutsättning att träningen utförs regelbundet och under en längre period. Motivationen till långvarig träning är dock ofta låg hos många äldre personer. Det finns därför ett behov av att identifiera träningsformer och träningsegenskaper som äldre personer attraheras av, och att undersöka om kvinnor och män föredrar olika former av träning, i syfte att optimera förutsättningarna för äldre personer att delta i fallpreventiv träning även under lång tid.

Avhandlingen innehåller fyra delarbeten med data från äldre kvinnor och män i ordinärt boende. Två delstudier baseras på tidigare insamlade data från 230 personer över 75 år, innehållande ett urval av frågeformulärer, mätningar av funktionsförmåga, frågan ”Är du rädd för att falla?” samt en ettårsuppföljning avseende fallhändelser. För två delstudier analyserades fokusgruppsdiskussioner med 10 kvinnor och 8 män mellan 70 och 80 år. Såväl kvantitativa som kvalitativa metoder har använts i avhandlingen.

Delstudie I baserades på data från falluppföljningen. Deltagarna kategoriserades baserat på fallhändelser under uppföljningsåret: i) de som inte föll, ii) de som föll en gång utan skador, iii) de som föll två eller fler gånger utan skador, och iv) de som föll och skadade sig så svårt att de fått uppsöka akutvårdscentral. Dessa data matchades med data från Skadedatabasen avseende

skadefall de följande 5 åren. Resultatet visade att individer som skadefallit under uppföljningsåret löpte nästan tre gånger så stor risk att ådra sig nya skadefall inom loppet av 5 år. Individer med ett eller flera fall utan skador löpte ingen ökad risk att skadefalla på sikt. Det förelåg ingen skillnad mellan kvinnor och män i andelen skadefall, men en större andel kvinnor ådrog sig fallrelaterade frakturer.

Delstudie II baserades på baslinjemätningarna och falluppföljningen, och undersökte sambanden mellan fallrädsla, kön och förekomsten av fall (definierat som minst 2 fallhändelser) under ett års tid. Vidare undersöktes också samband mellan fallrädsla och komponenterna i den rådande klassifikationsmodellen för funktion och funktionsnedsättning, ICF. Kvinnor och män analyserades separat. Resultaten tolkades utifrån en relationell genusförståelse. Resultatet visade att rapporterad fallrädsla inte innebar en ökad risk för att falla under kommande år, varken för kvinnor eller för män. Kvinnor föll inte i större utsträckning än män. Resultatet bekräftade att kvinnor oftare svarar ”ibland” eller ”ofta/alltid” på en direkt fråga om de är rädda för att falla medan män i högre utsträckning svarar ”sällan/aldrig”. Analysen med ICF som förklaringsmodell visade att fallrädsla var starkt associerat till Personfaktorer och Aktivitet/Delaktighet, både för män och kvinnor. Sambandet mellan Personfaktorer och fallrädsla var åt motsatt håll för kvinnor och män. Resultatet antyder att hur man svarar på frågan om man är fallrädd eller inte kan ha ett samband med den egna personliga bakgrunden (t ex ålder, utbildningsnivå, tidigare erfarenheter samt sociala konstruktioner), samt hur väl man presterar på funktionstester: god prestation innebär mindre fallrädsla. Betraktat utifrån ett genusperspektiv kan resultaten tolkas som att svaret på frågan om man är rädd för att falla sannolikt är starkt könskodat. Svaret ger ingen fallprediktiv ledning och frågan bör undvikas i klinik och forskning för personer i ordinärt boende.

Delstudie III visade hur äldre kvinnor och män blir medvetna om fallrisk i sin vardag, vilka åtgärder de kan vidta för att undvika att falla, och hur det kan upplevas att behöva ändra sitt beteende pga. upplevd fallrisk. Tre kategorier identifierades: *Varierande känslor* (t ex fallrädsla, tacksamhet och trots); *Bli varse fallrisk* (t ex genom egna erfarenheter, via media, eller genom att diskutera med andra); och *Utföra säkerhetsåtgärder* (t ex ändra rörelsemönster eller kompensera med hjälpmedel), vilka ledde fram till temat *Säkerhetsåtgärder genom fallriskmedvetenhet*. I många vardagssituationer tilllämpades strategier vilka uttrycktes i termer om inse, bortse och förutse. Dessa strategier varierade inom samma person i olika sammanhang.

Delstudie IV identifierade ett antal faktorer som har potential att påverka motivationen till långvarig kontinuerlig träning, inklusive faktorer som påverkar beslutet att börja träna. Önskemålen varierade mer inom gruppen kvinnor och inom gruppen män, än mellan kvinnor och män. Exempel på identifierade faktorer: *Träningsformens egenskaper*, t ex intensitet och grad av utmaning; *Bekräftelse* på utfört arbete, t ex genom synliga förändringar eller en uppmuntrande instruktör; *Glädjebringare*, t ex musik och humor; samt knep som bidrog till långvarigt deltagande, t ex kamratskap, fasta rutiner och sällskapsdjur.

Sammanfattningsvis visar avhandlingen att personer över 75 år i ordinärt boende som drabbas av ett skadefall har en nästan trefaldig risk att ådra sig nya allvarliga skadefall under de kommande 5 åren. Därför bör denna grupp erbjudas multifaktoriell bedömning snarast efter första skadefallet och adekvata fallförebyggande insatser. Avhandlingen ger inget stöd för att äldre kvinnor över 75 år faller eller skadefaller i högre utsträckning än män. Kvinnor tycks ha lättare att svara jakande på en direkt fråga om de är rädda för att falla jämfört med män, vilket kan vara ett uttryck för könskonstruktioner. Ett jakande svar innebar dock inte en ökad fallrisk, varken hos kvinnor eller hos män. Resultaten visar även att det finns många olika sätt att bli medveten om fallrisk i vardagen. En ökad fallriskmedvetenhet kan uppnås genom att erbjuda diskussionstillfällen med andra äldre och experter inom fallrisk. eller genom relevant information i media. Avhandlingen visar också att äldre personer är en heterogen grupp individer med individuella önskemål vad gäller träningspreferenser. Avhandlingen bidrar till en fördjupad förståelse om betydelsen av tidigare erfarenheter såsom fallhändelser, fallrädsla samt träningserfarenheter hos äldre kvinnor och män i ordinärt boende, och om vilka åtgärder äldre personer kan ta till för att själva förebygga framtida fall. Denna kunskap kan användas för att förbättra förutsättningarna för äldre personer att delta i fallpreventiva åtgärder.

Abbreviations

AGS/BGS	American Geriatrics Society/British Geriatrics Society
BMD	Bone mineral density
CFA	Confirmatory factor analysis
CI	Confidence interval
CMIN/df	Chi-square minimal per degrees of freedom
DXA	Dual-energy X-ray absorptiometry
ED	Emergency department
FoF	Fear of falling
HR	Hazard ratio
ICF	International Classification of Functioning, Disability and Health
IDB	Injury Database
MMSE	Mini-Mental State Examination
PAAR	Participatory and Appreciative Action and Reflection
ProFaNE	Prevention of Falls Network Europe
ProFouND	Prevention of Falls Network for Dissemination
RMSEA	Root mean standard error of approximation
SD	Standard deviation
SPPB	Short Physical Performance Battery
WHO	World Health Organization

Definitions

Ageing	A process or group of processes occurring in living organisms that with the passage of time lead to a loss of adaptability, functional impairment, and eventually death (1).
Balance	The ability to control the center of mass (COM) in relationship to the base of support (COM is defined as a point that is at the center of the total body mass). Also labelled *postural stability* (see definition of postural control) (2).
Behaviour	Anything a person does in response to internal or external events. Actions may be overt (motor or verbal) and directly measurable, or covert (e.g. physiological responses) and only indirectly measurable; behaviours are physical events that occur in the body and are controlled by the brain (3).
Community-dwelling	Living in ordinary housing, e.g. apartment or house, as opposed to living in institutions such as hospital settings or residential care facilities.
Disability	An umbrella term for impairments, activity limitations, and participation restrictions that results from the interaction between an individual's health condition and the personal and environmental contextual factors (4).
Frailty	A medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance, and reduced physiologic function that increases an individual's vulnerability for developing increased dependency and/or death (5).
Gender bias	Prejudices about gender that may lead to negative consequences for women or men on individual, group, or societal levels (6).
Exercise	Planned, structural movement via skeletal muscles that results in energy expenditure, and with the aim of improving or maintaining physical fitness (7).
Hazard ratio	The probability of occurrence of an event per unit time at risk; e.g. death or new disease, at a point in time, t (8).
Health	The ability to adapt and to self-manage within the domains of physical, mental, and social well-being (9).
Health behaviour	A combination of knowledge, practices, and attitudes that together contribute to motivate the actions we take, e.g. starting to exercise (8).
Health promotion	The combination of educational and environmental supports for actions and conditions of living leading to health. The purpose is to enable people to gain greater control over the determinants of their own health (10).
Healthy ageing	The process of optimising opportunities for physical, social and mental health to enable older people to take an active part in society without discrimination and to enjoy an independent and good quality of life (11).

Mobility	Moving by changing body position or location or by transferring from one place to another, by moving or manipulating objects, by walking, running, climbing, or by using various forms of transportation (4).
Mobility disability	The gap between an individual's ability (e.g. muscle strength or balance) and environmental challenges such as walking outdoors or on uneven surfaces (4).
Motivation	Mental functions that produce the incentive to act; the conscious or unconscious driving force for action (4).
Odds ratio	A measure of association which compares the odds of disease of those exposed to the odds of disease those unexposed (8).
Osteopenia/ osteoporosis	*Osteopenia*: T score between -1.0 to -2.5 standard deviations below the mean in young, white adult women *Osteoporosis*: T score below -2.5 standard deviations of the mean in young, white adult women (T score refers to a diagnostic treatment threshold based on BMD at the age of peak bone mass (12).)
Physical activity	All bodily movement that derives from the contraction of the skeletal muscles and results in increased energy expenditure (7).
Postural control	The ability to control the body's position in space for the dual purposes of *stability* and *orientation*: postural *orientation* is defined as the ability to maintain an appropriate relationship between the body segments, and between the body and the environment for a task; postural stability see *balance* (2).
Practitioner	Someone who is qualified or registered to practice a particular occupation or profession, e.g. physicians or physiotherapists.
Recall bias	Systematic error due to differences in accuracy or completeness of recall to memory of past events or experiences (8).
Risk factor	An attribute or exposure that is associated with an increased probability of a specified outcome, such as the occurrence of a disease (of fall event). Not necessarily a causal factor (8).
Sedentary	Refers to any waking activity characterized by an energy expenditure ≤ 1.5 metabolic equivalents *and* a sitting or reclining posture. In general this means that any time a person is sitting or lying down, they are engaging in sedentary behaviour. Common sedentary behaviours include TV viewing, video game playing, computer use, driving automobiles, and reading. (13).
Self-efficacy	An individual's belief in their ability to successfully perform a specific behaviour (14).
Well-being	Well-being integrates mental and physical health, and is associated with self-perceived health, longevity, healthy behaviours, mental and physical illness, social connectedness, productivity, and factors in the physical and social environment.

Original papers

The thesis is based on the following publications and manuscripts, which will be referred to by their Roman numerals in the text:

I Pohl P, Nordin E, Lundquist A, Bergström U, Lundin-Olsson L.
Community-dwelling older people with an injurious fall are likely to sustain new injurious falls within 5 years – A prospective long-term follow-up study
BMC Geriatrics 2014, **14**:120

II Pohl P, Ahlgren C, Nordin E, Lundquist A, Lundin-Olsson L.
Gender perspective on fear of falling using the classification of functioning as the model
Disabil Rehabil 2014 Apr 30. Epub ahead of print

III Pohl P, Sandlund M, Ahlgren C, Bergvall-Kåreborn B, Lundin-Olsson L, Melander Wikman A.
Fall risk awareness and safety precautions taken by older community-dwelling women and men – A qualitative study using focus group discussions
Submitted for publication

IV Sandlund M*, Pohl P*, Ahlgren C, Skelton D, Melander Wikman A, Lundin-Olsson L.
Gender perspective on older people's preferences for exercises in the context of falls prevention – a qualitative study
Manuscript

*Contributed equally

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Preface

As physiotherapist at a stroke unit I occasionally came across two scenarios: older women with mild stroke symptoms that would say: "I can't walk – my leg is paralyzed! I'm afraid I will fall!" Or, older men with severe stroke symptoms who would suffer severe falls at the unit because they attempted to walk to the bathroom on a flaccid leg. I have frequently reflected on these two situations and spent quite some time in convincing some women that the leg was only mildly paralyzed and would be fine to put weight on, as well as trying to convince some men not to take unnecessary risks, because the leg was completely paralyzed. Both situations awoke frustration in me: why was it that some women seemed to lack self-efficacy so much that it affected their rehabilitation? And why was it that some men would not accept physical weakness to such a degree that they were willing to take the risk of falling in order to remain independent? This was my pre-understanding of falls, gender, and fear of falling when I entered the academic world. Of course, these scenarios were not typical for *all* women or *all* men, and the opposite also occurred, but surprisingly often. I felt a strong urge to understand these gendered constructions, women's and men's choices of actions, and how to approach women and men with similar characteristics in better ways than with frustration.

During the process of writing this thesis I began to understand the complexity of human behaviour. What I intuitively thought to be a problem on an individual level turned out to be a more complex phenomenon on several levels. Human behaviour is a combination of knowledge, practices, and attitudes that together contribute to motivate the actions we take. This definition includes gender patterns: we are all part in shaping those patterns, every day and everywhere. Being aware of how masculinity and femininity patterns arise, and our own part in this process, may hopefully help physiotherapists and other clinicians in their work with rehabilitation of older people, and to understand why some people appear to have a 'risky behaviour', and why some people do not seem to dare to challenge their physical abilities.

I am convinced that practices and attitudes can be changed. With this thesis I hope to add a piece of knowledge to what is already known about falls in older people, about gendered patterns in society, and about facilitators and barriers to uptake and adherence with exercising. Hopefully it can contribute to less frustration in the daily work when patients take risks or are afraid to challenge themselves, and to understand some of the reasons why.

Introduction

Fall events are the leading cause of non-fatal injuries among older community-dwelling people. Injurious falls carry a huge cost to health and social services, individuals, families and caregivers (15, 16). Women are in general more affected by fall-related fractures (17, 18) and by activity avoidance due to a fear of falling (FoF) (19), but the mortality due to the consequences from falls is higher among men (20). In Sweden, the total number of fall-related injuries have increased in the past years. The region of Västerbotten have the highest rate of injurious falls in Sweden, and therefore fall-related research is of high priority in this region. Västerbotten is situated in northern Sweden and has four distinct seasons. During the winter the ground is often snowy and icy.

Research is needed to increase the understanding of fall risk awareness on several levels, and to improve the conditions for sustainable interventions to reduce falls and fall-related injuries. There is need to learn more about older community-dwelling women's and men's own views about fall risks in everyday life, and about their perceptions of and knowledge about falls prevention. This can be accomplished by involving older people actively in the research process. There is also reason to use a gender perspective in research and practice in order to bring the understanding about falls and FoF further. Physiotherapists within the fields of public health and gerontology, as well as primary health care and geriatrics, have an important role to play in developing, leading, and implementing evidence-based fall preventive and health promoting activities on individual, group and organizational levels.

The overall aim of the thesis was to gain a deeper understanding of certain risk factors for falls and injurious falls in older community-dwelling women and men, as well as of the development of fall risk awareness and preferred exercise characteristics in the context of falls prevention. This thesis uses the perspective of physiotherapists, as well as the perspective of older community-dwelling people.

The introduction section will provide the reader with a background to the incidence of falls followed by definitions in relation to falls and fall-related injuries. The subsequent sections describe what the consequences may be of falling, and important fall risk factors. The introduction ends with the theoretical framework this thesis is based upon, and finally the rationale.

Incidence of falls

Seen from a lifespan perspective, falls and fall-related injuries occur in all age groups (21, 22). Falls are particularly evident in children who learn how to walk (23) and in patients with neurological diseases, such as Parkinson's

disease (24), multiple sclerosis (25), stroke (26), and dementia (27). The rate of falling is considerably higher in frail older people who are hospitalized or living in residential care facilities, approximately 50% of older people fall at least once a year in residential care facilities (28, 29).

In developed countries approximately one-third of community-dwelling people aged 65 years or older fall at least once a year (30, 31). Women tend to fall more frequently than men (31-33). A quarter to half of the individuals who fall will do so repeatedly, with higher rates among the oldest-old (aged 85+) (30). The incidence of falls is expected to increase all over the world with ageing societies (34). In 2006 the group of people over 60 years was estimated to be 688 million (34). In 2012 the population older than 65 years were 19% in Sweden, and by 2060 it is estimated to be around 25% (35). Sweden also has a large number of the oldest–old (36). In 2050 this group is expected to reach 10% of the population in developed countries (37) (Figure 1).

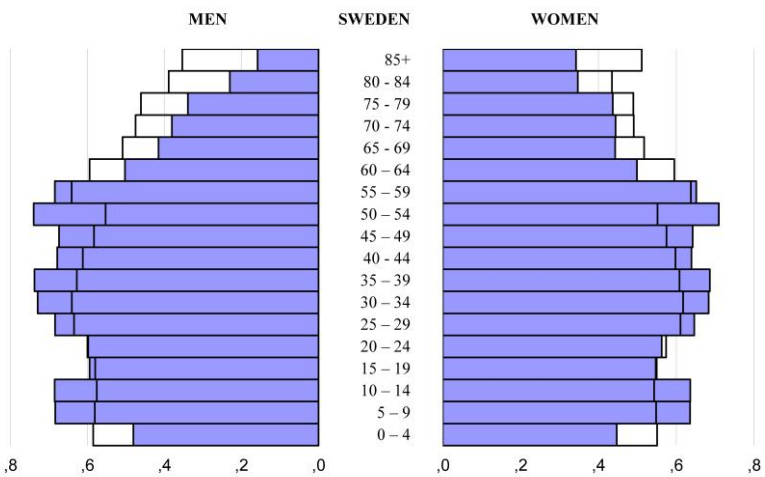

Figure 1. Population by age group, gender, in 2000 and 2050, in percentage of total population in Sweden in each group. The figure highlights the growing proportion of the older population in parallel with a decreasing proportion of the younger population. The triangular population pyramid will eventually be replaced by a more cylinder-like structure. Based on data from OECD (2007), Society at a Glance 2006: OECD Social Indicators, OECD Publishing. Published with kind permission.

The growing ageing population means a societal challenge because increasing age can entail increased illness and functional disability, making older people more dependent on medical and social services (11). In 2007, the WHO identified problem areas in relation to falls in older people, and urged for multisectoral research on several levels in order to better understand the problem with falls from different perspectives. An action plan was provided

addressing three specific strategies: 1) building awareness of the importance of falls prevention and treatment; 2) improving the assessment of individual, environmental, and societal factors that increase the likelihood of falls; and 3) improving strategies for evidence-based interventions (34). About the same time a European collaborative endeavour met to reduce the burden of falls injury in older people through excellence in research and promotion of best practice, the Prevention of Falls Network Europe, ProFaNE. The ProFaNE-group have systematically worked to standardise definitions and methods of measuring fall risk factors, falls and injurious falls. Standardisations are warranted for in order to compare data from different researchers, and to challenge and extend data that may lead to effective clinical guidelines and falls prevention interventions (22, 30, 38).

Definitions of falls and fall-related injuries

There is currently no universally used definition of what a 'fall event' is. In 1987, the Kellogg International Work Group proposed the definition 'unintentionally coming to the ground or some lower level and other than as a consequence of sustaining a violent blow, loss of consciousness, sudden onset or paralysis as in stroke or an epileptic seizure' (39). This ample definition has since then been modified several times, for example by the WHO as 'inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest in furniture, wall or other objects' (34). The ProFaNE-group proposed a high qualitative standardised definition that has won increasing ground: 'an unexpected event in which a person comes to rest on the ground or floor' (40).

Most definitions share the resemblance that the fall event should not be caused by extrinsic events, e.g. a car accident (41). In this thesis a fall event was defined as '*an event in which a person unintentionally comes to rest on the floor or ground, regardless of the cause and the consequences of the fall*'. The term 'unintentionally' was chosen because some fall events may actually be expected - but not intentional - for example when learning new balance challenging skills such as downhill skiing or when walking on icy ground.

There are different ways to define a person who has fallen: as someone who has fallen at least once, or as someone who has fallen at least twice over a defined period of time (42). Some researchers believe that one fall only, without any injuries, should be considered as an occurrence by chance alone, but the repetition of the event suggests an underlying high-risk state which predisposes them to falling (43-45). Researchers that support this opinion categorize no falls with one non-injurious fall in the same group. Others suggest that the very first fall always indicates a higher fall risk in an older person, why no falls is contrasted to at least one fall, with or without injuries (46). In

this thesis a 'fall' was defined as recurrent falls during a period of one year. Recurrent was defined as two or more falls (42).

Fall-related injuries are in general defined as a diagnosis in the International Statistical Classification of Diseases and Related Health Problems 10th Revision Version for 2010 (ICD-10) (47). Following the work of the ProFaNE-group, fall-related injuries are recommended to be defined according to their severity(48):
- a *serious injury* as a medically recorded fracture, head or internal injury requiring emergency or inpatient treatment;
- a *moderate injury* as wounds, bruises, sprains, cuts requiring a medical/ health professional examination such as physical examination, x-ray, suture; and
- a *minor injury* as minor bruises or abrasions not requiring health professional assistance and reduction in physical function for at least three days.

The minor injuries are not less important because of the possible psychological consequences they may bring. In this thesis an injurious fall is defined as '*a fall that leads to a visit at the emergency department (ED) because of fall-related injury*'. This definition also includes minor injuries, if they caused a visit to the ED.

Consequences of falls

The consequences of falls can be devastating for older people. Falls sometimes cause mortality, but are more often followed by injuries, pain, functional limitations, loss of independence, and substantial economic burden on health and social services (49). The risk of being transferred to a residential care facility is threefold in older community-dwelling people, even after a single non-injurious fall (46). The costs associated with fall-related injuries are mainly incurred by hospitalization (50), but the costs for home care after fall-related injuries are also substantial. In Sweden, the overall costs associated with fall-related injuries were approximately 24.6 billion Swedish crowns in 2012, of which almost 10 billions concerned individuals older than 65 years (51). The region of Västerbotten has currently the highest rate of injurious falls of Sweden.

Forty to sixty per cent of falls lead to injuries. Thirty to fifty per cent of falls result in minor injuries (bruises or lacerations), but up to 12% of all falls among community-dwelling people may require medical care due to fractures or traumatic brain injury (18, 52). In residential care facilities approximately 10% of falls result in serious injury, and at least 95% of hip fractures are caused by falls (53). Even simple ground-level falls have the potential to cause serious physical injuries (54). Fractures occur in 3-12% of falls, more common in women than in men (17, 18). In Sweden there is a decreasing

trend of hospitalized fall-related fractures in all age and sex specific groups apart from men over 80 years (55). Of all fall-related fractures, those of the hip are considered to be the most serious because they cause the greatest number of health problems and deaths (56). In 2012, approximately 18 000 individuals sustained a hip fracture in Sweden (35). The trend of sustaining a hip fracture is decreasing, but the incidence rate of other fall-related fractures is increasing (55). After hip fracture older people are at high risk for long-lasting disability (57). The incidence rate of hip fractures is substantially higher among people living in residential care facilities, especially during the first month after moving there (58).

Apart from physical injuries caused directly by the fall, there may be psychological consequences such as a fear of renewed falls, conceptualized as a fear of falling (FoF), and reduced quality of life. These consequences may lead to a change in behaviour, e.g. reduced participation and physical activity level (59). Lying on the floor for a long time is an often underestimated consequence of a fall. Inability to get up may lead to pressure sores, carpet burns, dehydration, hypothermia, pneumonia, and even death (60). This seems to be more common in the oldest-old (61). A general functional decline after a fall is also common and may affect the ability to be physically active and to stay independent, e.g. with gardening, bicycling, household activities, ability to walk, climb stairs, dress oneself, rise from a chair, cut toenails, or visit friends (49).

Risk factors for falls and fall-related injuries

The risk factors contributing to falls and fall-related injuries have been studied to a great extent (41, 62, 63). Falls in older people can be attributed to a wide variety of factors, including high age, individual capacity, the activity performed and environmental factors (34, 64, 65). It is well known that the risk of falling increases exponentially with the number of risk factors present (33). Given the seriousness of the consequences from falls, identifying predisposing fall risk factors early is of high priority. This may increase the possibilities to prevent or at least ameliorate the consequences, including the economic burden for society (34).

In order to organize the risk factors, different systems have been suggested. Usually they are categorized as ‘intrinsic’ (person specific) or ‘extrinsic’ (external to the person) (41, 63). This classification is somewhat limited because of the complexity of falls. The WHO proposed a classification system with four dimensions: biological, behavioural, environmental, and socioeconomic factors. This classification does not take previous and current experiences into consideration, for example previous falls, although previous falls is a well-known risk factor (63). Lord and colleagues (2007) proposed a more analytic classification, dividing risk factors into sociodemographic, balance

and mobility, sensory and neuromuscular, psychologic, medical, medication use, and environmental factors (59). Furthermore, the model of the International Classification of Functioning, Disability and Health (ICF), developed by the WHO, provides a system with the potential to organize fall risk factors with a systematic coding scheme for health-related outcomes and determinants on several levels (4). An overview of commonly identified risk factors for falls in community-dwelling people is presented in Table 1, based on a recent systematic review and meta-analysis of prospective studies. To be noted, some important risk factors are not included in the table, e.g. balance impairments and lower limb weakness, because the studies included in the analysis used a variety of measurements, and were thus difficult to compare (63).

Table 1. Independent predisposing fall risk factors in older community-dwelling people, classified according to the model of ICF

ICF component	Fall risk factors	Odds ratio (95% CI)
Body Function and **structure** Physiological functions of body systems (including mental functions)	Cognitive impairment	1.36 (1.12–1.65)
	Depression	1.63 (1.36–1.94)
	Urinary incontinence	1.40 (1.26–1.57)
	Dizziness	1.80 (1.39–2.33)
	Pain	1.39 (1.19–1.62)
	Fear of falling	1.55 (1.14–2.09)
	Visual impairment	1.35 (1.18–1.54)
Activity and **Participation** Execution of tasks or actions, and involvement in a life situation	Gait problems	2.06 (1.82–2.33)
	Physical disability	1.56 (1.22–1.99)
	Limited physical activity	1.20 (1.04–1.38)
Environmental Factors Physical, social and attitudinal environment	Living alone	1.33 (1.21–1.45)
	Use of walking aid	2.18 (1.79–2.65)
	Use of sedatives	1.38 (1.15–1.66)
	Use of antiepileptics	1.88 (1.02–3.49)
Personal Factors Particular background of an individual's life and living	Age	1.12 (1.07–1.17)
	Female sex	1.30 (1.18–1.42)
	History of falls	2.77 (2.37–3.25)
	History of stroke	1.61 (1.31–1.98)
	Rheumatic disease	1.47 (1.28–1.70)
	Parkinson's disease	2.71 (1.08–6.84)
Non-definable global health	Self-perceived poor health	1.50 (1.15–1.96)

Source: Deandrea S *et al*, 2010 (63)

Additional important fall risk factors have been identified, e.g. multiple drug prescription (usually more than 4) labelled as polypharmacy (66). For individuals living in residential care facilities it is more likely that falls are more due to physical impairments than to environmental hazards, because they are generally frailer than those living in the community (59).

Risk factors for injurious falls

Attempts have been made to identify specific risk factors for fall-related injuries. Syncope has for example been shown to increase the risk for fall-related injuries (52). Associations have also been found between injurious falls and new benzodiazepine prescriptions (67). One US based study including people over 65 years found that individuals who were admitted to the hospital due to ground-level falls had an increased risk of 30-day re-admission due to falls, especially if they had been treated in the intensive care unit (68). This study did not include only community-dwelling people.

For low-energy fractures, defined as falls from standing height or less, it has been suggested that the fall itself is the strongest risk factor in older women and men both (69). Additional identified risk factors for fractures are being a woman, previous fractures, and heredity. Another important risk factor for fractures is low bone mineral density (areal BMD, g/cm^2), measured with dual-energy X-ray absorptiometry (DXA) at the hip and spine (66, 70), i.e. osteopenia or osteoporosis. However, a recent study found that half of older women who fracture have normal BMD on DXA scan (71). Risks for developing osteoporosis include smoking, long-term use of corticosteroids, low body weight and hormonal changes (70, 72). A recent Swedish study on people between 40-95 years in Umeå found that presenting to the ED with a first-time fall-related injury that *not* involved fractures, increased the risk of experiencing future fractures (17). This study did not include only community-dwelling people.

Important risk factors for experiencing a hip fracture specifically are high age, maternal hip fracture, lower limb weakness, and impaired visual contrast sensitivity (42). In addition, using any psychotropic medication was found to increase the risk of experiencing a hip fracture (59). The risk of experiencing a hip fracture is almost doubled if a person has experience a previous wrist fracture (73).

Even though various risk factors have been identified for falls and fall-related injuries, it is important to acknowledge that there is an interaction between environmental conditions and an individuals' capacity and behaviour. Most falls in community-dwelling people occur during ordinary activities when a person is walking (74), and many falls occur when a person fails to avoid hazards or when the environmental demands are excessive in relation

to the physical abilities of the individual (65). This makes it difficult to identify the exact cause of a fall event. Furthermore, when screening for fall risk factors it is vital to use valid and reliable measurements.

This thesis focuses on three specific independent risk factors for falls and fall-related injuries: previous falls, fear of falling, and gender.

Previous falls

Because injurious falls may lead to severe consequences to the individual as well as society, there is reason to explore specific determinants that are likely to lead to injurious falls. There is indeed broad consensus that a previous fall, and especially recurrent falls, is an important risk factor for future falls (33). It has however not been investigated specifically if one non-injurious fall, recurrent non-injurious falls, or if an injurious fall severe enough to cause a visit to the ED, increases the risk of sustaining injurious falls in the long run for community-dwelling people. Knowing more about these conditions is likely to contribute to the understanding of when early preventive interventions should be offered to older people in clinical settings.

Measuring previous falls

Retrospectively collected data have often been used in previous research on falls (and still are in part), with recall periods ranging from 1 week to 4 years (40). Because of the potential problem of recollection bias, the ProFaNE-group has recommended researchers to ask participants of future intervention studies if they have fallen the last month when assessing history of falls. In addition, they recommended that prospectively collected data should be used on falls with monthly fall calendars, preferably for 12 months, in order to improve the possibilities to compare data and to receive more reliable data (75). Existing guidelines in the UK and the USA recommend that all patients over 65 years should be asked about previous falls at least once a year in clinical settings. If the patient presents with an acute fall; reports at least one injurious fall or recurrent non-injurious falls; or unsteady gait or balance the previous year, he or she should be assessed for fall risk factors, and subsequently be prescribed targeted interventions (76). There are currently no national guidelines in Sweden with similar recommendations.

Fear of falling

The interest in fear of falling (FoF) has increased in recent years, and the importance of including FoF in the physiotherapy assessment of fall risks among community-dwelling people has recently been stressed (77). FoF usually refers to the lack of self-confidence that normal activities can be performed without falling (78), but has also been defined as “a lasting concern about falling that leads to an individual avoiding activities that he/she re-

mains capable of performing" (79). Approximately 25% to 55% of community-dwelling older people acknowledge being afraid of falling (80). A history of recurrent falls is shown to be an independent risk factor for developing FoF (81), but FoF may exist without reported falls or injury from falling (82). Factors found to be associated with FoF include being a woman, impaired vision, depression, and chronic morbidity (83). FoF may involve several dimensions, e.g. a fear of looking ridiculous in public, a fear of pain, or a fear of losing one's independence (84).

FoF can be an appropriate reaction leading to safe behaviours when performing activities of daily life (e.g. avoid walking on icy sidewalks), but it can sometimes lead to undue activity restriction (83). The pre-understanding that falling leads to FoF, which leads to activity restriction, which then leads to deterioration of physical function, social isolation, depression and then an increased risk of falling still dominates the literature, but has recently been questioned (85). However, a recent review has suggested that when FoF leads to a 'stiffening strategy' which will affect balance performance by reducing the range of motion of the center of mass, FoF may indeed increase the risk of falling (86). The authors did not discuss the association to female gender. In order to understand the phenomenon FoF from several perspectives it would be highly interesting to link a self-reported FoF to a bio-psycho-social model, such as the ICF, and to add a gender perspective.

Measuring fear of falling

A range of tools are now available, but there is currently no golden standard for measuring FoF. Since FoF is a subjective feeling it is difficult to measure in an objective way. Because of the complexity, it has been suggested that FoF involves three components: a *cognitive* component (e.g., one's subjective estimation of the level of risk, and one's ability to avoid a fall); a *behavioural* component (e.g., walking slower on ice to avoid a fall); and a *physiological* component (e.g., increased autonomic reactivity). A recent review by Hadjistavropoulos and colleagues (2011) showed how these components are quite different aspects of FoF and should not be used interchangeably (85). The simplest form of assessments are single item questions such as "Are you afraid of falling?" with either yes or no, or with a graded response (87). A single item question is the system that is most used, but there are several variations. Measurements developed to assess fall-related self-efficacy include the Falls Efficacy Scale (88), which has been shown to be valid and reliable (89); measurements developed to assess fall-related activity avoidance include the Survey of Activities and Fear of Falling in the Elderly (SAFE) (90), also with satisfactory reliability and validity (89).

Gender

Researchers consistently report that being a woman is significantly associated with several fall-related issues, including FoF (91), low balance confidence and activity avoidance (92), experiencing falls (41, 63), and recurrent falls (43, 63, 93), fall-related injuries including fractures (94), osteoporosis (70), and pain (95). However, the mortality due to hip fractures is significantly higher in men, and approximately 20% of men aged >50 years are expected to experience a fragility fracture in their remaining lifetime (66). There seems to be very few attempts to try to understand and explore these differences between women and men. Instead they are accepted without questioning, indicating that older women are anxious, fragile and vulnerable. In fact, many researchers exclude men altogether when investigating the above mentioned fall risk factors, which makes the research strongly gender biased (96). The facts that not all fractures are fragility fractures; that older men also may suffer from osteoporosis; and that men have a higher mortality due to fall-related injuries (20), are rarely discussed from a gender perspective.

Falls prevention interventions and strategies

Falls prevention has been identified as a key priority in WHO Europe's strategy for the ageing population (34). As a field of practice, physiotherapy is concerned with prevention and rehabilitaton of movement disorders that limit, or threaten to limit the movement capacity, such as falls in older people (10). Physiotherapists working with older people in different clinical environments have an important role in primary prevention (promoting health behaviours to the general population), as well as secondary (preventing reoccurent events on an individual level) and tertiary prevention (reducing limitations in patients after injurious events such as hip fracture).

Building fall risk awareness

Following the call from WHO (2007), increasing the awareness of the consequences of falls, including the importance of safety precautions and falls prevention activities, is one of the most critical actions to be implemented on individual, group and societal levels (34). The first step to prevent falls is by becoming aware that the risk of falls exists. Not only in frail older people, but also in well-functioning community-dwelling people who perceive themselves as healthy. A recent report from the Swedish Civil Contingenties Agency (2014) stated that as little as 1% of the general population are aware that injurious falls dominate the causes for accidents, and that most people believe that accidents are mainly traffic related (51). Similar results have been found in the USA (15). Politicians and policy makers are usually more aware (over 30%) that injurious falls cause most deaths in the society (51), but increasing the awareness even more is likely to influence the allocation of resources for the prevention and treatment of falls.

Researchers have shown that when providing awareness campaigns in the general population about the benefits of exercise-based falls prevention programmes, it appears that many older people are still unaware of their own risk of falling (97). Older people who do not recognize their own fall risk, nor perceive that they are at risk for falling, are less likely to participate in fall risk interventions (65). Others have found that receiving information that falls can be prevented works as a facilitator to uptake in falls prevention exercise programmes on an individual level (98). Educational interventions to increase the awareness of and knowledge about preventing falls in older people has the potential to be cost-effective, but the evidence to support this is lacking. In order to increase the fall risk awareness in public on all levels, there is need to first identify how and why fall risk awareness emerges in older people in the first place, what older community-dwelling people already do in their everyday life to prevent falls, and if there are factors that may enhance fall risk awareness in older women and men.

Evidence-based exercise interventions

A diversity of falls prevention interventions have been developed targeting different aspects of fall risk. *Single interventions* such as exercise, home modifications, vitamin D supplementation, or treatment of vision impairments; *multifactorial interventions* (defined as two or more individually tailored interventions provided following a risk assessment); and *multiple components interventions* (defined as a fixed combination of two or more interventions), have been developed (99, 100). Furthermore, different settings have been addressed: residential care facilities, people presenting to the ED with a fall, hospital settings, and people who are being discharged home from hospital; as well as different populations, e.g. post-stroke, Parkinson's disease, or individuals with fear of falling. Considering the complexity and heterogeneity with falls, it is likely that no single approach to prevention will adequately address the problem of falls and fall-related injury in all older people (59, 101).

Exercise programmes have been the most thoroughly investigated single interventions. Among the major modifiable risk factors for falls, leg weakness, gait changes, and imbalance have been identified as the most significant (76). There is now convincing evidence that specific exercises with balance and strength components may prevent falls in community-dwelling older people in a group or home-based setting (102-104). The minimum dose of exercise to effectively reduce the risk and rate of falls has been estimated to be two hours a week on a regular basis, and contain moderate or high challenge to balance (103). Exercise has also been found to be an important component for treatment of bone health, and as prevention of fractures in later life (105, 106), and reducing fear of falling (107).

Despite these promising results, fall prevention exercise programmes have been shown to be difficult to implement (108-110). It has been estimated that 7 in 10 older people are likely to accept an invitation to participate in falls prevention exercise programmes, but the adherence in the long run is usually low (111-114). Because the effects from strength and balance exercises are only effective as long as the exercises are performed (104), it is vital to understand the motivating factors that influence older people's uptake and the adherence in the long run. Some important barriers and facilitators have been identified to influence uptake and adherence in fall prevention exercise programmes: barriers include denial and underestimation of the fall risk, poor self-efficacy, no previous history of exercise, and fear of falling; facilitators include social support, higher education, perception of the programme as relevant, and involvement in decision-making (98).

It has been recommended to ensure that the planned interventions are designed to meet the needs, preferences and capabilities of the individual (115), but it still remains to be explored what specific exercise properties older people do prefer, in order to optimize the conditions and attraction for older people to adhere. Evidence suggests that it is indeed possible to change behaviours, but the change generally requires comprehensive approaches at different levels (116). Awareness of the individual factors affecting exercise behaviour is essential for all health care personnel who meet older people in order to promote change in patterns of physical activity. Motivation has been identified as one of the most important and consistent predictors of exercise (117). There are indications that the motives to exercise differ in women and men in general: women are more concerned about their appearance, and men are motivated by challenges and competition (118). If this is true in older women and older men has not yet been well explored. Furthermore, it has been shown that studies investigating preferences for falls prevention and interventions are often female gender biased (96). Gender bias refers to how the pre-understanding of what is masculine and feminine, or of how women's and men's physical abilities may affect the planning, execution and implementation of physical activity advice and interventions. It may include both overlooking important differences, and exaggerating minor, less important, differences (6). Therefore, identifying preferred exercise properties and motivational factors for taking part in exercise programmes in the context of falls prevention should be explored from a gender perspective where both women and men are included.

Smart technology for fall risk prediction and falls prevention

The field of gerontechnology is developing rapidly with recent technological advances, adding promising solutions to assist in identifying individuals at risk of falling, for example by sensor-based wearable technology for a more

continuous monitoring (119-122), and for preventing falls by internet-based and virtual reality exercise interventions (120, 123, 124). The benefits from using technology include the potential to reach many people at a relatively low cost (123). There is however also reason to be critical because of the sometimes poor quality of the technological resources available. For example, a recent review found that the quality of websites offering falls prevention advice to older citizens across Europe varied greatly (125). One reason may be that older citizens are rarely involved as end-users in the development process, another may be that knowledge about falls and falls prevention is lacking in those who provide these websites.

Theoretical framework

This theoretical framework describes the starting point of the thesis when studying the material and searching for patterns within the data. Central to the thesis are risk and protective factors for falls. When managing fall-related issues in older people such as acute injuries or a FoF, the body should be understood not only as a biomechanical system with anatomical, physiological and pathological aspects, but as a complex system of social, political, cultural, economic, geographical, and psychological dimensions of health and illness in order to take a holistic view. This view, conceptualized as an embodied view (126), may help physiotherapists in planning for tailored interventions to people's individual circumstances, preferences, and realities. In an attempt to understand and explain the complexity of fall-related issues, several theoretical models and concepts within the scientific fields of behaviour psychology, motor control and gender science have been used, all of which may be described within the umbrella concept *dynamic systems theory*.

Dynamic systems theory

A systems approach in relation to the body and the nervous system was already suggested in the 60s by Nicolai Bernstein (127). However, the dynamic systems theory (DST) is a new and influential theory to the study of development (128), developed in the 20th century by Ester Thelen. This theory has the potential to guide physiotherapists in understanding how movement patterns emerge, how motor skills develop, how motivation works, and the impact of the environment and the task that is being performed on the movement patterns (Figure 2).

A dynamic system is seen as multiple interacting components such as muscles, sensory function, cognitive function, etc (129). All components (sub-systems) within a person are seen as continually linked and mutually interactive in the individual, and between the individual and the environment, in relation to the task that is being performed. The theory also proposes that no sub-system is more important in this process than others (128,

130). DST leads us towards an acknowledgement of situational and contextual factors that contribute to the emergence of behaviours in the moment, and towards a more complex view of seemingly simple phenomena (129, 130). One important characteristic of a dynamic system is that it is capable of self-organization. Self-organization refers to the formation of new patterns, not through the outside imposition of a controlling element, but as a result of internal cooperation in response to changing external conditions. This means that a new synchorized movement pattern may emerge spontaneously due to an interaction among sub-systems (130).

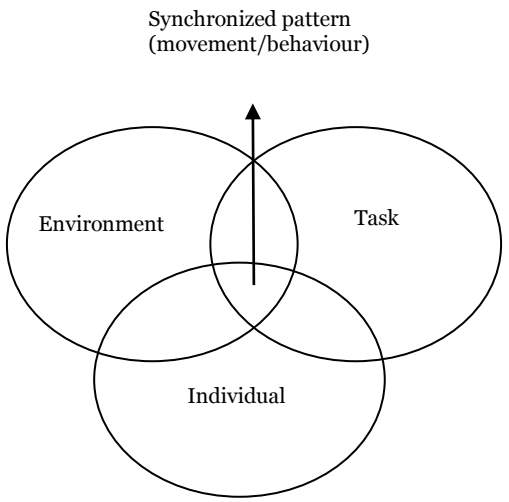

Figure 2. A diagram showing the interrelationships of individual, task and environment. Inspired by: Shumway-Cook & Woollacott. Motor control: translating research into clinical action, fourth edition, Baltimore: Lippincott Williams & Wilkins; 2012

The DST was initially presented as a theory of motor development in infants, for example the development of movement patterns such as kicking, stepping and reaching, but is now gaining increasing ground in many related areas. This approach does not only explain the development of new motor learning, but also how the loss of muscle and bone strength and acuity of the senses with ageing may result in change of movement patterns, and injuries to the neuromusculoskeletal systems due to, for example, fall events may produce changes in the way an individual moves, and the way that everyday tasks are performed (129). With this in mind, a DST can be used to the management of falls prevention in older people. The basic ideas of the DST can be used as an umbrella concept for the following perspectives: postural control, the model of ICF, gender perspective, and self-determination theory of motivation.

Postural control

Postural control is the very foundation of our ability to move independently and safely. The postural control system regulates the body's position in space for the purpose of orientation and balance. It is based on the central integration of vestibular, visual, proprioceptive, and tactile information and on an internal representation of the body's orientation in space. The internal model of the body's position is continuously updated on the basis of this multisensory feedback. This internal representation is used to forward motor commands controlling the body's position in space that take into account the environmental conditions. Postural control thus requires a complex interaction of musculoskeletal and neural systems in relation to the task being performed and the environment the task is being performed in (2).

Using a dynamic systems approach may assist in discerning the complexity of the system that influences postural control, and to identify more specifically where in the system any difficulties may lie. A fall usually occurs when the external demands exceeds a person's internal abilities to maintain stability (131). In a challenging situation where the task is too demanding, the environment is to difficult to manage, or the individual's postural control is not responding well, the consequence is either a fall, or that one of the components is adapted: a less demanding task is chosen, an assistive device is used to increase the stability, or the individual avoids the activity altogether. Either of these adaptations will help synchronizing the system.

The model of ICF

The International Classification of Functioning, Disability and Health, ICF, is a model to classify health and disability from body, individual, and societal perspectives (Figure 3). The model may be combined with the dynamic systems theory in order to improve the understanding of relationships between levels (129). The overall aim of the ICF classification is to provide a unified and standardised language and framework for the description and definition of components of health, health-related states and well-being (4). The ICF can be applied on several levels: individual, institutional, as well as social level. The ICF contains two parts, each with two components: Part 1, *Functioning and Disability* contains, a) Body Functions and Structures (physiological and psychological function of the body systems and their anatomical parts) and b) Activities (execution of tasks or actions by individuals) and Participation (tasks in life situations). Part 2, *Contextual factors* contains, c) Environmental Factors (physical and organizational context and setting) and d) Personal Factors (personal features impacting the individual's performance) (4). All the components of the ICF interact, which means that an individual's functioning in a specific domain is an interaction or complex rela-

tionship between the health condition and contextual factors: if something changes within one component, the other components will also be affected.

The model of ICF can be used within the dynamic systems theory as support for categorizing and structuring the characteristics of an individual and the context he or she lives in (132).

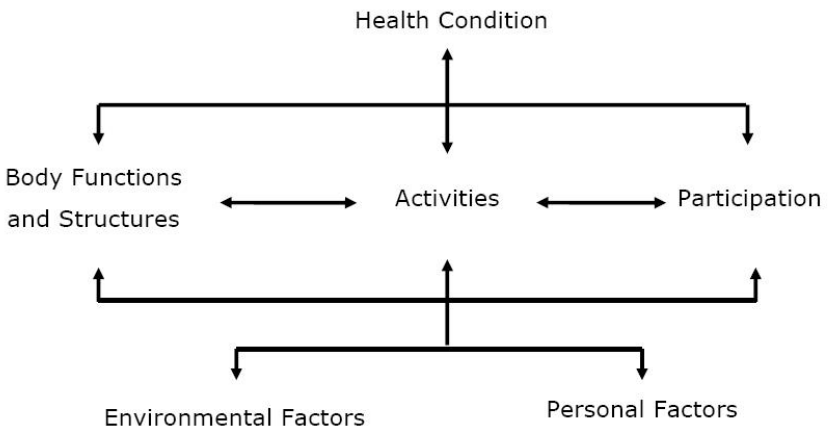

Figure 3. International Classification of Functioning, Disability and Health (ICF) model. Taken from: World Health Organization (WHO) (2001). International Classification of Functioning, Disability and Health. Geneva, Switzerland: WHO.

Gender perspective

A gender perspective can be seen as a 'lens' through which to consider the appropriateness of various policy options and how they will affect the well-being of both women and men (133). Gender can be used as an analytical tool for analyses of social factors creating and determining health (134). In general, the concept gender is used in health research as the binary categories male and female, i.e., the sex, but researchers often fail to discuss the social and cultural aspects of men's and women's lives, such as education, social policy, and gender norms (134-136). Gender is included within the contextual factor *Personal Factors* in the model of ICF as one of many important aspects of health. However, the model fails to define the meaning of the concept with the explanation that the meaning of gender, as well as other factors within *Personal Factors* (ethnicity, age, other health conditions, fitness, lifestyle, habits, coping styles, social background, etc.) strongly varies with social and cultural contexts (4).

In this thesis the understanding of gender derives from a social constructionist perspective, where gender is seen as socially constructed patterns that are shaped and reshaped on individual, as well as societal levels, dependent on time and context (137). The shaping of ourselves as a man or a woman in relation to others and the environment is referred to as "doing gender" (138). The social and cultural aspects are important because many social factors influence apparent gender differences. For example, in most European countries older women are poorer than older men, on average. This means a greater likelyhood of having fewer resources, less control over their lives, and being economically, socially, and materially disadvantaged compared to men (139). In addition, older women often outlive their husbands, and therefore live alone. The potential consequences are that women have less resources for important health care, medication, and leisure activities than older men. Furthermore, gender is seen as dynamic and relational, in that various forms of the gender-related concepts of "masculinities" and "femininities" coexist (140). These masculinities and femininities are patterns and practices that may be different from each other or share similarities, among them as well as between them, always including the physical body. A gender relational approach also highlights the impact of age, i.e., younger vs. older (141).

A growing body of research suggests that biological and social models cannot alone provide a complete framework for analyzing causes of gender differences in health, because the social and the biological factors are entangled and inseparable, and should thus be seen as co-creating factors (134, 136). This can for example be done by using a dynamic systems approach to gender, including a discussion about the influence of cells, hormones, as well as social and cultural aspects, combined with the tasks that are being performed, e.g. type of work or physical activity (142). Adding a gender approach into health care research has the potential to increase the awareness, and broaden the understanding, of how gendered patterns in society influence our own behaviours towards patients and clients, and how to avoid gender bias (133).

Self-determination theory

Motivation has been recognized as an important factor in behaviour change (143). Psychological strategies to change physical activity behaviour has been identified as one of the main issues that concerns physiotherapists in order to improve adherence. The roles of physiotherapists as promoters and preventers puts them in an ideal position to influence exercise behaviours in all clinical settings. The usage of motivational theories can help improving adherence to exercise, have a positive effect on long-term exercise behaviour, improve self-efficacy and reduce levels of activity limitation (144).

The self-determination theory (SDT) has gained increasing popularity for its relevance in understanding behavioural patterns in the physical activity

domain. SDT is a theory that rests on the principle that individuals have innate tendencies to develop their sense of self through proactive and engaged behavioural functioning (145). Self-determination is defined as the act of making up one's mind about what to think or do, without outside influence. According to Ryan and Deci (2000) the SDT is a concept of autonomous self regulation comprising both intrinsic and well-internalized extrinsic motivation (145, 146). SDT is focused on the process by which a person initiates a new, health-related behaviour and maintains it over time. According to this theory intrinsic motivation is prevalent only under certain conditions and in particular circumstances. SDT focuses on the environmental and social supports that when present facilitate and enhance intrinsic motivation. The theory also suggests that motivation depends, in part, on social and contextual factors which can facilitate or undermine intrinsic motivation (146).

The SDT was used in this thesis because it offers an explanation to, and provides strategies for, influencing both uptake and adherence in the long run. In addition, integrating the SDT with the model of ICF has the potential to provide a more holistic understanding of how other possible relevant determinants in other domains might still provide a barrier that prevents behavioural change.

Rationale for this thesis

Fall events and their consequences have large impacts on the individual and on society. Due to the impact of the consequences it is of great importance to identify older people at risk of falling as early as possible. There is today a broad consensus that a history of falls is an important risk factor for future falls in community-dwelling people (63). It has however been less well explored if one non-injurious fall, recurrent non-injurious falls, or if one injurious fall increases the risk of experiencing injurious falls in long-term in community-dwelling people.

A fear of falling (FoF) is common in older community-dwelling people, even without previous falls. It has been suggested that there is an association between FoF and experiencing recurrent falls. FoF has been reported to be more common in older women than in older men. Little is understood about why women tend to report FoF more often than men. In order to bring the understanding of FoF, future falls, and the apparent gender differences further there is need to explore these interrelationships between gender, FoF and recurrent falls, and to explore FoF from a gender perspective.

Following the call from WHO there is need to increase fall risk awareness on different levels. In order to identify which channels may be effective ways to increase fall risk awareness on individual, group and societal level, there is

need to identify how fall risk awareness emerges in older community-dwelling people, what actions may be taken to prevent falls, and if there are certain feelings involved in relation to fall risk awareness. To bring the understanding even further, a gender perspective is warranted for in order to identify any gendered patterns in experiences and actions taken.

Evidence-based exercise programmes containing strength and balance exercises are effective in reducing rate of falls and the risk of falling in older community-dwelling people, but the uptake and adherence is poor. There is need to identify what attracts older people to attend to exercise programmes in the context of falls prevention, in order to improve the conditions for older people to attend to exercise programmes. There is also need to explore if women and men are attracted by different or similar exercise properties.

Aims of the thesis

One aim was to gain a deeper understanding of falls regarding the risk factors previous falls, fear of falling, and gender. Another aim was to explore safety strategies in older community-dwelling women and men in terms of fall risk awareness and actions taken to protect from falls, as well as to identify preferred exercise characteristics in the context of falls prevention. A gender perspective was used throughout the thesis.

Specific aims

- To determine if a history of: i) one single non-injurious fall, ii) at least two non-injurious falls, or ii) one injurious fall within the previous 12 months leads to an increased risk of sustaining injurious falls in long-term in older women and men over 75 years (paper I).
- To assess the interrelationship between a fear of falling, gender, and recurrent falls within a period of 12 months, and to evaluate the usefulness of the ICF as the model when performing a factor analysis with commonly used measurements for older people at risk of falling (paper II).
- To assess the associations between self-reported fear of falling and the different components of the ICF among women and men respectively, and to relate the findings to a gender relational approach (paper II).
- To explore and analyse older women's and men's views, experiences, and feelings in relation to fall risks in everyday life; their own experiences from safety precautions for preventing falls; and how fall risk awareness emerges in everyday life. Furthermore, to identify possible gendered patterns in fall risk awareness, and in the choices of precautionary actions (paper III).
- To explore the preferences of community-dwelling older women and men regarding exercises in the context of preventing falls. Furthermore, to explore if women and men share similarities regarding the preferences for exercise properties, or if women and men have different preferences (paper IV).

Methods

This part of the thesis will provide a detailed account of the research methods employed. An overview of the four studies included is presented in Table 2.

Table 2. An overview of the four studies of this thesis

Aim of study I-IV	Source of data	Design	Participants	Methods of analyses
To investigate if 1 non-injurious fall; ≥2 non-injurious falls; or ≥1 injurious fall increases the risk for future injurious falls leading to a visit at the ED.	Baseline assessments, prospective 1-year follow-up on falls, and long-term (about 5 years) follow-up on injurious falls from Injury database	Prospective longitudinal study design	Community-dwelling people (*n*=230): 75-93 years old, 72% women, MMSE scores ≥ 24 p	Andersen-Gill method of Cox regression for multiple events
To compare women and men regarding fear of falling and future falls in relation to the ICF. Results are interpreted with a gender relational approach.	Baseline assessments and 1 year prospective follow-up on falls	Cross-sectional and longitudinal study design	Same participants as described above	Log-linear regression, Confirmatory factor analysis, Structural equation modelling
To explore older women's and men's understanding of fall risk and their experiences with safety precautions taken to prevent falls.	8 multistage focus group sessions (4 within the same group) between October 2012 and January 2013	Qualitative design	Community-dwelling people (*n*=18): 70-80 years old, 56% women	Qualitative content analysis
To explore the preferences of community-dwelling older women and men regarding exercise properties in the context of preventing falls.	12 focus group sessions (6 within the same group) between October 2012 and March 2013	Qualitative design	Same participants as described above	Qualitative content analysis

The thesis is based on data from two separate, well-defined populations. All participants that took part in the studies of this thesis were at the time of data collection living in ordinary housing in the city of Umeå. Two quantitative studies focused on specific fall risk factors, and two qualitative studies focused on fall risk awareness and safety strategies, and on exercise preferences in the context of falls prevention.

Procedures in studies on fall risk factors

In this section the procedure with recruitment and baseline characteristics of the participants will be described, as well as data collection, and statistical methods, and withdrawals (Figure 4).

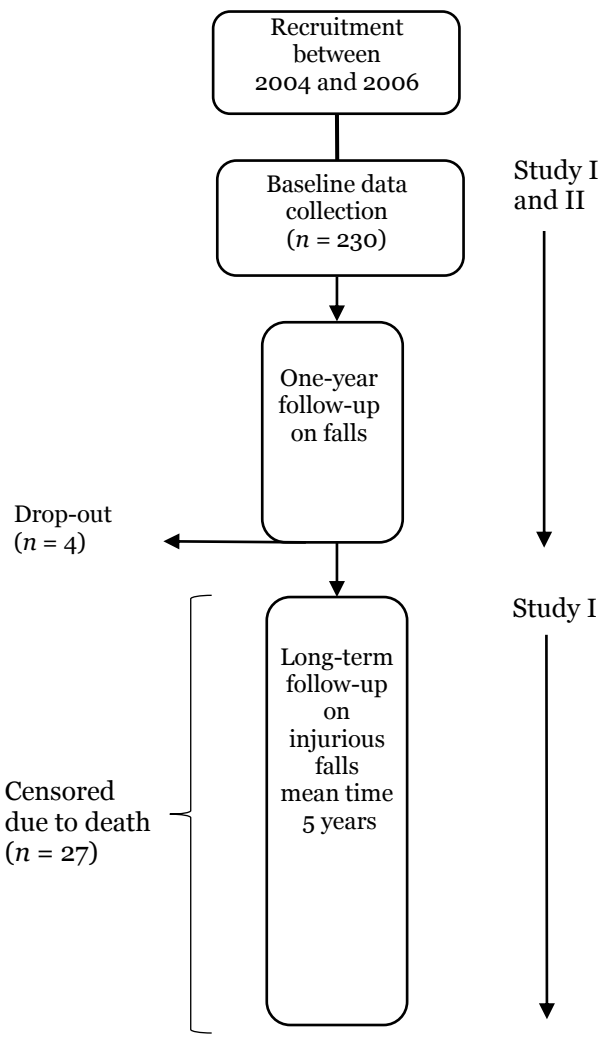

Figure 4. Flowchart of participants in study I and II

Settings and participants

The participants in study I and II were recruited between 2004 and 2006, prior to this thesis, as a sample of convenience through advertisements in the local press, senior citizen organizations, and primary care clinics. The inclusion criteria were: ≥ 75 years of age, able to walk without walking device for at least 10 meters and cognitive function corresponding to scores of 24 or more in the Mini Mental State Examination (MMSE). In total, 230 participants between 75 and 93 years of age, 166 women and 64 men, were recruited. The mean age was 79.5 (± 3.7) years and the mean MMSE score was 27.7 (± 1.8). Extensive baseline data were collected, as well as self-reported questionnaires and performance-based tests including gait function, Short Physical Performance Battery (SPPB), and assessments of sensory function, e.g. vision and proprioception in lower limbs. The participants were also asked if they were afraid of falling by using a single item question with a three-category response scale of *rarely/never*, *sometimes*, or *often/always*. Similar single item questions have been reported to correlate well with validated scales including the Falls Efficacy Scale (r = 0.43) and the Survey of Activities and Fear of Falling in the Elderly scale (r = -0.59) (90). In addition, the participants were offered a bone mass density assessment by dual-energy X-ray absorptiometry (DXA). Baseline assessments were conducted in a standardised manner at the Clinical Research Centre at the University Hospital of Umeå. All assessments and questionnaires are described in detail elsewhere (147).

Background information on the participants is shown in Table 3. In short, the great majority were women (72%); 110 women (66%) and 13 men (20%) lived alone; 96 (42%) had experienced at least one fall the previous year; and 35% – significantly more women – used a walking device outdoors. In general, men rated their general health as significantly poorer than did women.

Data collections

One-year follow-up on self-reported falls

After completing the baseline assessments, the participants were followed for one year regarding fall events with monthly fall calendars. This data collection was completed in 2006. The participants were instructed to fill in a fall calendar each day to state whether they had fallen or not. The calendars were returned in a pre-paid envelope to the research team at the end of each month. In case of an actual event, the participants were telephone interviewed with a standardised question form regarding the conditions of, and any consequences from, the fall(s). If the calendar was not returned as agreed, the participants were reminded by a telephone call. The incidence rate of falls was presented as number of falls/100 person-years.

Table 3. Baseline characteristics and performance-based tests

Variable	Total (*n* = 230)	Women (*n* = 166)	Men (*n* = 64)	*p-value**
Age (years), mean (SD)	79.5 (3.7)	79.6 (3.6)	79.3 (4.0)	0.559
Living alone, n (%)	123 (54)	110 (66)	13 (20)	< 0.001
History of falls, 12 months, n (%)	96 (42)	87 (52)	39 (61)	0.244
History of fractures previous 5 years, n (%)	95 (41)	85 (51)	10 (16)	< 0.001
Activities-specific Balance Confidence scale 0-100%, mean (SD)	75 (19)	73 (19)	82 (18)	< 0.001
Geriatric Depression Scale 15 items, 0-15 points, mean (SD)	1.7 (2.0)	2.0 (2.1)	1.0 (1.5)	0.061
Uses walking device, n (%)	81 (35)	67 (40)	14 (22)	0.009
Uses ≥ 1 prescription drug[a], n (%)	105 (46)	86 (52)	19 (30)	0.003
Osteoporosis or osteopenia, n (%)	164 (71)	126 (82)	38 (61)	0.001
Impaired visual acuity, n (%)	18 (8)	14 (9)	4 (6)	0.565
Dizziness, n (%)	38 (17)	30 (18)	8 (13)	0.308
Timed Up-and-Go (sec), mean (SD)	10.4 (2.8)	10.5 (2.9)	10.1 (2.4)	0.354
Survey of Activities and Fear of Falling in the Elderly, 17-51 points, mean (SD)	22 (4.8)	23 (4.9)	21 (4.3)	0.003
Five-times Sit-to-Stand (sec), mean (SD)	11.7 (3.7)	11.9 (4.0)	11.1 (2.8)	0.190
Preferred gait speed (m/s) over a distance of 6.1 m, mean (SD)	1.0 (0.2)	1.0 (0.2)	1.1 (0.2)	0.028
Self-rated health[b], 1-5 points, mean (SD)	2.9 (0.8)	3.0 (0.8)	2.6 (0.7)	0.004

SD=standard deviation; *p-value calculated with students *t*-test for mean values, and with Chi-square tests for proportions

[a] calcium preparations, potassium saving diuretics, oxicams, anilides, benzodiazepine derivatives (anxiolytics or hypnotics)

[b] 1=very poor, 2=poor, 3=fair, 4=good, 5=very good

Long-term follow-up on registered injurious falls

In order to determine if a history of a single non-injurious fall, two or more non-injurious falls, or one injurious fall during the initial one-year follow-up on falls would show an increased risk of sustaining injurious falls in the long run, data from the one-year follow-up was linked to the University Hospital of Umeå's on-going injury registration – the Umeå Injury Database (IDB). The personal identity numbers of the 230 participants were matched with data from the database as well as with the death certificate registry from the Swedish Tax Agency, from the inclusion date until the 31st December 2010. The IDB includes a data set of injuries due to accidents and trauma from the well-defined geographic area of Umeå. In case of an accident causing a visit to the ED, the patient or an accompanying person filled out a questionnaire with details surrounding the accident, including data on injury mechanism, activity performed at the time of injury and injury type. Up to three injury types were documented (94). For this study, only accidents caused by falls were included, excluding e.g. traffic related accidents. Death occurring more

than three months after the injury event was not considered to be caused by the fall itself. Causes of death were not investigated.

Withdrawals

There were four drop-outs during the one-year follow-up on falls: one died and three were unable to pursue the full follow-up due to medical reasons. These individuals were nevertheless included and categorized according to their falls as long as they were part of the study. During the long-term follow-up 27 individuals (11%) died: 12 men (19% of all men), and 15 women (9% of all women) (Figure 4).

Statistical analysis (study I)

Based on the status on fall events during the one-year follow-up on falls, the participants were categorized as: i) those with no falls, ii) those who had experienced one fall only without serious injury, iii) those who had experienced recurrent falls without serious injuries, and iv) those who had experienced at least one fall with serious injury. The time to any injury event was analysed using a Cox proportional hazards model, employing the Andersen-Gill extension allowing for multiple events per subject (148). The category with no falls was chosen as reference group, no other reference groups were tested. The total observation time to the registered injury events was calculated as the time from the inclusion in the long-term follow-up until censoring or any event. An event was defined as a fall requiring a visit at the ED. Participants were censored on date of death or at end of study (31st December 2010).

The inclusion date in the long-term follow up differed between groups. An overview of possible scenarios is shown in Figure 5. The reasons for choosing different starting points were twofold. First, it mirrors a clinical situation. Second, this approach allowed us to use valuable data collected on all injurious falls, also those that occurred within the one-year follow-up. Potential confounders were included as covariates in the model: age, sex, SPPB score, and use of potential risk medications at baseline. The confounding factors were chosen because the factors covary with the dependent variable in that the factors may cause the injurious falls. The assumption of proportional hazards was tested for each covariate using Schoenfeld residuals (149). No variable violated the proportional hazards assumption. The level of significance was set at $p < 0.05$. P-values were calculated with the students *t-test* for mean values, and the Chi-square test for proportions, performed in the Statistical Package for the Social Sciences, version 18.0 and 19.0 (SPSS Inc., Chicago, IL, USA). The Andersen-Gill extension for multiple events analysis was performed in Stata (version 12, StataCorp, College Station, TX, USA).

A sensitivity analysis was conducted using the same statistical method (Andersen-Gill extended Cox regression) in order to assess the robustness of the findings (150). In the sensitivity analysis all individuals were included at the end of the one-year follow-up instead of different starting points.

Statistical analysis (study II)

In order to investigate relationships between fear of falling, gender and falls; and relationships between fear of falling and the components of the ICF, the statistical analyses were performed in three steps.

First, a log-linear analysis of associations was performed to search for associations between gender, fear of falling at baseline, and falls the forthcoming year, using three dichotomized variables: 1) the sex (women or men); 2) fear of falling (yes or no); and 3) falls during the follow-up year (falls or no falls). Falls was defined as having experienced at least two falls during the follow-up year. One fall only was grouped with no falls, hence zero and one fall was compared to recurrent (at least two) falls. The decision to use recurrent falls as definition was based on the assumption that one fall might occur by chance alone. Fear of falling was dichotomized based on the answers to the question 'Are you afraid of falling': 'yes' was based on *sometimes* and *often/always*; and 'no' on *rarely/never*.

Second, a confirmatory factor analysis (CFA) (151) was performed in order to investigate if the model of ICF was appropriate to use (i.e. model fit) in the further analysis by confirming the factor structure of the model in relating the observed measures (hereafter labelled indicators) to each of the components of the ICF (hereafter labelled factors). The ICF describes disability as an umbrella term for problems at any level of the body, including participation, activity and body functions/structures. It also takes account of environmental and personal factors surrounding a person (152, 153). For these reasons it was decided that the ICF is an appropriate model to be used for the classification of fall risk factors and measurements used. A selection of 44 variables from the previously collected data from 2004-2006 were included as indicators (Table 4). All variables were related to fall risk and each variable was classified into the different components of the ICF. For example, the variable 'gait speed' was classified as walking within the components 'Activity and Participation'. The measurement Activities-specific Balance Confidence (ABC) scale (154) was classified within the component 'Personal Factors' because of the focus on self-confidence while performing different activities (Table 4).

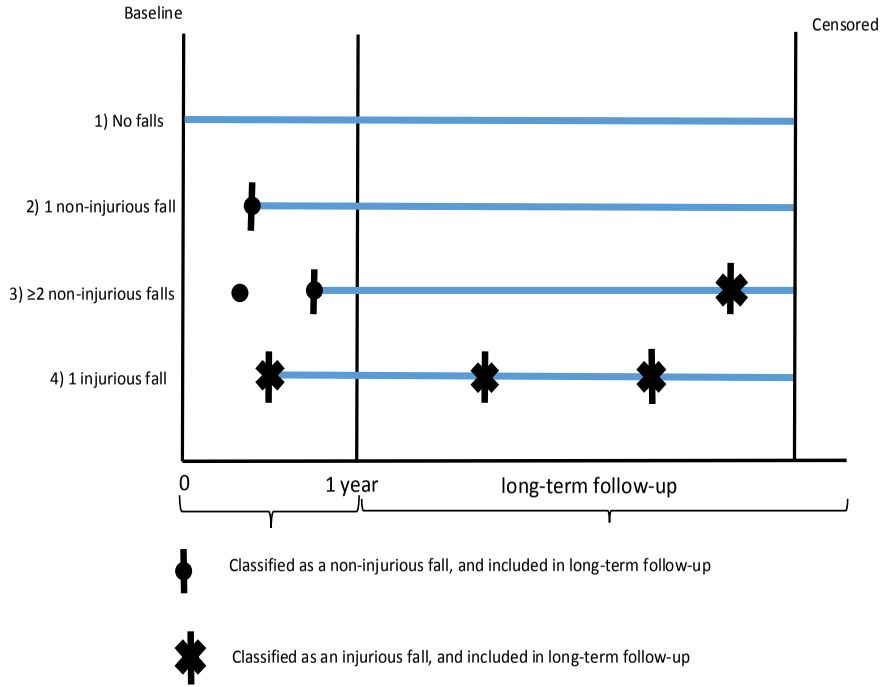

Figure 5. Starting date for the long-term follow-up on injurious falls depending on falls during the baseline year: category 1 were included on the day they were included in the initial study; category 2 were included on the day they had their single non-injurious fall; category 3 were included on the day they had their second non-injurious fall, regard less of how many falls they had during the monitoring period; and category 4 were included on the day they had their first injurious fall.

A decision was made to merge the components Activity and Participation into one factor, because they are associated with each other. Some of the measurements used could be linked to both. This approach is supported by the WHO when categories seem to overlap (4). The classification process was performed in accordance with suggested linking rules (153, 155). There were no clear recommendations on how to classify the question about global self-rated health, i.e., in which component it best belongs, and therefore this variable was modelled as having a direct effect on fear of falling. Gender was used as grouping variable, therefore it was not placed in Personal Factors, which is usually done. Prior to the analyses, all variables were transformed so they all had the same direction, i.e., zero equaled 'lowest/worst', and maximum score of the variable was 'highest/best'. To evaluate the model fit with the CFA, goodness-of-fit was assessed with the ratio between chi-square and the degree of freedom, df (CMIN/df), and with the root mean squared error of approximation (RMSEA). RMSEA measures differences between a model and collected data. RMSEA ≤ 0.05 has been suggested to indicate a good fit to the data, ≤ 0.08 an acceptable fit, and ≥ 0.010 is recommended not to be accepted (156). An acceptable fit between the model and the sample data by CMIN/df ratios has been suggested to be in the range of 2 to 1, or 3 to 1 (157).

Third, after confirming that the model of ICF was eligible to use as the model, a structural equation modelling (SEM) was performed in order to provide estimates of the associations between the factors and the fear of falling with regression weights (positive or negative direction). This analysis was performed in SPSS including Analysis of Moment Structures (AMOS).

Fear of falling was in this analysis not dichotomized, but used as the original three-category response scale *rarely/never, sometimes,* and *often/always.*

Table 4. Description of the variables and measurements used in study I and II.

ICF	Variables	Standardized assessment or question; scale; further information	Studies	
			I	II
Personal factors	Age	Self-reported, confirmed by national register; interval scale	√	√
	Sex	Women/men; nominal scale	√	√
	Education level	Self-reported, three levels: ≤ 6 years, 7-9 years, ≥ 10 years; ordinal scale	-	√
	Experienced falls	Self-reported falls in the past 12 months; 0, 1 or ≥ 2 falls, ≥ 1 injurious fall; ordinal scale	√	√
	Experienced fractures	Self-reported fractures the past 5 years; 0, 1 or ≥ 2 fractures; ordinal scale	√	√
	Perceived confidence of one's balance	Activities-specific Balance Confidence (ABC) scale (0-100%) (152): ordinal scale; higher score indicates more balance confidence in 16 daily activities of greater or lesser challenge during position changes or walking.	-	√
	Habits concern. food	Mini Nutritional Assessment (0-30 points) (156); ordinal scale	-	√
	Emotional distress/ depressive symptoms	Geriatric Depression Scale 15 items (0-15 points) (157); ordinal scale	√	√
	Health conditions	Self-reported, related to fall risk: arthritis, stroke, Parkinson's disease, diabetes mellitus, lung disease, heart disease, cancer, hypertension, inflammatory bowel syndrome, thyroid disease, anemia, B-vitamin deficiency, kidney diseases, epilepsy, depression, eye diseases, osteoarthritis in knee or foot, normal pressure hydrocephalus, polyneuropathy, leg ulcer; interval scale	√	√
Environmental factors	Place to live	Self-reported: cottage/bungalow, apartment, or senior living/sheltered housing; ordinal scale	-	√
	Immediate family	Self-reported: living with another person(s) or living alone; ordinal scale	√	√
	Assistive technology	Self-reported: no device, use walking device indoors, or walking device outdoors only; ordinal scale	√	√
	Drugs (medication use)	Prescription drugs considered to be related to the risk of falling: calcium preparations, potassium sparing diuretics, oxicams, anilides, benzodiazepine derivatives, thiazides; interval scale	√	√
	Clothes	Habitual foot wear at home: shoes, slippers, bare feet, or socks; ordinal scale	-	√
	Attitude of others	Response to the questions: "Do you think somebody else is afraid that you might fall?"; no/I don't know/yes; ordinal scale	-	√

Table 4 continued

ICF	Variables	Standardized assessment or question; scale; further information	Studies I	Studies II
Body Function and Structure	Bones of hip and spine	Bone density: Dual-energy X-ray absorptiometry (65): normal bone density, osteopenia, osteoporosis; ordinal scale	-	√
	Gait pattern functions & Dividing attention	Dual-task cost in step-width, *counting backwards*, GAITRite system (158); a change in step-width of 3.6 mm or more predicts falls (159), ≤ 3.6 mm, or > 3.6 mm; ordinal scale	-	√
	Gait pattern functions & Dividing attention	Dual-task cost in step-width, *carrying an object*, GAITRite system (158); a change in step-width of 3.7 mm or less predicts falls (159), ≥ 3.7 mm, or < 3.7 mm; ordinal scale	-	√
	Attention and executive function	Trail Making Test B (160); time in seconds to perform the task; interval scale	-	√
	Attentional functions	Response to the questions: "Do you need to think about being careful when walking: ...indoors? ...outdoors in the summer when on even ground? ...on uneven ground? ...during the winter on snowy ground?" never/rarely, sometimes, or often/always; ordinal scale	-	√
	Memory functions	Mini Mental State Examination (161), 0-30 points, higher score indicates better cognitive function; ordinal scale	√	√
	Dizziness	For any reason and length, no or yes; ordinal scale	-	√
	Sensation of falling	Response to the questions: "Do you feel unsteady when walking indoors? ...outdoors?", never/rarely, sometimes, or often/always; ordinal scale	-	√
	Visual acuity function	Assessed (with glasses if necessary) from a distance of 3 meters using a letter chart as part of the Physiological Profile Assessment tests (162); excellent, good, fair, poor; ordinal scale	-	√
	Visual contrast sensitivity	Assessed by 15 circular 25-mm-diameter patches containing edges with reducing contrast, as part of the Physiological Profile Assessment tests (162); excellent, good, fair, poor; ordinal scale	-	√
	Auditory perception	Hearing subjectively: Self-reported perception of hearing ability; normal or impaired; ordinal scale	-	
	Hearing function	As perceived by trained assessor using normal speaking voice; normal or impaired; ordinal scale	-	√
	Touch function	Monofilament 5.07 touch test on sole of feet and lateral malleolus: normal or impaired; ordinal scale	-	√
	Proprioceptive function	Protractor placed between lower limbs, impaired if degrees differed between the positions of left and right big toes with eyes closed and feet up, mean of 5 trials: good <2 degrees; between 2-4 degrees; impaired >4 degrees ; ordinal scale	-	√
	Sensitivity to vibration	128 Hz tuning fork at lateral malleolus and tibia tuberosity: normal or impaired; ordinal scale	-	√
	Emotional functions	Single-item question: "Are you afraid of falling?", never/rarely, sometimes, often/always; ordinal scale	√	√

Table 4 continued

ICF	Variables	Standardized assessment or question; scale; further information	Studies I	Studies II
Activity and Participation	Self-care	Barthel Index (163) (0-20 points where higher score indicates better function); ordinal scale	√	√
	Changing body position, incl walking	Timed Up and Go (164), time in seconds to stand up, walk 3 meters, turn, walk back, and sit down; interval scale	-	√
	Activity avoidance	Survey of Activities and Fear of Falling in the Elderly (88) (17-51 points where higher score indicates greater avoidant behaviour); ordinal scale	-	√
	Maintaining upright position	Standing balance (165) (0-4 points); 0 = standing < 10 s with feet together; 1 = standing ≥ 10 s with feet together; 2 = standing in semi-tandem-position ≥ 10 s; 3 standing in tandem-position 3-9.99 s; 4 = standing in tandem-position ≥ 10 s; ordinal scale	-	√
	Changing basic body position	Five times sit-to-stand (166) time in seconds; interval scale	-	√
	Walking	Preferred gait speed 2.4 meters and 6.1 meters with the GAITRite system (158), time in seconds, interval scale	√	√
	Changing and maintaining body position	Short Physical Performance Battery (SPPB) (0-12 points); ordinal scale	√	-
	Non-definable general health	Response to the questions: "In general, would you say your health is excellent, very good, good, fair or poor?" (0-5 points); ordinal scale	-	√

Procedures in studies on fall risk awareness and exercise preferences

Study III and study IV are based on data from a participatory action research project with the aim to create an evidence-based falls prevention exercise application for smartphones and tablet devices (hereafter referred to as the App) with older people as co-creators. Participatory action research is particularly useful when exploring gendered patterns within certain communities, or when making inequalities visible when the aim is to change attitudes (158, 159). The cross-disciplinary research team consisted of researchers in physiotherapy, informatics, eHealth, and gender science, with experiences from both qualitative methodology and participatory research. All but one researcher involved had at least PhD credential, and all researchers were women. The project was conducted through a series of multistage focus groups (160). An inductive approach was used.

Settings and participants

For the purpose of creating the App, it was pre-determined to include individuals with diversified experiences regarding fall events, education level, marital status, previous occupation, exercising, walking devices, and the use of information and communication technology, including computers and mobile phones. The choice to purposively select individuals with a broad spectrum of experiences was also a way to increase the credibility of the study. A purposive sampling involves a deliberate selection of participants who share particular characteristics and have the potential to provide rich and relevant data pertinent to the research questions (161, 162).

The inclusion criteria were 70 years or older and living in the city of Umeå. In order to reflect the overall community-dwelling population it was determined that approximately 30% of the participants should have experienced at least one fall event within the previous 12 months. Recruitment took place in September and October 2012 in several senior citizen organizations in Umeå. Thirty-six individuals volunteered to participate. All who signed up to participate were contacted by telephone and interviewed by PP with an, in advance prepared, question guide regarding the previously described experiences. Furthermore, the habitual level of physical activity was assessed with the International Physical Activity Questionnaire, IPAQ (163). Following the instructions of IPAQ, the level of habitual physical activity was determined as low, moderate, or high based on how much time had been spent on the activity the previous week, and how strenuous it had been. Participatory action research requires active engagement (159), and therefore the participants were purposively selected not only based on their experiences, but also on their ability to express themselves.

Eighteen participants, 10 women and 8 men, were carefully selected based on the criteria to have a wide variety of experiences represented and invited to participate. The number of participants was determined because of the desire to include two full focus groups. Three individuals declined to participate because of other assignments on the first session, which was mandatory due to important information. One individual declined to participate because her best friend had not been chosen. Instead four other persons with similar experiences were invited and accepted to participate. Characteristics of the participants are presented in Table 5. In short, the mean age was 74.6 ± 3.5 years. All individuals were retired, most from white-collar employments, defined as office or professional workers whose jobs did generally not involve manual labor. Thirty per cent had experienced at least one fall during the last 12 months. The physical activity level was in general classified as moderate to high, with a few exceptions.

Data collections

Data were collected by means of multistage focus groups with a co-operative inquiry process to gain an extended unit of analysis (160). Prior to the first session, the 18 participants were divided into two focus groups of equal size with similar distribution regarding sex, experiences from falls, and level of physical activity according to the IPAQ. Paper III is based on data from session 1-4 (October 2012-January 2013), and paper IV on session 1-6 (October 2012-March 2013). All focus group sessions took place in a spacey common room at a community centre and lasted for 2.5 hours each including a short coffee break. The topics of fall risk awareness and of exercising permeated all sessions in different degrees. An overview of the contents of the sessions is shown in Table 6. The discussions were led by a moderator (one of the researchers, varying from time to time), but all researchers were active throughout the discussions. The discussions were guided by a question guide, but the participants also influenced the foci of discussions (160). In order to increase dependability, the same questions were used in both focus groups.

The multistage focus group methodology was chosen because it combines elements of group dynamics and a qualitative approach, and is seen as relevant and fruitful method within collaborative research designs (160). This methodology includes all the benefits from ordinary focus groups, i.e., a way to study experiences, attitudes, and views within a certain area, and to facilitate the participant's discussion and reflection, thus generating deeper insights, building on one another's responses. Participants can come with ideas or perspectives they might not have thought of in individual interviews (161, 164). The methodology of the multistage focus groups allowed for practice and reflections between the meetings. By meeting on several occasions

during a longer time period this method added new perspectives and enriched the data even more, which may elevate the participant's experiences to a higher level of abstraction (160). To enhance credibility a member check was performed on the fifth session in order to verify the findings about the safety precautions to avoid falls in everyday life. In order to detect any gendered patterns among the participants, one of the researchers observed to what extent the men and women took part in the discussions, and took notes about if women and men preferred to discuss certain issues.

Table 5. Characteristics of the 18 participants of study III and IV

Code	Age	Focus group	Partner or living alone	White/blue collar	Falls last 12 months Yes/No	Physical activity level based on IPAQ
W1	74	1	Partner	White	Yes	Moderate
W2	70	1	Partner	White	No	Moderate
W3	73	1	Partner	Blue	No	Moderate
W4	71	1	Partner	White	No	Moderate
W5	76	1	Living alone	Blue	No	Moderate
W6	75	2	Living alone	White	No	Moderate
W7	80	2	Living alone	Blue	Yes	Low
W8	74	2	Partner	White	No	Moderate
W9	71	2	Partner	White	Yes	High
W10	70	2	Partner	White	No	Low
M1	72	1	Partner	White	Yes	Low
M2	80	1	Living alone	White	No	Moderate
M3	78	1	Partner	White	Yes	High
M4	76	1	Partner	White	No	Moderate
M5	70	2	Partner	White	No	Moderate
M6	79	2	Partner	White	No	Moderate
M7	75	2	Partner	White	No	Low
M8	79	2	Partner	White	Yes	Moderate

Abbreviations: W=woman; M=man

Examples of white-collar worker (defined as office or professional workers whose jobs do generally not involve manual labor): office worker, police officer, nurse. Examples of blue-collar worker (defined as workers whose job requires manual labor): taxi driver, waitress.

The level of physical activity was determined as low, moderate, or high, based on how much time had been spent on the activity the previous week, and how strenuous it had been (163). Examples of activities performed: cycling, swimming, water aerobics, walks, table tennis, weight lifting

Table 6. Multistage focus group topic guide

Study	Session	Topic
III and IV	October, 2012	Presentation of the larger project, the researchers and participants. Information about the reasons for doing the research. Discussion about the personal meaning of 'joy of movement' and 'balance'.
III and IV	November, 2012	Creating a name for the project, and designing a logotype inspired by the photovoice technique. Discussion about falls and consequences and how to avoid them.
III and IV	December, 2012	Lecture on balance and testing different exercises. Discussion about how new technology may inspire to physical activity.
III and IV	January, 2013	Identifying altered strategies due to natural ageing process or to protect from falls in everyday life, and how this is perceived. Discussions in smaller groups as well as in joint focus groups.
IV	February, 2013	Identifying needs for the App. Discussions in smaller groups as well as in joint focus groups about motivation to exercise.
IV	March, 2013	Identifying how/where/when one likes to exercise by the use of personas technique. Discussion in smaller groups as well as in joint focus groups about exercise preferences.

To guide the co-operative inquiry, a Participatory and Appreciative Action and Reflection (PAAR) methodology was adopted (165). By using an inquiry and reflection approach based on appreciation, PAAR adds a positive resource of inspiration instead of focusing on problems. It is a matter of how to ask the questions. Building on what you want more of, and what you need, helps individuals to creative thoughts, and may open an imaginative mind, at its best (159). Because of the positive atmosphere, PAAR has the potential to encourage people to make their voices heard, and to encourage an exchange of knowledge (165) (Figure 6).

Figure 6. Participants discussing and exploring the contents of the exercise-based application for smartphones and tablet devices under progress.

To further inspire the conversations at the sessions, different actions were used, such as photovoice technique (166, 167) and personas technique (168). These techniques can be used within participatory action research to trigger new thoughts and ideas (159). For example, after the first session one of the groups were sent a disposable camera with the task to take photographs of what inspires them to move around in everyday life (both exercising and otherwise moving the body), and in which environments. The cameras were returned in a pre-paid envelope to the research team, and at the next session both groups were shown a selection of photographs in order to trigger the discussions. Open-ended and broad questions such as "What does this photograph make you think about?", or "What feelings does this photograph awake in you?" were asked. The photovoice technique has been proven useful when exploring risk perception in older people (169). In addition, data from the first sessions formed the basis for the construction of five fictional characters created to represent the different user types, i.e. personas. These personas were then presented to the participants, who rated how well the descriptions defined themselves and the way they preferred to exercise.

In order to explore the specific topic of fall risk awareness more in-depth and to detect possible gendered patterns (similarities or differences) in the discussions about fall risk awareness, and/or the choices of safety strategies

taken among the participants, the fourth session was organized differently: the participants were divided into six smaller groups with three participants in each group to ensure that everyone had their say. Two groups consisted of women only, two groups of men only, and two groups were gender mixed. This approach was chosen because the aim was to gain new knowledge about cultural and social processes, for example if the gendered patterns differed when among others of the same sex compared to gender mixed groups. Prior to the discussions the participants were given a discussion guide with the following questions: *What strategies, if any, have you changed in everyday life due to the ageing process or in order to avoid falling?*, *What brought on those changes?*, and *How did you experience doing those changes?* None of the researchers were present during the discussions in the smaller groups, but all discussions were digitally recorded. After 30 minutes of discussions in the smaller groups, the participants gathered for a joint discussion within the larger focus group.

All researchers took part in the discussions, but were careful not to take too much space. Not all researchers were present at all times. The two focus groups met about once a month. To change conditions for the groups, the time of day varied from one session to another. After each session, the research team gathered in order to discuss any gendered patterns in the focus group discussions, and to give feedback to each other as a reminder not to dominate the discussions. All discussions in study III and IV were transcribed verbatim prior to the analyses; 1-4 by PP, and 5-6 by a hired secretary.

Data analysis (study III and IV)

Each study was analysed as a separate unit of data using qualitative content analysis (170), a technique for analysis of texts grounded in empirical data with an explorative and descriptive character (171). This technique is appropriate for highlighting similarities as well as differences within a data material (170). One of the advantages with qualitative content analysis is that the analysis starts close to the text, looking at the manifest content of the text. Thereafter abstraction can be used, step by step, until the latent content or theme is reached (170). This approach may decrease the bias of the study, when the researcher is forced to stay close to the text instead of interpreting too much early in the analysis. Another advantage is that the analysis is systematically performed and results in a description of the meaning of qualitative material (172).

As a first step, all authors read all transcripts to obtain an understanding of the whole, focusing on the specific research questions. The transcripts were transferred into the software system OpenCode (173). In order to reduce the mass of text into manageable portions, the text was condensed into smaller meaning units and codes. The procedure with coding of the data was perfor-

med by two of the authors (PP and MS). An example of the coding process is shown in Table 7.

Table 7. Examples of meaning units, condensed meaning units and codes.

Meaning unit	Condensed meaning unit	Code
I never go out on long walks nowadays without the mobile phone, it's a security thing that I can call for help.	Never goes on long walks without the security of the mobile phone.	Feeling secure with assistive technology.
I inevitably come to think about those statues of Stalin and Lenin that were torn down in the 90s. The statues just stood there and fell over. That's how it feels when you fall, at least for me.	Thinks about statues that are torn down when reflecting on how it feels to fall.	Feeling rigid when falling.

The codes were then clustered based on similarity of the content and the relation to each other (171). The initial clusters were merged into sub-categories within one main category, and labelled with a title that provided an overall description of their content (171). To increase the credibility of the interpretations, the categories were cross-examined by all authors to ascertain that they were defined in such a way that they were internally as homogeneous as possible, and externally as heterogeneous as possible (170). To enhance the confirmability, the categories were presented at several seminars to senior researchers with experiences from qualitative research to further discuss specific formulations. The categories and sub-categories were discussed until consensus was reached among the researchers.

Ethical approvals

All participants gave their written consent to participate after being informed about the purpose, methods, procedures, potential benefits and potential harms. The participants were informed about the right to withdraw at any time and that participation was completely confidential. The Regional Ethical Review Board in Umeå approved all studies (study I Dnr 2011-191-31M; study II Dnr 04-071M; study III and IV Dnr 2012-170-31M).

Results

Participants who experienced an injurious fall during the follow-up year were at significant risk of experiencing new injurious falls in long-term compared to those with no falls. At baseline, women reported FoF more often than did men, but reporting FoF was not associated with recurrent falls the forthcoming year neither in women nor in men. Women did not experience recurrent falls more often than did men. The multistage focus groups revealed that fall risk awareness in everyday life develops from different reasons and is accompanied with diverse feelings. Both women and men were implicitly and explicitly aware of fall risks in everyday life, and took precautionary actions accordingly. There were greater variations among women and among men in how fall risk awareness emerged, and what precautionary actions were taken, than between women and men. At times, both women and men deliberately exposed themselves to risky situations. Several channels to increase fall risk awareness were identified. An increased awareness was for example achieved by the frequent discussions with their peers. The multistage focus groups also showed that the particapants had different preferences regarding exercise properties in the context of falls prevention. No clear gendered patterns were found, but instead a wide variety of preferences were identified among women as well as among men.

Impact of previous falls on future injurious falls (study I)

This section is initated with results from the one-year follow-up on self-reported falls, and thereafter the follow-up on injurious falls in long-term.

One-year follow-up on self-reported falls

The self-reported monthly fall calendars showed that between baseline and the following 12 months, 111 (48%) of the 230 participants fell at least once. Of those who fell, 54 (23%) experienced recurrent falls. One man and one woman experienced extreme amounts of falls (49 and 58 falls respecttively). In total there were 320 falls, corresponding to an incidence rate of 95 falls/100 person-years, whereof 93 (29%) falls resulted in injuries requiring medical care, but only few required hospital care. Seven (2%) falls resulted in fractures. There was no significant difference between the proportion of women who fell, or of men who fell: 77 (46%) women experienced falls compared to 34 (52%) men (p=0.481). This was also the case for women and men with recurrent falls: 35 (22%) women experienced recurrent falls, compared to 19 (30%) men (p=0.207).

Based on the one-year prospectively collected data on falls all participants (including drop-outs) were classified according to severity and frequency of the experienced falls: *no falls* (n=119; 52%); *a single non-injurious fall*

(*n*=51; 22%); *recurrent non-injurious falls* (*n*=51; 22%); or *one fall severe enough to cause a visit to the ED* (*n*=20; 9%). The two participants with multiple falls were classified as recurrent non-injurious falls.

Long-term follow-up on registered injurious falls

The total observation time of the long-term follow-up was 1159 person-years. This number corresponds to approximately 5 years per individual. Data from the IDB showed that during the long-term follow-up, 70 (30%) of the 230 participants had sustained fall-related injuries severe enough to be registered at the ED, corresponding to an incidence rate of approximately 8 injurious falls per 100 person-years. In total, 91 events were registered in the IDB from the index date to end of study. Fifteen (7%) of the participants suffered recurrent injurious events. In total, 129 injuries were registered in the IDB. There was no significant difference between the proportion of women's and men's total injuries (p=0.822), although women accounted for 7 hip fractures and 27 other fractures, while men accounted for no hip fractures and 5 other fractures. Other injuries registered were contusion/bruise, laceration, abrasion, luxation, strain/sprain, internal injury, and concussion, covering 82% of the fall-related injuries. Twenty-seven (11%) participants died during the long-term follow-up, but none within three months following an injurious fall.

The Anderson-Gill method of Cox regression for multiple events showed that those with at least one injurious fall during the one-year monitoring period had an almost threefold risk of sustaining new injurious falls within the next five years (HR 2.78; 95% CI, 1.40—5.50; *p*-value 0.003) compared to the reference group (no falls group). The other groups, i.e. single and recurrent non-injurious fall groups, showed no increased risk of sustaining future injurious falls compared to the reference group (HR 1.17; 95% CI, 0.69—1.98; *p*-value 0.55; and HR 1.51; 95% CI, 0.79—2.88; *p*-value 0.22 respectively). About one third (28%) of those who experienced no falls during the follow-up year experienced injurious events during the long-term follow-up.

The sensitivity analysis, based on the total one year follow-up time for all participants, confirmed data to remain robust in that results were similar to the primary analysis (Table 8 and Figure 7).

Table 8. Hazard ratio (HR) for injurious falls in long-term in four defined categories, based on the sensitivity analysis.

Fall category	Unadjusted HR (95% CI)	*p*-value	Adjusted* HR (95% CI)	*p*-value
No falls (*n*=119)	1 (reference)		1 (reference)	
One single fall without injury (*n*=51)	1.01 (0.59—1.73)	0.96	0.96 (0.57—1.62)	0.89
At least two non-injurious falls (*n*=40)	1.17 (0.63—2.16)	0.63	1.26 (0.65—2.44)	0.49
One injurious fall (*n*=20)	2.81 (1.42—5.56)	0.003	2.32 (1.15—4.68)	0.01

*Adjusted for age, sex, Short Physical Performance Battery score, potential risk medications

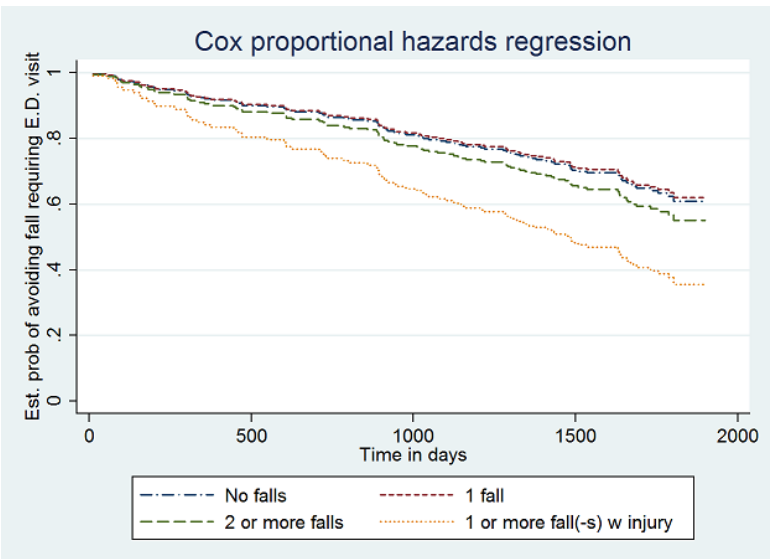

Figure 7. Estimated probability of avoiding injurious falls requiring a visit to the emergency department, based on the sensitivity analysis with the Andersen-Gill extended Cox regression.

Fear of falling, recurrent falls, and the ICF (study II)

Twenty-three per cent of the women answered *often/always* on the single item question 'Are you afraid of falling?', and 32% answered *sometimes*. When merging *often/always* and *sometimes* into 'yes', 55% responded posi-

tively on this question at baseline. The corresponding ratios for men were 11% answering *often/always* and 11% answering *sometimes*, making up for 22% when merged into 'yes'.

The general log-linear analysis of associations confirmed that there was a significant relationship between reporting FoF ('yes') at baseline and the sex (p<0.001). There was, however, no association between reported FoF at baseline and recurrent falls the forthcoming year (p=0.79). Thus reporting FoF at baseline did not lead to future recurrent falls either in women or in men. Furthermore, there was no association between the sex and recurrent falls the forthcoming year (p=0.32). To be noted, fall-related injuries were not the focus of this study.

Model fit of the ICF

Confirmatory factor analysis indicated that the model fit of the ICF components was acceptable (RMSEA=0.086; CMIN/df=2.7), except for the contextual factor *Environmental Factors*: there were no significant factor loadings to any of the indicators used. Thus the measurement model was established, and the final analysis was performed without the component *Environmental Factors*.

Fear of falling in relation to the ICF components

The regression weights between the factors (i.e. the components of ICF) and FoF are shown in Figure 7. The only factors that showed significant structural pathways (p<0.001) to the FoF were *Personal Factors* and *Activity/Participation* (marked with solid paths in the figure 8). There was also a significant difference between women and men regarding the regression weights for the factor *Personal Factors*: for women this weight was positive, and for men it was negative. The positive regression weight for women indicated that a higher score on this factor yielded less FoF. A higher score was achieved by, for example, longer education, better nutriation, and fewer depressive symptoms. In contrast, the negative regression weight for men indicated that a lower score on this factor yielded less FoF. A lower score was achieved by, for example, higher age, poorer nutrition, and more depressive symptoms.

For *Activity/Participation* the regression weights were positive for women and men both, meaning that higher scores (i.e. better performance) on the factor yielded less FoF in both sexes. A higher score was achieved by less activity avoidance, performing well on physical performance-based tests such as timed-up-and-go or gait speed, and a higher level of habitual physical activity.

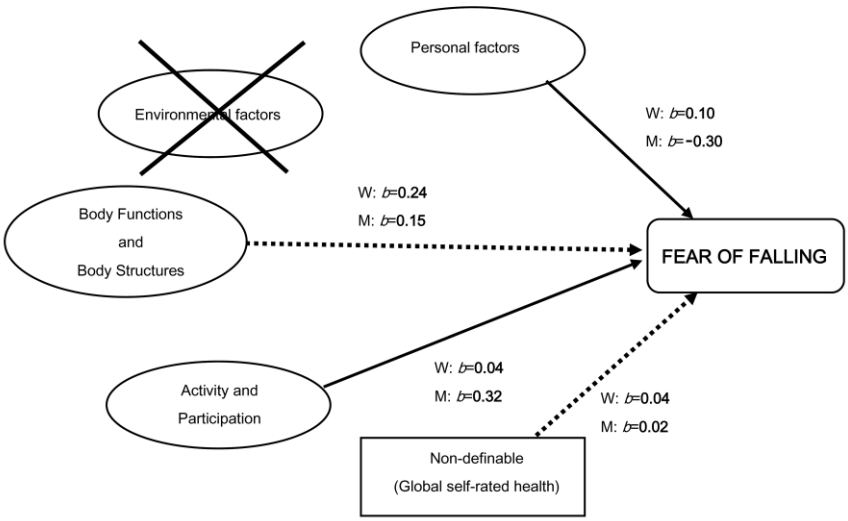

Figure 8. Structural equation model exploring the pathways of the ICF model to Fear of Falling. The factors are represented by the ellipses. Values adjacent to arrows are regression weights, labelled as *b*. M = men, W = women. Solid paths are statistically significant. No interrelationships between the factors were tested.

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Fall risk awareness and safety precautions (study III)

The older women's and men's experiences from fall risk awareness, and how they chose to protect themselves from falling, had several similarities and differences, and were both implicit and explicit. By discussing on several occasions within the focus groups an active reflection process was initiated, and memories were triggered. Three categories with several sub-categories emerged from their stories (Table 9). A comprehensive theme tied them together: *Safety precautions through fall risk awareness*.

Table 9. Main theme, three categories and their sub-categories

Theme	Categories	Sub-categories
SAFETY PRECAUTIONS THROUGH FALL RISK AWARENESS	Facing various feelings	Deliberately ignoring physical changes Feeling fear and insecurity Feeling limitations Pleased about changes
	Recognizing one's fall risk	Alarming experiences Public information Gradually growing insights Mutual experience sharing
	Taking precautions	Adapting movement strategies Adapting the environment Compensating with assistive technology Selecting activities

Facing various feelings

A growing awareness of fall risk was associated with diverse feelings. There were no clear gendered patterns. Some participants (both women and men) chose to ignore an apparent fall risk, mainly because of a desire to continue to feel young but also to challenge themselves. The participants disliked patronizing promptings about being more careful, and wanted to continue with old activities. One man said "*I hadn't been downhill skiing for about 30 years, but last year I bought some stuff and it was fun, you know! My son seemed to think it was fun, too – so far, anyway.*" (M1) He felt happy, proud and self-confident when being able to ski downhill again, and he deliberately overlooked the risks of falling in the hills. Some participants (both women and men) felt fear and insecurity, this fear had several dimensions: Not being able to care for an ill partner, not being able to get up from the floor in case of a fall, and a fear of getting hurt were some of the dimensions included. One woman was afraid of the inconvenience a fall would lead to: *"My life became very difficult after the fracture. I was alone at home with three dogs, my husband was away, and there I was with a broken arm, and supposed to take care of everything with a plaster cast on my arm. It was hard!"* (W9)

When the ageing body was perceived as stiff and painful, some participants felt limited. The participants described how their reaction time had become slower, as well as the ability to avert a fall: "*I inevitably come to think about*

those statues of Stalin and Lenin that they tore down in the 90s. The statues just stood there and fell over. That's how it feels when you fall, at least for me." (W1) In addition, the sudden realization that other people see you as an older person came as a shock: *"Maybe they see that I'm starting to stumble. It came as a shock, frankly. I thought of myself as healthy and fit."* (M5) Some participants were instead pleased with changes, they accepted that the body was ageing and felt wise and grateful about still being independent. One man says: *"You try to embrace the important things in life and try to make a habit out of it. For instance, by being more careful in certain situations."* (M3) This attitude among the participants was not expressed with mourn about loss of function. Furthermore, a gratitude towards the concern of others was also described, for example when a stepladder was given as a safety assistive device by a grown-up child. Women in general seemed to accept assistive devices more easily than men. Walking aids were difficult to accept for some participants, because they were seen as a threat to personal integrity. Others again were grateful, because the assistive device increased their possibilities to remain independent: *"I have accepted how to use the assistive device. It has all come back to me, that feeling 'I can manage myself!' I don't have to shout for the kids, 'Can you help me with this?'"* (M4)

Recognizing one's fall risks

How a fall risk awareness emerged differed among the participants and with the context. *Alarming experiences* reflected a sudden onset of awareness. This could for example be injurious falls including bicycle accidents, or a notice about an illness of importance, e.g. osteoporosis. These events initiated the process of thinking about hazards in a new way. One woman says: "*It took me two broken ribs to realize that, no – I can't continue like before. There is something I need to change.*" (W1) *Public information* described how fall risk awareness emerged through the media. If the participants perceived the information as relevant to themselves, a reflective process was initiated. One woman had experiences from adverse effects from sleeping pills and watched a program on television: "*I saw [doctor's name] on television. He said that X [a common sleeping pill] was the worst tablet old people could take because then they would fall and break their legs. And I was so upset about this, now I never take any sleeping pills. I'm retired – I can stay awake all night (laughs).*" (W1) A slowly emerging awareness was also described, often related to increasing sensory impairments, such as vision. The gradually emerging awareness was more common among the male participants: "*It sneaks up on you!*" (M3)

Mutual experience sharing described how new or deepened fall risk awareness was achieved by the frequent discussions within the focus groups. By exchanging experiences and knowledge with each other and the researchers,

the participants – as well as the researchers – started to reflect on how they acted in everyday life and how the environment around them influenced what they did. The participants stressed the importance of meeting with peers more often in society. They were given useful ideas from their peers, for example how to improve safety indoors as well as outdoors. The participants talked to friends and family about what they had learned, continuing the reflection process inbetween the meetings. One woman says to another woman: *"I think of you every time I get off a bus in the winter, that the soles of my shoes are warmer and I must be careful.'* (W8)

Taking precautions

A variety of precautions were taken to avoid falls in everyday life. There were large variations among the women as well as among the men. *Adapting movement strategies* described motor behaviours and alterations, e.g. taking smaller steps, fixing the gaze while balancing on one leg, or walking more slowly. Stiffer bodies and slower reactions lead to an increasing need of support. One man says: *"My knee is so stiff that I have to lie flat on my back to vacuum under the bed."* (M2) *Adapting the environment* included for example removing carpets, using safer footwear, using a night-light on, and changing the bath tub into a shower. Some participants had begun to use anti-slip shoe devices, especially the women. Some men agreed that mens' bicycles had become increasingly difficult to mount and dismount. Changing the bike into a woman's bike was suggested: "*The frame is tricky. You have to climb over it somehow".* (M8) *Compensating with assistive technology* described ways to prolong independence by using different safety equipment. Mobile phones were appreciated as assistive technologies. One woman says: "*I never go out on long walks nowadays without the mobile phone, it's a security thing that I can call for help"* (W9)

Selecting activities described strategies when choosing activities, or avoiding activities. One woman explained that she had stopped climbing up on top of a chair that was placed on a high bench, this was seen too dangerous now. Some participants asked for help more easily when in need, for example with changing curtains. Putting away the bicycle for the winter was something that was discussed; not all participants did this. A FoF sometimes made individuals avoid activities they were used to do, because it was now perceived as risky. One woman remembered her feelings of insecurity when she wanted to climb a ladder while she was alone: "*There was this nesting box hanging from the tree, almost falling down. I went for the ladder to adjust it, and put it against the birch. Then I thought, 'No, you are not going to do this when you are all alone!' Afterwards I felt happy about the decision"* (W10)

Three strategies about how the participants chose to do when deciding to go through with an activity or not were described implicitly, e.g. crossing an icy street in the winter, hopping over ditches in the forest, or climbing on something unstable when reaching into a high cabinet. The strategies were *ignoring* (continuing with the risky activity), *gaining insight* (realizing the danger in a certain situation), and *anticipating* (thinking ahead and acting in advance). The strategies were present to different degrees and permeated all of the choices made. It seemed that the personality of the participant influenced how the activities were chosen to some degree: some participants were more spontaneous, and some were more thoughtful. However, this was not the case in all situations. The strategies could differ within the same person in different contexts, and there were no clear gender patterns regarding those strategies.

Exercise preferences in the context of falls prevention (study IV)

The participants described a diversity of ideas and suggestions on how to make exercising in the context of falls prevention more attractive. There were larger variations among the women and among the men than between women and men regarding the preferences. Many participants were active on a regular basis with Nordic pole walking, bicycling, aerobics, gym, dancing etc., and had a clear picture of what they expected from an attractive exercise form, others had less experiences from this kind of activities, but were nevertheless able to provide ideas and suggestions. Many opinions regarding preferences, and what could help promote a sustainable exercise behaviour were suggested and six main categories emerged (Table 10).

Motives to start exercising

The participants gave several motivating factors to why they would start exercising. With respect to gender differences, women more often explained that exercising was a necessity in order to manage everyday life responsibilities: "*I need it to survive, so I just have to keep going myself.*" (W2) Men more often expressed a wish to remain fit. Both women and men were eager to treat injuries or diseases, e.g. osteoporosis or fractures. Advice from a professional practitioner such as physicians or physiotherapists, or concerned relatives, had great impact on the decision to start exercising. Public information about the benefits from exercising also proved to be important motivators: *"I have started to do an exercise programme in which you should stretch. I saw it on some kind of TV show."* (W9)

Table 10. Six categories and their sub-categories describing preferences to exercise in the context of falls prevention

	Categories	Sub-categories
Uptake	Motives to start exercising	Preserve health Treat injury or disease Encouragement by clinicians or relatives Information
	Barriers to start exercising	Health problems Poor self-discipline Environmental barriers Feelings of vulnerability Societal expectations
Adherence	Exercise characteristics	Mode (program vs. integrated) Level of intensity (intense vs. calm) Level of challenge (challenging vs. easy) Social context (alone vs. in large group)
	Confirmation	Professional instructor Visible results Quantified results Achievements
	Spirit lifters	Outdoor exercises Rhythm and music Exercise equipment Humour
	Maintenance tricks	Companionship Routines and challenges Pets and nature Safety issues

Barriers to start exercising

Health problems were not only mentioned as motivators, but also as major barriers to start exercising, e.g. arthritis. Lack of self-discipline proved to be difficult to overcome. However, once a threshold was overcome, the mood also improved: *"Sometimes you feel so tired and grumpy and feel pain everywhere. But after a few hundred meters it starts to feel really good, and then I want to continue."* (W9) During the winter it was even easier to give in to poor self-discipline. A feeling of vulnerability made it hard to start exercising, for example, a fear of falling: *"Of course if you have suffered fractures a few times you are very scared after that."* (W9) This was more common among the women with previous fractures. Being a minority in a certain context, for example the only man in an exercise class, was also a barrier to start exercising. They felt uncomfortable until other men arrived.

Exercise characteristics

Adherence was in many ways influenced by the exercise properties, which needed to be individually adaptable to be attractive in long-term. There was great variability in preferences in exercise mode, intensity, challenge and social context. There were some differences between women and men, but both enjoyed structured exercise programmes as well as integrated training in everyday life. Those who were not used to exercising in structured exercise programmes in general seemed to prefer more integrated everyday training, but those with previous experiences from exercise programmes preferred this mode of exercising. The preferred degree of intensity varied between individuals, no gendered patterns were identified. A tempo that was either too high or too low was experienced as frustrating. Similar patterns were found regarding the level of challenge. However, it was also considered motivating with a higher level of challenge, if the instructor explicitly explained that it was alright to adapt their performance to their own physical capabilities. Some participants preferred to exercise alone while others wanted to exercise together with peers: *"The social aspect is very important in group training. You start to talk to each other and get to know each other, that's fun."* (W4)

Confirmation

Confirmation proved to be equally important to women and men. The instructor role was important, not only for giving encouragement. The instructor should preferably be about the same age as the participants, but the sex was less important. Visible results were important to both women and men, the participants enjoyed when their work 'paid off': "*I want to see a concrete result*." (M3) Counting steps and calorie expenditure with the help of new technology helped many participants to keep up the motivation, especially men: "*It measures my speed, and how far I've walked and how many calories have been spent."* (M5) However, women also enjoyed the technology as exercise support. Some participants emphasized that they were content knowing that they had accomplished what they had planned. An inner feeling of achievement was important for women and men both: *"When you know you have done something you can take a shower and sit down with a clear conscience."* (M5)

Spirit lifters

Exercising outdoors was seen as a more natural way to exercise by some participants: "*I had a gym card once. I went a few times but I don't get the point – why biking indoors when you can bike outdoors and get fresh air?"* (M5) Nevertheless, during the winter season many participants preferred to exercise indoors, especially those with a fear of falling. Inspired by each

other and the researchers during the project, some participants became aware of the possibility that they could add some exercises during their walks. The addition of humour, rhythm, and music came out as strong spirit lifters: *"Yes, music, I like music! Absolutely! For me music is very important when exercising."* (W6) The music should fit their taste and the movements should be synchronized with the music to be most enjoyable. Exercise equipment was inspiring to some participants, with some gender differences: women usually preferred to use equipment that was already available in the household, while men preferred 'real' equipment, such as dumbbells: *"It's fun with the real stuff!"* (M1) Nordic walking poles were appreciated by both women and men, and gave a sense of belonging to a group: *"When you take ordinary walks and you meet unfamiliar people you just keep walking, but with poles you say hello, it's as if you belong to a group, it's nice.*" (M1)

Maintenance tricks

To prevent lapses from happening, friends or spouses could inspire each other to keep going. Having company was nice and inspiring: "*It's much nicer if we're together compared to if I'm alone. It's incredible, so twosomeness is probably important*." (M3) Dogs were mentioned as a trigger to take regular walks, and were valued as company: "*We had a dog, and I miss him so much, he was the best exercise help I ever had."* (M7) Nature could also be enjoyed without a dog; the sense of freedom, listening to the birds and getting fresh air was almost addictive. Picking mushrooms was considered an excellent form of exercise and the urge to fill the freezer triggered the outdoor activity. Sticking to routines was also important, as was setting achievable goals. Once started, it was easier to continue. A fear of falling could inhibit ordinary activities, but compensating with assistive devices by, for example, Nordic walking poles or bringing a mobile phone on walks, provided a sense of security.

Discussion

One main finding of this thesis was that community-dwelling people over 75 years who visited the ED due to an injurious fall within one year showed a significant risk of experiencing new injurious falls within the following 5 years compared to those with no falls. Furthermore, a larger proportion of women than of men reported fear of falling (FoF). There were significant associations between reporting FoF and the ICF components *Personal Factors* and *Activity/Participation* both in women and men, but in *Personal Factors* the associations were in different directions. Interpreted with a gender relational approach there is reason to believe that reporting FoF rather reflects a tradition for older women to be more open about everyday concerns, and instead may have induced a behaviour that protects from falls. In contrast, many older men may not be willing to admit to being 'afraid' due to a traditional masculinity pattern. Moreover, the answer to this single item question had no predictive value for future multiple falls in that we found no association between reporting FoF and experiencing future recurrent falls.

Another main finding was the rich description of how the focus group participants became aware of increased fall risk in everyday life through different sources of information and experiences. An increased awareness was achieved by a sudden onset from own experiences, the media, by listening to their peers in the project, and by reflecting inbetween the meetings among others. The participants also gave many examples of precautionary actions. There were no clear gendered patterns, with some exceptions, and some individuals deliberately ignored risky situations, and even exposed themselves on purpose to fall risks. Some participants were offended when relatives asked them to be more careful, and others were grateful for the support and interpreted such comments as a sign of careing. A third main finding was that the focus group participants reported a diversity of exercise preferences in the context of falls prevention with large variations among women and among men. The findings illustrate that older community-dwelling people are a heterogenous group of individuals with different needs and wishes, and should not be categorized as 'old women' or 'old men', but rather as individuals with personal preferences.

Previous falls as risk factor for injurious falls

Previous falls is one of the strongest predisposing factors for falls and injurious falls in older people. The findings in study I indicate that community-dwelling people over 75 years who have experienced an injurious fall are at high risk of sustaining new injurious falls within the next 5 years. Similar findings have been found by others (16). Our sample of 230 community-dwelling people may well represent the overall population in this age group regar-

ding falls, because the proportion of falls requiring medical care was in agreement with others (174), as was the distribution of injury types during the long-term follow-up (175). Based on our findings (paper I) it is justified that practitioners who meet community-dwelling people over 75 years in any clinical setting ask them about injurious falls the previous 12 months. If they had an injurious fall they should be offered a multifactorial assessment to identify any predisposing underlying risk factors. The assessment should be followed by adequate interventions. Exercise interventions with strength and balance exercises formed after individual preferences (paper IV) may be one intervention, but may not be the first choice if other more serious conditions are detected. This management is particularly important when meeting older patients in the ED after an injurious fall, because of the high risk of readmission to the ED in the first month (68). Although frequently shown by others (18, 175, 176), our findings did not support that recurrent non-injurious falls increase the risk of sustaining an injurious fall in the future in community-dwelling people over 75 years.

If the patient is offended by the question, it may be explained to the person that there are indications that the risk of sustaining new injurious falls is almost threefold after an injurious fall. The findings in paper III indicate that community-dwelling people older than 70 years may accept information and advice about fall-related issues if the advice makes sense to them, especially if the information is given by a physician. This is in agreement with previous research (177, 178). Individuals who have experienced a recent fall have been shown to be more likely to acknowledge risk of future falls (109). It has also been suggested that people need basic information about the benefits of preventive behaviours, if they are to make well-informed, rational, positive choices about what forms of health-promoting behaviour they should carry out (115). Including the patients in the decision making process is clearly in line with evidence-based practice (179).

Considering the serious consequences from falls in older people on individual and societal levels, and the substantial evidence-based research on the topic, it may be seen as a major concern that there are no national guidelines in Sweden for the management of falls and falls prevention. Our results support the existing recommendations in the American and British Geriatrics Society (AGS/BGS) guidelines that all older people who present to the ED with an injurious fall, or report an injurious fall during the previous year, should be offered a multifactorial fall risk assessments coupled with tailored interventions (76). It should however be noted that older people are a heterogeneous group of individuals: in general 65 year old community-dwelling individuals have more resources than 95 year old frail individuals with dementia living in a residential care facility.

Many risk factors for injurious falls are modifiable and efforts should be made to identify these factors in the multifactorial assessments. Integrating dynamic systems approach with, for example, the model of ICF may assist in understanding why community-dwelling individuals over 75 years with injurious falls are at significant risk of sustaining new injurious falls the forthcoming 5 years, and to identify modifiable risk factors. For example, the previous injurious fall may lead to tissue damage, pain, and a fear of new falls (corresponding to the ICF components *Body Structure and Function*); mobility limitations, and a reduction in activity and social participation (the ICF components *Activity/Participation*). These factors may lead to a sedentary lifestyle (*Personal Factors)* with the potential to cause physical weakness, depression, frailty and ultimately new injurious falls. In addition, there may be other predisposing factors prior to the first injurious fall, e.g. dizziness or cognitive impairments within the components *Body Function and Structure,* and medication use or use of walking aids within *Environmental Factors*. Some *Personal Factors* such as age, and previous experiences, for example falls, are not modifiable, but should be identified because it gives much information about a person's background. Other lifestyle factors and habits such as nutrition and smoking should also be identified. Thus, a checklist based on the ICF may support in organizing the multifactorial assessments to identify modifiable risk factors.

In contrast to others (175) we found no difference in the proportion of injurious falls between women and men (paper I). However, compared to men a larger proportion of women experienced fall-related fractures, and this is in agreement with other studies (17). One well-known risk factor for fall-related fractures in older people is osteoporosis (66), corresponding to 'change in Body Structure' within the ICF, although far from all fractures are caused by osteoporosis (69, 71). Fragility fractures are particularly evident among older women (180). The issue of osteoporosis has been explored in detail from a biosocial gender perspective using a dynamic systems approach (181). The equal importance of cells, hormones, as well as cultural aspects and lifestyle factors, e.g. exercising, sun exposure, and smoking, were highlighted. The study concluded that the development of bone mass is possible to influence throughout the life-span, and that osteoporosis is not an inevitable part of being an older woman. There are large cultural differences, and osteoporosis is also suggested to be vastly understudied in older men (181). This example shows how the use of a gender perspective and dynamic systems theory may provide a better understanding of the complexity of the causes of falls and fall-related issues in older people.

Gender and fear of falling as risk factors

We found that women reported FoF more often than did men. The proportion of individuals who reported FoF (55% women and 22% men) was within the range of what has previously been reported (182). In contrast to others (92) we also concluded that reporting FoF did not predict future recurrent falls in long-term, neither in women nor in men. Moreover, by using a gender relational approach, we highlighted that the reason to why so many more women seem to report FoF than do men, may to some extent be due to gendered patterns in society. For these reasons we conclude that using the single item question "Are you afraid of falling?" has little value in clinical settings as well as in falls-related research in community-settings. Nevertheless, this question is still very common in contemporary research with the argument that it correlates well with validated scales including the Falls Efficacy Scale.

FoF and falls-related self-efficacy are often used synonymously in the literature. In fact, many existing measurements, including the single item question "Are you afraid of falling?", are based on self-efficacy beliefs, i.e., the confidence that one will not fall while performing certain activities. Balance confidence is also closely related to self-efficacy beliefs (85). Although found reliable and valid (89) it has recently been argued that falls-related self-efficacy (or balance confidence) and FoF are actually distinct dimensions, and therefore assessing the self-efficacy may not be the best way to assess FoF (85). These measurements only evaluate the cognitive aspect of FoF. Furthermore, there are reasons to believe that individuals with low self-efficacy also score lower on falls-related efficacy scales (85).

A recent systematic review showed that FoF was strongly associated with performance-based tests (83). We found a significant relationship between FoF and performance-based tests within the ICF component *Activity/Participation*. The same pattern was found in both women and men, indicating that poor physical outcomes can make a person feel unsteady and afraid to fall, regardless of the sex. Another study found that FoF was associated with reduced gait speed and stride length, and increased double support phase and step width in normal and dual task conditions in community-dwelling people from 65 years (183). The authors also implied that visual impairments were strongly associated with these indicators. Assessing gait and balance in relation to FoF will measure the behavioural component of FoF (85). Experiments have been performed to include all three components (i.e., cognitive, physiological, and behavioural) (184). The cognitive aspect of FoF was assessed with the FES-I (Falls Efficacy scale International). The authors found that many older people (almost 30%) – both women and men – either underestimate or overestimate their risk of falling in relation to their physiological risk of falling. Among those who overestimated their fall risk, significantly more were women (184). It is likely that the estimation about how

risky a situation is will have an impact on what risks a person is willing to take. If the level of FoF is adequate in relation to the actual fall risk and the physical ability of an individual, it is likely that a FoF protects from falls. An exaggerated FoF may instead lead to unnecessary functional limitations, while too low levels of FoF may probably increase the risk of falling. Older community-dwelling people with good physical ability have been found to tend to take minor behavioural risks in relation to the environmental demands, whereas individuals with poor ability may take either very high risks, or choose a safer way with no risks (185).

There are several aspects to take into consideration when discussing FoF. It has for example become a long-standing, well-known 'fact' that women report FoF more often than men, to the extent that many researchers exclude men, although the opposite can also be found (186). This reoccurring association between female sex and reporting FoF has been explored with a gender relational approach in paper II, suggesting that reporting FoF or not is probably strongly gendered. Older men may identify themselves with the masculinity ideal of being physically strong, tough, robust, and fearless, while women often identify with femininity ideals of being sensitive, careful, and open about concerns (187). This indicates that older men are less prone to admit to being afraid (of anything) than older women. Others have suggested that the question 'Are you afraid of falling?" is less suitable for men, because they will probably deny being afraid to fall (188). In addition it has been shown that when asking *what* is feared specifically, it may involve dimensions such as fear of looking ridiculous in public (84).

Historically women have, in general, been subordinate to men, e.g. by low incomes and inequitable access to decent work, caregiving responsibilities associated with mothering, grandmothering and looking after one's spouse and older parents that prevent or restrict working for an income, and by domestic violence (133). This is likely to have influenced women's general assertiveness. Assertiveness has been found to be linked with status and evolves from education and work roles, thus women's assertiveness has been shown to change over time (189). Assertiveness resembles self-efficacy in that both concepts reflect a belief in one's own abilities. We found in women that higher scores on measurements within *Personal Factors* (e.g. higher level of education, better eating habits, and fewer experiences from falls or fractures) were associated with lower level of FoF. A completely different pattern was seen in men, i.e. lower scores – lower levels of FoF. Furthermore, the majority (45%) of women answered "rarely/never" when being asked "Are you afraid of falling?", and 32% answered "sometimes". The alternative "sometimes" is usually dichotomized as "yes", but this answer may rather reflect a sound concern which instead protects from falls. This is supported by the re-

sult that there was no gender difference in experiencing recurrent falls the forthcoming year.

For the clinical management of fear, it is certainly important to distinguish fearful individuals with activity restriction from those with merely a concern about falling, because the activity restriction itself may lead to a sedentary life with the potential to cause falls. We urge clinicians and researchers to be aware that gendered patterns may influence how older community-dwelling people respond to measurements of FoF. Trying to assess all three components of FoF will probably give better guidance (85). In addition, when planning for interventions and designing research projects, it is important to adopt a gender awareness that permeats the research process in order to avoid a gender bias.

Emergence of fall risk awareness and safety precautions taken

The awareness of fall risks in everyday life is low in the general population (51). The older participants implicitly and explicitly described many examples of how fall risk awareness emerges in everyday life, e.g. from own experiences, from information in the media that is perceived as personally relevant, by gradually emerging, and from hearing the stories of their peers of the study (paper III). Apart from reflecting discussions, the practical balance exercises also proved to increase the awareness about the importance of postural control in relation to falls. Seen from a gender perspective, there were larger variations in the emergence of fall risk awareness among the women and among the men than between women and men.

Ageing may typically involve non-disease specific slow onsets of impairments that may have an impact on postural stability, although it is important to recognize that older people are a heterogeneous group, and that the process of ageing occurs at very different rates among various individuals and groups (1). From a dynamic systems perspective, many of the described situations involved individual disabilities in relation to the task that was being performed in a challenging environment. Individual factors that were mentioned were, for example, slower arm reaction and slower gait speed which both have been shown to increase the risk of falling (41). Decline in the physiological systems, e.g. reduction in reaction time and visual acuity, may affect the postural stability, as well as mobility and the ability to manage activities in everyday life, also in older people who perceive themselves as fit (42, 190).

In privileged, well-functioning, active individuals it has been found that about half of the falls occur outdoors during walking and vigorous activity (191, 192) mainly in public places where there often are environmental hazards such as cracked pavements, uneven ground, and slippery surfaces

(193). In 2012, it was found in Sweden that more women than men fell outside the own home. Many fall events occur during the winter when walking on snow or ice. Seen from a societal perspective, it should be of high priority to focus on a safe environment where people usually walk, including removing snow and ice from pavements, and mending cracked pavements. Given the fact that there will be even more old people in the future who will experience age-related physiological changes, making the outdoor environment safer are probably cost-effective measures.

Half of the falls occur in commonly used rooms within old people's own homes (190). From a citizen's perspective, a preventive change of behaviour can be initiated by a collaborative approach similar to ours including a group of peers and professionals who work with fall-related issues. Giving well-functioning, active individuals the opportunity to meet and reflect over fall-related issues may be beneficial to help them identify habitual tendencies to either overestimate or underestimate fall risks in everyday life, and if a change in behaviour appears to be necessary. They may also share ideas on how to improve safety at home, e.g. by simple assistive devices. People may not be used to openly reflect over their own behaviours, and it can be difficult to detect patterns of which you yourself are a part. Reflecting together with peers may support learning, and prompt a safer behaviour, and meeting with people with different background enhances a mutual learning process.

Another way to increase public awareness about fall risks, and that undertaking specific physical activites has the potential to improve balance and prevent falls, is by running campaign activities. Valuable suggestions are, for example, provided by the ProFouND-group (Prevention of Falls Network for Dissemination), an EC funded initiative to bring about the dissemination and implementation of best practice in falls prevention across Europe (www.profound.eu.com). The campaigns should be implemented on a local as well as national level, working in partnerships. These partnerships should not only include professionals that work with older people: based on our findings (paper III) the community-dwelling people have much knowledge and should therefore be involved in planning and implementing the campaigns. Including older people in the campaigns may increase the trustworthiness, and the possibilities for a successful raise of awareness without being perceived as a threat to older people's identity. Similar dissemination interventions have proven effective in reducing injurious falls (194). However, there are also examples of previous public awareness campaigns sponsored by drug companies, which may instead reinforce some pre-existing perceptions and attitudes, for example that all older women have brittle bones and need preventive medication (181). Given the costs involved for injurious falls in older people, more government resources should be allocated for the prevention of falls.

Preferred exercise properties in the context of falls prevention

An understanding of the ICF contextual (*Personal* and *Environmental*) factors affecting programme participation is important, as programme participation may ultimately influence an individual's likelihood of future falls and fall-related injuries (195). Exercise programmes may be one of the interventions for people who sustained injurious falls (paper I). It has however been shown to be difficult to implement falls prevention exercise programmes. One reason that has been identified is that many older people are unaware of their own risk of falling (97), and that individuals who do not recognize their own fall risk, nor perceive that they are at risk of falling, are less likely to participate in fall risk interventions (65). Seen from a gender relational approach, one important explanation to why many older people do not recognize their own fall risk may be that they do not want to be identified as being "old". This can be seen as a sign of an existing ageism in Western society. People treat signs of old age as stigma and avoid notice of them in their personal lives (196). Denying old age will probably have an impact also on the willingness to accept participation in falls prevention exercise programmes.

Most community-dwelling people do however acknowledge that fall prevention is useful in principle for the unspecified "other" (115). Raising the awareness about fall risks in the general population is important, and can be done through several channels (paper III). Furthermore, when designing falls prevention exercise programmes, focus should be on promoting health with positive messages by designing programmes that are perceived as relevant, and the patients or clients should be involved in the decision making process (179). The self-determination theory of motivation (144) can be used as a strategy to stimulate a change in exercise behaviour and most importantly sustain it. Firstly it must be recognized that the motivation to change must come from the individual. Once the fall risk awareness is in process (paper III), it may hopefully act as a motivator for older people to take an interest in preventing falls by, for example, balance and strength training. Physiotherapists play a unique role in promoting this motivation and to support the decisions made by the patient/client. Building an accepting and trusting relationship with the client, referred to as relatedness, will allow for open discussions to identify personal barriers and preferred exercise properties. Poor self-efficacy (referred to as competence) has been identified as a barrier to initiate exercising (98, 117). One must have the belief that one has the power to produce the desired effect before one will attempt it. Self-efficacy must be nurtured by building on success, and thefore exercises that are challenging, but most importantly possible to achieve, must be prescribed (144).

Following the call to explore the needs, preferences and capabilities of the individual (115) to ensure that design of exercise interventions in the context of falls prevention meet those needs, we specifically addressed these issues. We aimed at identifying personal barriers and what properties of an exercise programme may be preferred by older community-dwelling people (paper IV). The result from the multistage focus groups indicated that the older participants had many different preferences based on experiences and attitudes. There does not appear to be a one-size-fits-all approach. Therefore individually tailored exercise programmes with individual adjustments in terms of mode, intensity, challenge and social context are crucial. Additional important factors for a sustainable exercise behaviour was a wish to receive confirmation that provides joy and satisfaction, as well as personal tricks to prevent lapses and relapses.

Because of prevailing beliefs that fall-related issues such as fall-related injuries and fear of falling mainly affect older women, many practitioners and researchers exclude men from their interventions or exercise programmes. However, since men also benefit from strength and balance exercises they should be offered the same opportunities to exercise as women. We found that women and men shared similar requirements for innovative exercise forms and that the variations of the preferences varied more among women and among men, than between women and men (paper IV). The finding that individuals with no previous experience from exercising found it more difficult to motivate themselves to attend to structured exercise programmes may be met in several ways. For example, if the patient/client has the need for a high level of social support and confirmation, the practitioner may either accompany the patient/client on several occasions to the exercise class in order to make the patient/client feel safe with the new environment, or suggest that the patient/client brings a friend. Another solution for continuous support that has been suggested by others is the use of exercise buddies, or peer mentors, i.e., specially trained older citizens. Peer mentorship has been proven successful in getting older people active and staying active (177). If the patient/client dislikes or finds it difficult to attend groups and prefers to exercise at home, the practitioner may prescribe a tailored exercise programme to be performed in the person's own home based on preferred exercise properties.

Based on the large variations among women and among men, practitioners should be prepared to offer flexible solutions. Furthermore, the use of smart technology has the potential to give continuous feedback and support in many ways to encourage a long-term continuation of the exercise programme. Seen from a dynamic systems perspective, behaviour is both flexible and stable, and behaviour and behaviour change follow predictable patterns (3). Although flexible, organisms tend to return to their preferred state of relative

stability: patterns in behaviour self-organize, and settle into preferred states which are stable or unstable. When stable, they resist change (128). This may, in part, explain why it is so challenging to motivate the uptake and adherence to falls prevention exercise programmes. Therefore we encourage practitioners to offer flexible solutions to their patients/clients so that exercising ultimately may become an everyday habit. We identified important exercise properties that may attract both women and men in such a programme, and conclude that women and men share many similarities as well as differences, and therefore the take-away message to practitioners is: "see the individual, not an old person".

Methodological considerations

This section will discuss ethical considerations, validity, strengths and limitations about the methods used and the results.

Ethical considerations

The participants of the studies were not described in detail. In study I and II the participants are only presented on a group level, and in study III and IV the participants are described with details relevant to the context. A more detailed description may facilitate for the reader to judge if the results are possible to generalize to other contexts, but due to ethical reasons this is not appropriate. Instead, the analytic process was described step by step to make it easier for the reader to decide if the results are transferable to other contexts, and to provide enough details to use similar methods in other contexts.

Study I and II were based on a one year follow-up on fall events in 230 community-dwelling people over 75 years of age. In case of a fall the participants were interviewed about the consequences. In case recurrent falls occurred, the participants were recommended to seek health care based on the assumption that two or more falls may occur due to underlying health problems. During the one-year follow-up 48% experienced falls, but prior to the study 55% reported having experienced previous falls. It cannot be excluded that the results from the DXA scan, in combination with filling out the fall calendars every day, may have increased the participant's falls risk awareness. The raised awareness may also have lead to a positive long-term effect. Nevertheless, many injurious fall events occurred during the long-term follow-up.

The participants from study I and II are not expected to have a direct benefit from these studies, but the knowledge about the long-term consequences will contribute to the understanding of fall risk factors in community-dwelling people older than 75 years. This new knowledge is expected to form the base for tailored, situation specific interventions, and may lead to the making of

national guidelines for falls prevention, and thus have a positive effect on the participants in the long run.

The participants from study III and IV clearly expressed that they had experienced a direct benefit from taking part in the research project through the multistage focus groups. The frequent discussions about falls and fall risk, in addition to the reflection time inbetween the meetings, had made them more aware of risks in everyday life. We do, however, have no knowledge about if this increased awareness lead to fewer falls as they were not monitoring falls.

There is a risk that the participants in study III and IV felt inferior to the researchers, even though the research team deliberately and purposively strived at having a democratic approach, and to have an interactive relationship with the participants (197). The members of the research team positioned themselves as being 'outsiders in collaboration with insiders', i.e. as researchers performing research *with* persons over 70 years, as opposed to *on* (197). This position was necessary because the project was initiated by the researchers and not in collaboration with the participants. Furthermore, the participants were not invited to lead any of the focus group sessions, to participate in the planning of the contents of the sessions, to take part in analysing data, or in writing scientific manuscripts. In that sense the project may not be seen as fully democratic. There were no previous relationships between the researchers and the participants that may have influenced the analyses.

The participants were offered to borrow an iPad or iPhone according to their liking during the project. This offer probably encouraged several individuals to engage in the project, but also worked as a facilitator to continue. This may have affected the level of participation in study III and IV to our advantage in that the level of participation was very high. Another factor that may have influenced the willingness to participate was an offer to have the transports to the community centre paid for.

Validity

There are different aspects of validity to discuss within quantitative and qualitative research to ensure the quality of the research, but basically validity involves showing that the research is trustworthy and useful (198). In the quantitative studies the measurements chosen are considered to be valid and reliable in relation to falls, and together capture a spectrum of fall risk factors. However, the validity of the single item question "Are you afraid of falling?" is questionable. We found this question to have no predictive value, and the answer is probably strongly gendered. In addition, single item questions are limited by their inability to measure variability in degrees of fear (89). Concern about falling involves several aspects, including fall-related

self-efficacy; confidence in maintaining balance, and a concern about falling during activites. When planning for interventions involving FoF, researchers should clearly identify what aspects of FoF they will be targeting in order to increase validity (89). In addition, based on our results it is likely that the answer to some of the more complex questionnaires, such as the ABC (154) or the SAFE (90), is also influenced by gendered patterns. We recommend that this should be taken into consideration when using those questionnaires.

The results of the studies may not be generalized into other settings or contexts: the 230 participants in the quantitative studies were a sample of convenience, and were in general physically active and without major health problems. Therefore it cannot be assumed that the results are fully generalizable to older people living in other settings. Furthermore, the data were collected in Umeå in northern Sweden, therefore the content is culturally relevant mainly within a Swedish context. However, the characteristics of this population is in many ways representative for other countries in Scandinavia and northern Europe, why the results are probably also applicable for community-dwelling people living in these areas.

Within qualitative research, trustworthiness is often further devided into transferability, credibility, dependability, and confirmability (199). Credibility relates to truth value, in quantitative research corresponding internal validity; dependability concerns how reliable the results are if the studies were to be repeated; and confirmability refers to neutrality, i.e. to what extent the findings were affected by personal interests (170). These aspects have to some extent been mentioned in the methods section, and will be further discussed in the strengths and limitations section.

Strengths and limitations

A major strength is the use of the gender perspective throughout the thesis. This is rarely done in research where sex-related issues are discussed (135). A gender perspective has the potential to broaden the understanding of many apparent sex-related differences within health care. A gender relational approach is relevant in order to discuss variations among women as well as among men, and between older and younger individuals.

Another major strength was the combination of qualitative and quantitative methods to answer the research questions. Together the methods answered the research questions that could not have been answered by quantitative methods alone, as well as the opposite.

A third strength was the prospective data collection on falls with monthly fall calendars, as recommended by the ProFaNE-group (75). In addition, the use of the IDB with structured and thoroughly collected data about the conse-

quences and circumstances surrounding the fall proved to be a valuable source of data.

An additional strength was the choice of the Andersen-Gill method of multiple events. This method was chosen because it was thought to best answer the research question about future injurious falls and take recurrent falls into consideration (200).

The use of multistage focus groups was is a strength because it gave rich data in a previously untried way within the field of physiotherapy. The process over time gave us the benefits of mutual knowledge exchange through reflective discussions, and offering participants as well as the researchers a reflection time between the focus group sessions. However, to improve data collection even further, one-to-one interviews could have been performed, or other sources of data been used, for example questionnaires, as triangulation to further improve credibility.

Qualitative content analysis to analyse data was chosen because it can be used to explore variations within a text unit, where similarities and differences may be identified. With their different fields of expertise, the researchers were able to analyse data from different angles and perspectives, which was a strength. Another method that could have been used, especially for study IV, was the methodology of grounded theory. This method may lead to development of new models that later can be tested with quantitative methods.

The choice to define a fall as having experienced at least two falls (i.e. recurrent) was based on the idea that one fall may be by chance alone, but two or more falls may be a sign of underlying health problems, and therefore considered a higher risk to renewed falls. This definition is common in contemporary research on falls, but it is possible that the results had been different if a fall had been defined as having experienced at least *one* fall.

A power calculation was performed prior to this thesis, therefore it may be assumed that 230 individuals were a large enough sample when performing the follow-up on falls. However, when comparing smaller groups as was done in the quantitative studies of this thesis, there is a risk that the power was too low to show true differences. For example, there were only 20 individuals in the group of people with injurious falls (study I). The choice to categorize the many measurements into the components of the ICF may have had an impact on the power of the analysis, for example that *Environmental factors* did not constitute a factor. Analysing women and men separately may also have influenced the results because of the low number of included men, but this was made in order to explore gendered patterns. Another model, for example as proposed by Lord (2007) or by WHO (2007) may have been a better choice in order to reduce to number of factors. The model fit of

ICF was however shown to be acceptable. Furthermore, some of the measurements could have been categorized in other components, which may have given a different result. For example, the ABC (154) measures balance confidence. Confidence is usually categorized as a personality function within the component 'Body function' (b1266) (4), relating to assertiveness, and self-assurance. Our decision to categorize the ABC within 'Personal Factors' was based on that 'confidence' is contrasted to being timid, insecure and self-effacing, which did not seem to be appropriate. One could not say that someone is too 'shy' to perform a balance demanding activity. It has been proposed that the ABC rather reflects a person's perceptions about activities and function in daily contexts (201).

The act of dichotomizing variables is presented with some important issues: everything cannot be simplified. Women and men are almost always dichotomized by their biological sex as being polar opposites, but there are many variations within the gender which has been shown in this thesis (study II-IV). In addition, dichotomizing the answer whether somebody is afraid of falling or not is making a complex phenomenon too simple, and researchers and clinicians may miss important information. This may also contribute to the pre-understanding that female sex is a predisposing factor to FoF, which may lead to a gender bias. Another limitation was the use of a paper and pencil test to assess FoF. This primarily evaluates the cognitive aspect of fear, and does not reflect the physiological or behavioural components (85).

The purposive sample of participants in the qualitative studies has probably influenced the results in several ways. Most participants were former white-collar workers. It is possible that the discussions would have been different if a larger number of former blue collar workers had been included. Furthermore, the participants were in general fairly active. We might have been able to collect richer and more valuable information if more of the participants had been less physically active and living a sedentary life. A way to increase the credibility even further could have been to include even older or younger participants, or individuals from other cultures. Given the fact that all participants were engaged in senior citizens organisations, this may have influenced their level of participation due to previous experiences from familiar meetings with other older people. Including participants with no connection to senior citizens organisations may have broadened the spectrum of experiences more. This could for instance have been accomplished by advertising in a local newspaper, by using snowball sampling, or by recruiting older people from primary care units. The use of purposive samples is however most commonly used (202), and recommended in qualitative research (161).

In focus groups there may be a problem with 'unspoken rules' within the group, hiding variances (203). There is always a risk that the participants an-

swered questions in socially acceptable ways, rather than expressing their own opinions. However, the participants did not always agree with each other, why this was not considered a major problem. Moreover, Kitzinger (203) suggests that the ideal focus group size is 4 to 8 participants. The choice to include 9 participants may have influenced the findings in that all participants were not given the opportunity to make their voice heard. However, according to recommendations of the COREQ a number of 4-12 participants is acceptable when using focus group methodology (161).

In the qualitative studies some of the activities that the participants chose to talk about were activities that changed during winter, because the discussions were held during the winter season. In Umeå, where the participants live, the ground is covered with snow and ice for several months, and this affected the performance of some activities, e.g. bicycling. This may decrease the transferability (170) to areas with different climate. The results concerning fall risk awareness may probably be transferred to community-dwelling people in other regions with similar climate.

To add transparency and trustworthiness, quotations from several different participants of both sexes were added. This hopefully adds to the consistency between the data presented and the study findings (161).

The cross-disciplinary research team consisted of women only, this may have limited the understanding of the issues discussed. A balance between female and male researchers would probably have broadened the perspectives even further, increasing the credibility.

Some methodological considerations specifically concerns the participatory action research. It may be argued that knowledge production within action research, as in other qualitative methods, is never neutral, but always pursued with some interest in mind (in this case creating an App with exercise programmes). This is referred to as confirmability and may bias the results. In addition, the relations of power may influence the outcome – the researchers are always an authority because of the connection to the academic world, as much as they try to create conditions for mutual understanding (197). This thesis may represent the documentation of a successful collaboration and be used as a case study of not only the process but also the product of the collaboration within the field of physiotherapy. This becomes public knowledge to the extent that the knowledge can be transferred to someone in a different context that is similar (i.e. other regions or another community). It also resulted in a product (the App) that can be used in other settings.

Clinical implications

A multifactorial risk assessment should be offered to all community-dwelling people over 75 years who, in clinical settings, report having experienced an injurious fall leading to a visit at the ED the past year. Furthermore, performance-based tests regarding gait, balance and mobility should be performed, as well as lower limb strength. Following the risk assessment, appropriate interventions should be offered. Even though the literature supports exercise as one of the most effective interventions for community-dwelling people, there may be other risk factors that have a higher priority. Exercises may therefore not be the most appropriate, effective, or safe initial intervention, but should be offered later.

Fear of falling (FoF) is more often reported by older women than by older men in community settings. Reporting FoF or not is probably strongly influenced by the gender of the individual due to gendered patterns in society: older women who report FoF when being asked if they are afraid of falling may in fact make a correct estimation of risky situations, and older men who are asked if they are afraid of falling will probably not admit to being afraid. Moreover, the single item question "Are you afraid of falling?" will assess the cognitive component of FoF reflecting mainly self-efficacy and balance confidence, but does not assess the behavioural or physiological components of FoF. The single item question is not valuable for the prediction of future falls. However, reporting FoF may also reflect the physical ability in both women and men, and therefore it is important to test gait and balance functions if a person reports FoF.

There are several channels to increase fall risk awareness in older people. Health care professionals should arrange public campaigns in order to increase awareness of fall risks in the larger population. This should have high priority. Fall risk campaigns should preferably be planned and executed in collaboration with older citizens, because it has been shown that older people may not recognize that they are at risk of falling. Using their peers may increase the possibility that older community-dwelling people acknowledge that they too are at risk of injurious falls, and pay more attention to general information about the health benefits of balance and strength exercises. Relevant information should preferably also be shown in the public media. In addition, health care professionals may arrange community-based meeting points in collaboration with the community and senior citizens organizations where older people are offered in-depth discussions with peers about fall risks in everyday life. The older people may increase fall risk awareness by learning from each other, and by opportunities to reflect. These meetings should preferably contain practical components, including challenging balance exercises in a safe environment. Trying challenging

balance exercises may provide an opportunity for older people to acknowledge their own functional ability in a safe way. These activities may together increase the ability to identify early signs of fall risk in the general population, and the knowledge and understanding about when to seek help from health care professionals.

When offering and prescribing falls prevention exercise programmes to older community-dwelling people, the self-determination theory can be used to stimulate a change in exercise behaviour and to sustain it. To improve the conditions for both uptake and long-term adherence, the exercise programmes should be based on individual desires and requirements instead of standardised solutions. Listening to older women's and men's own views and experiences, and, from this starting point, jointly negotiating the contents of the exercise programme may strengthen meaningfully shared decision making. Important aspects to identify and acknowledge are exercise mode, level of challenge, and need of confirmation. In addition, older women and men have different, but also similar, needs and preferences. Following our results, there is need to offer a diversity of exercise programmes on individual as well as group level. This may be achieved by improved collaboration between different actors in order to provide good quality instructors and variation.

In order to design falls prevention exercise programmes that are perceived as relevant to the patient/client, some specific findings should be addressed:

- Take different stages into account: reasons to start (or not) the falls prevention exercise programme are likely to differ from those to adhere and maintain (e.g. satisfaction with the programme such as the instructor, level of intensity and challenge, spririt lifter and confirmation);

- Tailor the exercise programmes to the individual preferences (e.g. indoors, outdoors, group or alone); if necessary, offer peer-mentorship for support

- Relate contents of the exercise programme to a personally set, achievable goal;

- Address behavioural aspects and help the patient/client to reflect on potential motivators and barriers (e.g. attitudes, self-efficacy and fear of falling);

- Address outcome expectations for each individual and how feedback on perceived success may be provided;

- Avoid barriers (especially health related such as physical limitations) by tailoring exercises to the individual;

- Address safety issues by helping the patient/client to reflect on potential risks where the exercises will by performed.

Finally, it is important that health care professionals adopt a gender awareness when assessing and reacting to a reported FoF, and when negotiating falls prevention intervention programmes, in order not to reinforce socially shaped patterns, and to focus on individual preferences instead. A gender awareness means taking into consideration factors such as culture, age, class, values, and attitudes that may influence what it means to be an older man or an older woman in different contexts. These factors influence both the patient/client, as well as the practitioner in the relation between them.

Implications for future research

With respect to Swedish conditions and the Nordic climate with snowy and icy winters, there is need to explore older community-dwelling women's and men's views about and experiences from the concept fear of falling, and what is put into this concept. This may lead to improved ways to assess fear of falling within Scandinavian conditions.

There are several occupations involved in falls prevention interventions, but the collaboration between them is currently not optimal. There is need to identify what different health care professionals in public health and primary health care do today to offer and prescribe falls prevention exercise programmes for community-dwelling older people; what they base their decisions on; and to what extent they include the older people for shared decision making. This may contribute to the development of new models and guidelines to improve collaborative approaches and partnerships between the different occupations and community-dwelling older people, in order to provide best possible conditions for the prevention of falls and fall-related injuries.

Based on our findings that older community-dwelling people have individual preferences, the development of a checklist is warranted for. A checklist may be used to support public health or primary health care practitioners when discussing exercise behaviours with their clients or patiens, and when prescribing exersice-based programmes. The checklist should address both uptake and adherence, because the reasons to uptake and the adherence in long term may differ, and should preferably be based on the ICF in order to include all the different components and contextual factors. The detailed findings may also assist in improving already existing evidence-based exercise programmes in order to make them more attractive, or when planning for new evidence-based exercise programmes.

Conclusions

- A history of one injurious fall within the previous 12 months in community-dwelling people over 75 years lead to an almost threefold risk of sustaining new injurious falls in long-term compared to those with no falls.
- Asking community-dwelling women and men over 75 years if they are afraid of falling has no predictive value for future recurrent falls. Moreover, the answer is probably strongly gendered and will therefore be of no significant value in clinical practice or in research projects.
- The model of ICF proved to be an appropriate model in a factor analysis with fall-related measurements.
- Older community-dwelling women and men over 70 years described several channels to become aware of fall risks in everyday life. Precautionary actions included assistive devices and adaptation of movement patterns. Fall risk awareness emerges from various reasons. Both women and men may deliberately expose themselves to fall risk situations to maintain quality of life, and may be offended by patronizing comments.
- An increased fall risk awareness may be achieved by arranging public campaigns and meeting points for older people with experts on fall prevention through mutual knowledge exchange. Therefore, inviting older community-dwelling people when planning for public campaigns together with experts in the field is recommended.
- Older community-dwelling people have a diversity of requirements on exercise characteristics with focus on falls prevention. No clear gendered patterns in the perceptions of motivating factors were found, but rather a great variation among women and among men. It is therefore of high value to offer a diversity of exercise activities to older people, and to see the individual instead of an old woman or an old man when suggesting forms of exercise. Both women and men enjoyed for example getting confirmation and use of spirit lifters.

The results from this thesis may be considered when developing national guidelines for prevention of falls and fall-related injuries; when planning for and implementing falls prevention exercise programmes; and when prescribing exercise programmes to older community-dwelling people older than 70 years in the context of falls prevention.

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References

1. Spirduso W, Francis K, MacRae P. Physical dimensions of aging. 2nd ed. Champaign: Human Kinetics; 2005.
2. Shumway-Cook A, Woollacott M. Normal postural control. In: *Motor control. Translating research into clinical practice*. 4th ed. Baltimore: Lippincott Williams & Wilkins; 2012.
3. Michie S, Johnston M. Theories and techniques of behaviour change: Developing a cumulative science of behaviour change. Health Psychology Review. 2012;6(1):1-6.
4. WHO. ICF: International Classification of Functioning, Disability and Health. Geneva, Switzerland:World Health Organization. 2001.
5. Morley JE, Vellas B, van Kan GA, Anker SD, Bauer JM, Bernabei R, et al. Frailty consensus: a call to action. J Am Med Dir Assoc. 2013;14(6):392-7.
6. Abel T, Graf N, Niemann S. Gender bias in the assessment of physical activity in population studies. Soz Praventivmed. 2001;46(4):268-72.
7. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep. 1985;100(2):126-31.
8. Porta MS, Greenland S, Last JM. International Epidemiological Association. A dictionary of epidemiology. 5th ed. Oxford: Oxford University Press; 2008.
9. Huber M, Knottnerus JA, Green L, van der Horst H, Jadad AR, Kromhout D, et al. How should we define health? BMJ. 2011;343:d4163.
10. WCPT. Policy statement: Physical therapists as exercise experts across the life span. [Cited 2014 October 15] Available from: www.wcpt.org/policy/ps-exercise%20experts2011.
11. The Swedish national institute of public health. Healthy ageing: a challenge for Europe. Stockholm: National Institute of Public Health; 2007. [Cited 2014 October 18] Available from: http://www.fhi.se/PageFiles/4173/Healthy_ageing.pdf
12. WHO Study Group on Assessment of Fracture Risk and its Application to Screening for Postmenopausal Osteoporosis, World Health Organization. Report of a WHO study group [meeting held in Rome from 22 to 25 June 1992]. Geneva: World Health Organization; 1994.
13. Sedentary Behaviour Research Network. Letter to the editor: standardized use of the terms "sedentary" and "sedentary behaviours". Appl Physiol Nutr Metab. 2012;37(3):540-2.
14. Bandura A. Self-efficacy: the exercise of control. Basingstoke: W. H. Freeman; 1997. 604 p.
15. Gill TM, Murphy TE, Gahbauer EA, Allore HG. Association of injurious falls with disability outcomes and nursing home admissions in community-living older persons. Am J Epidemiol. 2013;178(3):418-25.
16. Close JC, Lord SR, Antonova EJ, Martin M, Lensberg B, Taylor M, et al. Older people presenting to the emergency department after a fall: a population with substantial recurrent healthcare use. Emerg Med J. 2012;29(9):742-7.

17. Nordström P, Eklund F, Björnstig U, Nordström A, Lorentzon R, Sievänen H, et al. Do both areal BMD and injurious falls explain the higher incidence of fractures in women than in men? Calcif Tissue Int. 2011;89(3):203-10.
18. Tinetti ME, Doucette J, Claus E, Marottoli R. Risk factors for serious injury during falls by older persons in the community. J Am Geriatr Soc. 1995;43(11):1214-21.
19. Fletcher PC, Guthrie DM, Berg K, Hirdes JP. Risk factors for restriction in activity associated with fear of falling among seniors within the community. J Patient Saf. 2010;6(3):187-91.
20. O'Neill S, Brady RR, Kerssens JJ, Parks RW. Mortality associated with traumatic injuries in the elderly: a population based study. Arch Gerontol Geriatr. 2012;54(3):e426-30.
21. Talbot LA, Musiol RJ, Witham EK, Metter EJ. Falls in young, middle-aged and older community dwelling adults: perceived cause, environmental factors and injury. BMC Public Health. 2005;5:86.
22. Bailey C, Jones D, Goodall D. What is the evidence of the experience of having a fall across the life course? A qualitative synthesis. Disability and Health Journal. 2014;7(3):273-84.
23. Shumway-Cook A, Woollacott M. Development of postural control. In: *Motor control. Translating research into clinical practice*. 4th ed. Baltimore: Lippincott Williams & Wilkins; 2012.
24. Wood BH, Bilclough JA, Bowron A, Walker RW. Incidence and prediction of falls in Parkinson's disease: a prospective multidisciplinary study. J Neurol Neurosurg Psychiatry. 2002;72(6):721-5.
25. Matsuda PN, Shumway-Cook A, Bamer AM, Johnson SL, Amtmann D, Kraft GH. Falls in multiple sclerosis. American Academy of Physical Medicine and Rehabilitation. 2011;3(7):624-32; quiz 32.
26. Weerdesteyn V, de Niet M, van Duijnhoven HJ, Geurts AC. Falls in individuals with stroke. J Rehabil Res Dev. 2008;45(8):1195-213.
27. van Doorn C, Gruber-Baldini AL, Zimmerman S, Hebel JR, Port CL, Baumgarten M, et al. Dementia as a risk factor for falls and fall injuries among nursing home residents. J Am Geriatr Soc. 2003;51(9):1213-8.
28. Rubenstein LZ, Josephson KR, Robbins AS. Falls in the nursing home. Ann Intern Med. 1994;121(6):442-51.
29. Rapp K, Becker C, Cameron ID, König HH, Büchele G. Epidemiology of falls in residential aged care: analysis of more than 70,000 falls from residents of bavarian nursing homes. J Am Med Dir Assoc. 2012;13(2):187.e1-6.
30. Peel NM. Epidemiology of Falls in Older Age. Can J Aging. 2011:1-13.
31. Rapp K, Freiberger E, Todd C, Klenk J, Becker C, Denkinger M, et al. Fall incidence in Germany: results of two population-based studies, and comparison of retrospective and prospective falls data collection methods. BMC Geriatr. 2014;14:105.
32. Delbaere K, Close JC, Heim J, Sachdev PS, Brodaty H, Slavin MJ, et al. A multifactorial approach to understanding fall risk in older people. J Am Geriatr Soc. 2010;58(9):1679-85.

33. Tinetti ME, Kumar C. The patient who falls: "It's always a trade-off". JAMA. 2010;303(3):258-66.
34. WHO: Global Report on Falls Prevention in Older Age. Geneva, Switzerland: World Health Organization. 2007. [Cited 2014 November 14]. Available from: www.who.int/ageing/projects/falls_prevention_older_age/en/.
35. Statistics Sweden (SCB). Statistisk årsbok (in Swedish). Stockholm: Statistiska Centralbyrån; 2014.
36. Davey A, Malmberg B, Sundström G. Aging in Sweden: local variation, local control. Gerontologist. 2014;54(4):525-32.
37. Christensen K, Doblhammer G, Rau R, Vaupel JW. Ageing populations: the challenges ahead. Lancet. 2009;374(9696):1196-208.
38. Skelton DA, Hauer K, Lamb S. Re: 'falls definition validation'. Age Ageing. 2007;36(1):111-2.
39. The prevention of falls in later Life. A report of the Kellogg International work Group. Copenhagen: Lægeforeningens Forlag; 1987.
40. Hauer K, Lamb SE, Jorstad EC, Todd C, Becker C, PROFANE-Group. Systematic review of definitions and methods of measuring falls in randomised controlled fall prevention trials. Age Ageing. 2006;35(1):5-10.
41. Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults: a review of the literature. Maturitas. 2013;75(1):51-61.
42. Masud T, Morris RO. Epidemiology of falls. Age Ageing. 2001;30 Suppl 4:3-7.
43. Nevitt MC, Cummings SR, Kidd S, Black D. Risk factors for recurrent nonsyncopal falls. A prospective study. JAMA. 1989;261(18):2663-8.
44. Gangavati A, Hajjar I, Quach L, Jones RN, Kiely DK, Gagnon P, et al. Hypertension, orthostatic hypotension, and the risk of falls in a community-dwelling elderly population: the maintenance of balance, independent living, intellect, and zest in the elderly of Boston study. J Am Geriatr Soc. 2011;59(3):383-9.
45. Pijpers E, Ferreira I, de Jongh RT, Deeg DJ, Lips P, Stehouwer CD, et al. Older individuals with diabetes have an increased risk of recurrent falls: analysis of potential mediating factors: the Longitudinal Ageing Study Amsterdam. Age Ageing. 2012;41(3):358-65.
46. Tinetti ME, Williams CS. Falls, injuries due to falls, and the risk of admission to a nursing home. N Engl J Med. 1997;337(18):1279-84.
47. Pless IB, Hagel BE. Injury prevention: a glossary of terms. J Epidemiol Community Health. 2005;59(3):182-5.
48. Schwenk M, Lauenroth A, Stock C, Moreno RR, Oster P, McHugh G, et al. Definitions and methods of measuring and reporting on injurious falls in randomised controlled fall prevention trials: a systematic review. BMC Med Res Methodol. 2012;12:50.
49. Stel VS, Smit JH, Pluijm SM, Lips P. Consequences of falling in older men and women and risk factors for health service use and functional decline. Age Ageing. 2004;33(1):58-65.
50. Davis JC, Robertson MC, Ashe MC, Liu-Ambrose T, Khan KM, Marra CA. International comparison of cost of falls in older adults living in the community: a systematic review. Osteoporos Int. 2010;21(8):1295-306.

51. Schyllander J. Fallolyckor: statistik och analys [Injurious falls: statistics and analysis]. Karlstad: Swedish Civil Contingencies Agency, 2014.
52. Nevitt MC, Cummings SR, Hudes ES. Risk factors for injurious falls: a prospective study. J Gerontol. 1991;46(5):M164-70.
53. Tinetti ME. Factors associated with serious injury during falls by ambulatory nursing home residents. J Am Geriatr Soc. 1987;35(7):644-8.
54. Sterling DA, O'Connor JA, Bonadies J. Geriatric falls: injury severity is high and disproportionate to mechanism. J Trauma. 2001;50(1):116-9.
55. Nilson F, Moniruzzaman S, Andersson R. Fall-related fracture trends among elderly in Sweden - exploring transitions among hospitalized cases. J Safety Res. 2013;45:141-5.
56. Bloem BR, Steijns JA, Smits-Engelsman BC. An update on falls. Curr Opin Neurol. 2003;16(1):15-26.
57. Rohde G, Haugeberg G, Mengshoel AM, Moum T, Wahl AK. Two-year changes in quality of life in elderly patients with low-energy hip fractures. A case-control study. BMC Musculoskelet Disord. 2010;11:226.
58. Rapp K, Becker C, Lamb SE, Icks A, Klenk J. Hip fractures in institutionalized elderly people: incidence rates and excess mortality. J Bone Miner Res. 2008;23(11):1825-31.
59. Lord SR, Sherrington C, Menz H, Close J. Environmental risk factors for falls. In: *Falls in older people: risk factors and strategies for prevention*. 2nd ed. Cambridge: Cambridge University Press; 2007.
60. Tinetti ME, Liu WL, Claus EB. Predictors and prognosis of inability to get up after falls among elderly persons. JAMA. 1993;269(1):65-70.
61. Fleming J, Brayne C, Cambridge City over-75s Cohort (CC75C) study collaboration. Inability to get up after falling, subsequent time on floor, and summoning help: prospective cohort study in people over 90. BMJ. 2008;337:a2227.
62. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med. 1988;319(26):1701-7.
63. Deandrea S, Lucenteforte E, Bravi F, Foschi R, La Vecchia C, Negri E. Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. Epidemiology. 2010;21(5):658-68.
64. Close JC, Lord SL, Menz HB, Sherrington C. What is the role of falls? Best Pract Res Clin Rheumatol. 2005;19(6):913-35.
65. Connell BR, Wolf SL. Environmental and behavioral circumstances associated with falls at home among healthy elderly individuals. Atlanta FICSIT Group. Arch Phys Med Rehabil. 1997;78(2):179-86.
66. Geusens P, Dinant G. Integrating a gender dimension into osteoporosis and fracture risk research. Gend Med. 2007;4 Suppl B:S147-61.
67. Bartlett G, Abrahamowicz M, Grad R, Sylvestre MP, Tamblyn R. Association between risk factors for injurious falls and new benzodiazepine prescribing in elderly persons. BMC Fam Pract. 2009;10:1.
68. Ayoung-Chee P, McIntyre L, Ebel BE, Mack CD, McCormick W, Maier RV. Long-term outcomes of ground-level falls in the elderly. J Trauma Acute Care Surg. 2014;76(2):498-503.

69. Järvinen TL, Sievänen H, Khan KM, Heinonen A, Kannus P. Shifting the focus in fracture prevention from osteoporosis to falls. BMJ. 2008;336(7636):124-6.
70. Sambrook P, Cooper C. Osteoporosis. Lancet. 2006;367(9527):2010-8.
71. Aspray TJ. New horizons in fracture risk assessment. Age Ageing. 2013;42(5):548-54.
72. Kanis JA, Melton LJ, Christiansen C, Johnston CC, Khaltaev N. The diagnosis of osteoporosis. J Bone Miner Res. 1994;9(8):1137-41.
73. Kanis JA, Johnell O, Oden A, Johansson H, McCloskey E. FRAX and the assessment of fracture probability in men and women from the UK. Osteoporos Int. 2008;19(4):385-97.
74. Bergland A, Pettersen AM, Laake K. Falls reported among elderly Norwegians living at home. Physiother Res Int. 1998;3(3):164-74.
75. Lamb SE, Jørstad-Stein EC, Hauer K, Becker C, Prevention of Falls Network Europe and Outcomes Consensus Group. Development of a common outcome data set for fall injury prevention trials: the Prevention of Falls Network Europe consensus. J Am Geriatr Soc. 2005;53(9):1618-22.
76. Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society. Summary of the Updated American Geriatrics Society/British Geriatrics Society Clinical practice guideline for prevention of falls in older persons. J Am Geriatr Soc. 2011;59:148-57.
77. Filiatrault J, Belley A-M, Laforest S, Gauvin L, Richard L D, J, Parisien M, et al. Fear of falling among seniors: A target to consider in occupational and physical therapy practice? Physical & Occupational Therapy in Geriatrics. 2013;3(31):197-213.
78. Reelick MF, van Iersel MB, Kessels RP, Rikkert MG. The influence of fear of falling on gait and balance in older people. Age Ageing. 2009;38(4):435-40.
79. Tinetti ME, Powell L. Fear of falling and low self-efficacy: a case of dependence in elderly persons. J Gerontol. 1993;48 Spec No:35-8.
80. Murphy SL, Williams CS, Gill TM. Characteristics associated with fear of falling and activity restriction in community-living older persons. J Am Geriatr Soc. 2002;50(3):516-20.
81. Lach HW. Incidence and risk factors for developing fear of falling in older adults. Public Health Nursing. 2005;22(1):45-52.
82. Clemson L, Kendig H, Mackenzie L, Browning C. Predictors of Injurious Falls and Fear of Falling Differ: An 11-Year Longitudinal Study of Incident Events in Older People. J Aging Health. 2014 Aug 12. [Epub ahead of print]
83. Denkinger MD, Lukas A, Nikolaus T, Hauer K. Factors Associated with Fear of Falling and Associated Activity Restriction in Community-Dwelling Older Adults: A Systematic Review. Am J Geriatr Psychiatry. 2015;23(1):72-86.
84. Yardley L. Fear of falling: links between imbalance and anxiety. Reviews in Clinical Gerontology. 2004;13:195-201.
85. Hadjistavropoulos T, Delbaere K, Fitzgerald TD. Reconceptualizing the role of fear of falling and balance confidence in fall risk. Journal of Aging & Health. 2011;23(1):3-23.

86. Young WR, Mark Williams A. How fear of falling can increase fall-risk in older adults: Applying psychological theory to practical observations. Gait Posture. 2015;41(1):7-12.
87. Lawrence RH, Tennstedt SL, Kasten LE, Shih J, Howland J, Jette AM. Intensity and correlates of fear of falling and hurting oneself in the next year: baseline findings from a Roybal Center fear of falling intervention. J Aging Health. 1998;10(3):267-86.
88. Tinetti ME, Richman D, Powell L. Falls efficacy as a measure of fear of falling. J Gerontol. 1990;45(6):P239-43.
89. Jørstad EC, Hauer K, Becker C, Lamb SE, Group P. Measuring the psychological outcomes of falling: a systematic review. J Am Geriatr Soc. 2005;53(3):501-10.
90. Lachman ME, Howland J, Tennstedt S, Jette A, Assmann S, Peterson EW. Fear of falling and activity restriction: the survey of activities and fear of falling in the elderly (SAFE). J Gerontol B Psychol Sci Soc Sci. 1998;53(1):P43-50.
91. Austin N, Devine A, Dick I, Prince R, Bruce D. Fear of falling in older women: a longitudinal study of incidence, persistence, and predictors. J Am Geriatr Soc. 2007;55(10):1598-603.
92. Zijlstra GA, van Haastregt JC, van Eijk JT, van Rossum E, Stalenhoef PA, Kempen GI. Prevalence and correlates of fear of falling, and associated avoidance of activity in the general population of community-living older people. Age Ageing. 2007;36(3):304-9.
93. Rossat A, Fantino B, Nitenberg C, Annweiler C, Poujol L, Herrmann FR, et al. Risk factors for falling in community-dwelling older adults: which of them are associated with the recurrence of falls? J Nutr Health Aging. 2010;14(9):787-91.
94. Bergström U, Björnstig U, Stenlund H, Jonsson H, Svensson O. Fracture mechanisms and fracture pattern in men and women aged 50 years and older: a study of a 12-year population-based injury register, Umeå, Sweden. Osteoporos Int. 2008;19(9):1267-73.
95. Hedman AM, Fonad E, Sandmark H. Older people living at home: associations between falls and health complaints in men and women. J Clin Nurs. 2013;22(19-20):2945-52.
96. Wurzer B, Waters DL, Hale LA, Leon de la Barra S. Long-term participation in peer-led fall prevention classes predicts lower fall incidence. Arch Phys Med Rehabil. 2014;95(6):1060-6.
97. Yardley L, Todd C. Encouraging positive attitudes to falls prevention in later life: a report for Help the Aged. London: Help the Aged; 2005.
98. Bunn F, Dickinson A, Barnett-Page E, Mcinnes E, Horton K. A systematic review of older people's perceptions of facilitators and barriers to participation in falls-prevention interventions. Ageing & Society. 2008;28:449-72.
99. Shubert TE. Evidence-based exercise prescription for balance and falls prevention: a current review of the literature. J Geriatr Phys Ther. 2011;34(3):100-8.
100. Lamb SE, Becker C, Gillespie LD, Smith JL, Finnegan S, Potter R, et al. Reporting of complex interventions in clinical trials: development of a taxonomy to classify and describe fall-prevention interventions. Trials. 2011;12:125.
101. Rose DJ. Preventing falls among older adults: no "one size suits all" intervention strategy. J Rehabil Res Dev. 2008;45(8):1153-66.

102. Gillespie LD, Robertson MC, Gillespie WJ, Sherrington C, Gates S, Clemson LM, et al. Interventions for preventing falls in older people living in the community. Cochrane Database Syst Rev. 2012;9:CD007146.
103. Sherrington C, Tiedemann A, Fairhall N, Close JC, Lord SR. Exercise to prevent falls in older adults: an updated meta-analysis and best practice recommendations. N S W Public Health Bull. 2011;22(3-4):78-83.
104. Iliffe S, Kendrick D, Morris R, Masud T, Gage H, Skelton D, et al. Multicentre cluster randomised trial comparing a community group exercise programme and home-based exercise with usual care for people aged 65 years and over in primary care. Health Technol Assess. 2014;18(49):vii-xxvii, 1-105.
105. Bean JF, Vora A, Frontera WR. Benefits of exercise for community-dwelling older adults. Arch Phys Med Rehabil. 2004;85 (7 Suppl 3)
106. Skelton DA, Beyer N. Exercise and injury prevention in older people. Scand J Med Sci Sports. 2003;13(1):77-85.
107. Kendrick D, Kumar A, Carpenter H, Zijlstra GA, Skelton DA, Cook JR, et al. Exercise for reducing fear of falling in older people living in the community. Cochrane Database Syst Rev. 2014;11:CD009848.
108. Yardley L, Kirby S, Ben-Shlomo Y, Gilbert R, Whitehead S, Todd C. How likely are older people to take up different falls prevention activities? Prev Med. 2008;47(5):554-8.
109. Horne M, Speed S, Skelton D, Todd C. What do community-dwelling Caucasian and South Asian 60-70 year olds think about exercise for fall prevention? Age Ageing. 2009;38(1):68-73.
110. McInnes E, Askie L. Evidence review on older people's views and experiences of falls prevention strategies. Worldviews Evid Based Nurs. 2004;1(1):20-37.
111. Merom D, Pye V, Macniven R, van der Ploeg H, Milat A, Sherrington C, et al. Prevalence and correlates of participation in fall prevention exercise/physical activity by older adults. Prev Med. 2012;55(6):613-7.
112. Buttery AK, Husk J, Lowe D, Treml J, Vasilakis N, Riglin J. Older people's experiences of therapeutic exercise as part of a falls prevention service: survey findings from England, Wales and Northern Ireland. Age Ageing. 2014;43(3):369-74.
113. Nyman SR, Victor CR. Older people's participation in and engagement with falls prevention interventions in community settings: an augment to the Cochrane systematic review. Age Ageing. 2012;41(1):16-23.
114. Yardley L, Bishop FL, Beyer N, Hauer K, Kempen GI, Piot-Ziegler C, et al. Older people's views of falls-prevention interventions in six European countries. Gerontologist. 2006;46(5):650-60.
115. Yardley L, Beyer N, Hauer K, McKee K, Ballinger C, Todd C. Recommendations for promoting the engagement of older people in activities to prevent falls. Qual Saf Health Care. 2007;16(3):230-4.
116. Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. Lancet. 2003;362(9391):1225-30.
117. Phillips EM, Schneider JC, Mercer GR. Motivating elders to initiate and maintain exercise. Arch Phys Med Rehabil. 2004;85 (7 Suppl 3).

118. Guerin E, Bales E, Sweet S, Fortier M. A Meta-Analysis of the Influence of Gender on Self-Determination Theory's Motivational Regulations for Physical Activity. Canadian Psychology-Psychologie Canadienne. 2012;53(4):291-300.
119. Ejupi A, Lord SR, Delbaere K. New methods for fall risk prediction. Curr Opin Clin Nutr Metab Care. 2014;17(5):407-11.
120. Gschwind YJ, Eichberg S, Marston HR, Ejupi A, Rosario H, Kroll M, et al. ICT-based system to predict and prevent falls (iStoppFalls): study protocol for an international multicenter randomized controlled trial. BMC Geriatr. 2014;14:91.
121. Klenk J, Chiari L, Helbostad JL, Zijlstra W, Aminian K, Todd C, et al. Development of a standard fall data format for signals from body-worn sensors : the FARSEEING consensus. Z Gerontol Geriatr. 2013;46(8):720-6.
122. Schwickert L, Becker C, Lindemann U, Maréchal C, Bourke A, Chiari L, et al. Fall detection with body-worn sensors : a systematic review. Z Gerontol Geriatr. 2013;46(8):706-19.
123. Joseph RP, Durant NH, Benitez TJ, Pekmezi DW. Internet-Based Physical Activity Interventions. Am J Lifestyle Med. 2014;8(1):42-68.
124. van Het Reve E, Silveira P, Daniel F, Casati F, de Bruin ED. Tablet-based strength-balance training to motivate and improve adherence to exercise in independently living older people: part 2 of a phase II preclinical exploratory trial. J Med Internet Res. 2014;16(6):e159.
125. Whitehead SH, Nyman SR, Broaders F, Skelton DA, Todd CJ. The quality of English-language websites offering falls-prevention advice to older members of the public and their families. Health Informatics J. 2012;18(1):50-65.
126. Nicholls DA, Gibson BE. The body and physiotherapy. Physiother Theory Pract. 2010 Nov;26(8):497-509. PubMed PMID: 20795873. eng.
127. Shumway-Cook A, Woollacott M. Motor Control: Issues and Theories. In: *Motor control. Translating research into Clinical practice*. 4th ed. Baltimore: Lippincott Williams & Wilkins; 2012.
128. Miller PH. Theories of developmental psychology. Johanneshov: MTM; 2014. [Cited 2014 October 18] Available from: http://www.legimus.se/work/redirect?MedieNr=CA13014
129. Holt KG, Wagenaar RO, Saltzman E. A dynamic systems/constraints approach to rehabilitation. Rev Bras Fisioter. 2010;14(6):446-63.
130. Thelen E. Dynamic systems theory and the complexity of change. Psychoanalytic Dialogues. 2005;15(2):255-83.
131. Shumway-Cook A, Woollacott M. Aging and postural control. In: *Motor Control. Translating Research into Clinical Practice*. 4th ed. Baltimore: Lippincott Williams & Wilkins; 2012.
132. Levac D, DeMatteo C. Bridging the gap between theory and practice: dynamic systems theory as a framework for understanding and promoting recovery of function in children and youth with acquired brain injuries. Physiother Theory Pract. 2009;25(8):544-54.
133. Women, ageing and health: a framework for action. Geneva: WHO; 2007.
134. Ohman A. Global public health and gender theory: the need for integration. Scand J Public Health. 2008;36(5):449-51.

135. Gustafson PE. Gender differences in risk perception: theoretical and methodological perspectives. Risk Anal. 1998;18(6):805-11.
136. Phillips SP. Including gender in public health research. Public Health Rep. 2011;126 Suppl 3:16-21.
137. Connell R. Gender. Cambridge: Policy Press; 2002.
138. West C, Zimmerman D. "Doing Gender". Gender & Society. 1987;2(1):125-51.
139. Foster L, Walker A. Gender and active ageing in Europe. European Journal of Ageing. 2013;10(1):3-10.
140. Connell R. Gender, health and theory: Conceptualizing the issue, in local and world perspective. Soc Sci Med. 2011;74(11):1675-83
141. Calasanti T. Gender relations and applied research on aging. Gerontologist. 2010;50(6):720-34.
142. Springer KW, Hankivsky O, Bates LM. Gender and health: Relational, intersectional, and biosocial approaches. Soc Sci Med. 2012;74(11):1661-6.
143. Resnick B. Geriatric rehabilitation: the influence of efficacy beliefs and motivation. Rehabil Nurs. 2002;27(4):152-9.
144. McGrane N, Galvin R, Cusack T, Stokes E. Addition of motivational interventions to exercise and traditional Physiotherapy: a review and meta-analysis. Physiotherapy. 2014 Jun 2. [Epub ahead of print]
145. Ryan RM, Deci EL. Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. Contemp Educ Psychol. 2000;25(1):54-67.
146. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol. 2000;55(1):68-78.
147. Nordin E. Assessment of balance control in relation to fall risk among older people. Dissertation. Umeå: Umeå University; 2008. 95 p.
148. Andersen P, RD G. Cox's regression model for counting processes: a large sample study. Annals of Statistics. 1982;10:1100-20.
149. Kleinbaum D, Klein M. Survival Analysis: A Self-Learning Text. 3rd ed. New York, NY: Springer New York; 2012.
150. Thabane L, Mbuagbaw L, Zhang S, Samaan Z, Marcucci M, Ye C, et al. A tutorial on sensitivity analyses in clinical trials: the what, why, when and how. BMC Med Res Methodol. 2013;13:92.
151. Brown T. Confirmatory factor analysis for applied research. New York: Guilford Press; 2006.
152. WHO. Towards a common language. ICF. Geneva, Switzerland: World Health Organization; 2002.
153. Scherer MJ, DiCowden MA. Organizing future research and intervention efforts on the impact and effects of gender differences on disability and rehabilitation: the usefulness of the International Classification of functioning, Disability and Health (ICF). Disabil Rehabil. 2008;30(3):161-5.
154. Powell LE, Myers AM. The Activities-specific Balance Confidence (ABC) Scale. J Gerontol A Biol Sci Med Sci. 1995;50A(1):M28-34.
155. Cieza A, Geyh S, Chatterji S, Kostanjsek N, Ustün B, Stucki G. ICF linking rules: an update based on lessons learned. J Rehabil Med. 2005;37(4):212-8.
156. Browne M, Cudeck R. Alternative ways of assessing model fit. Newbury Park, CA: Sage; 1993.

157. Carmines E, McIver J. Analyzing models with unobserved variables: Analysis of covariance structures. Thousand Oaks, CA: Sage publications; 1981.
158. Andersson E. Malmens manliga mysterium: en interaktiv studie om kön och tradition i modernt gruvarbete [The male mystery of the Ore: an interactive study on gender and tradition in modern mining]. Dissertation. Luleå: Luleå University of Technology; 2012.
159. Reason P, Bradbury H. The SAGE handbook of action research participative inquiry and practice. Los Angeles, SAGE; 2008.
160. Hummelvoll J. The multistage focus group interview. Norsk Tidsskrift for Sykepleieforskning. 2008;1(10):3-14.
161. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care. 2007;19(6):349-57.
162. Pope C, Mays N. Reaching the parts other methods cannot reach: an introduction to qualitative methods in health and health services research. BMJ. 1995;311(6996):42-5.
163. Tomioka K, Iwamoto J, Saeki K, Okamoto N. Reliability and validity of the International Physical Activity Questionnaire (IPAQ) in elderly adults: the Fujiwara-kyo Study. J Epidemiol. 2011;21(6):459-65.
164. Barbour RS, Kitzinger J. Developing focus group research : politics, theory and practice. London: SAGE; 1999.
165. Ghaye T, Melander-Wikman A, Kisare M, Chambers P, Bergmark U, Kostenius C. Participatory and appreciative action and reflection (PAAR) - democratizing reflective practices. Reflective Practice. 2008;9(4):361-97.
166. Wang C, Burris MA. Photovoice: concept, methodology, and use for participatory needs assessment. Health Educ Behav. 1997;24(3):369-87.
167. Wang CC. Photovoice: a participatory action research strategy applied to women's health. J Womens Health. 1999;8(2):185-92.
168. Cooper A. The inmates are running the asylum. Indianapolis, Ind.: Sams; 2004.
169. Rush KL, Murphy MA, Kozak JF. A photovoice study of older adults' conceptualizations of risk. J Aging Stud. 2012;26(4):448-58.
170. Graneheim UH, Lundman B. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. Nurse Educ Today. 2004;24(2):105-12.
171. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. Qual Health Res. 2005;15(9):1277-88.
172. Schreier M. Qualitative content analysis in practice. Los Angeles: SAGE; 2012.
173. OpenCode 4.0. UMDAC and division of Epidemiology and Public Health Sciences. Sweden: Department of Public Health and Clinical Medicine at Umeå University. [Accessed 2013 Mar 15]. Available from: http://www.phmed.umu.se/enheter/epidemiologi/forskning/open-code/
174. Tinetti ME. Clinical practice. Preventing falls in elderly persons. N Engl J Med. 2003;348(1):42-9.
175. Stevens JA, Sogolow ED. Gender differences for non-fatal unintentional fall related injuries among older adults. Inj Prev. 2005;11(2):115-9.

176. Koski K, Luukinen H, Laippala P, Kivela SL. Physiological factors and medications as predictors of injurious falls by elderly people: a prospective population-based study. Age Ageing. 1996;25(1):29-38.
177. Horne M, Skelton D, Speed S, Todd C. The influence of primary health care professionals in encouraging exercise and physical activity uptake among White and South Asian older adults: experiences of young older adults. Patient Educ Couns. 2010;78(1):97-103.
178. Schutzer KA, Graves BS. Barriers and motivations to exercise in older adults. Prev Med. 2004;39(5):1056-61.
179. Hoogeboom TJ, Kittelson AJ, van der Sluis G, van Meeteren NL. Evidence-based practice in physiotherapy: time to involve the patient? Physiotherapy. 2014;100(4):363-4.
180. Cummings SR, Melton LJ. Epidemiology and outcomes of osteoporotic fractures. Lancet. 2002;359(9319):1761-7.
181. Fausto-Sterling A. The Bare Bones of Sex: Part 1 - Sex and Gender. Journal of Women in Culture and Society. 2005;30(2):1491-527.
182. Scheffer AC, Schuurmans MJ, van Dijk N, van der Hooft T, de Rooij SE. Fear of falling: measurement strategy, prevalence, risk factors and consequences among older persons. Age Ageing. 2008;37(1):19-24.
183. Donoghue OA, Ryan H, Duggan E, Finucane C, Savva GM, Cronin H, et al. Relationship between fear of falling and mobility varies with visual function among older adults. Geriatr Gerontol Int. 2014;14(4):827-36.
184. Delbaere K, Close JC, Brodaty H, Sachdev P, Lord SR. Determinants of disparities between perceived and physiological risk of falling among elderly people: cohort study. BMJ. 2010;341:c4165.
185. Butler AA, Lord SR, Taylor JL, Fitzpatrick RC. Ability Versus Hazard: Risk-Taking and Falls in Older People. J Gerontol A Biol Sci Med Sci. 2014 Nov 11. [Epub ahead of print].
186. Jefferis BJ, Iliffe S, Kendrick D, Kerse N, Trost S, Lennon LT, et al. How are falls and fear of falling associated with objectively measured physical activity in a cohort of community-dwelling older men? BMC Geriatr. 2014;14:114.
187. Courtenay WH. Constructions of masculinity and their influence on men's well-being: a theory of gender and health. Soc Sci Med. 2000;50(10):1385-401.
188. Myers AM, Powell LE, Maki BE, Holliday PJ, Brawley LR, Sherk W. Psychological indicators of balance confidence: relationship to actual and perceived abilities. J Gerontol A Biol Sci Med Sci. 1996;51(1):M37-43.
189. Twenge JM. Changes in women's assertiveness in response to status and roles: a cross-temporal meta-analysis, 1931-1993. J Pers Soc Psychol. 2001;81(1):133-45.
190. Lord SR, Sherrington C, Menz H, Close J. Postural stability and falls. In: *Falls in older people: risk factors and strategies for prevention*. 2nr ed. Cambridge: Cambridge University Press; 2007.
191. Kelsey JL, Procter-Gray E, Hannan MT, Li W. Heterogeneity of falls among older adults: implications for public health prevention. Am J Public Health. 2012;102(11):2149-56.

192. Skalska A, Wizner B, Piotrowicz K, Klich-Rączka A, Klimek E, Mossakowska M, et al. The prevalence of falls and their relation to visual and hearing impairments among a nation-wide cohort of older Poles. Exp Gerontol. 2013;48(2):140-6.
193. Li W, Keegan TH, Sternfeld B, Sidney S, Quesenberry CP, Kelsey JL. Outdoor falls among middle-aged and older adults: a neglected public health problem. Am J Public Health. 2006;96(7):1192-200.
194. Tinetti ME, Baker DI, King M, Gottschalk M, Murphy TE, Acampora D, et al. Effect of dissemination of evidence in reducing injuries from falls. N Engl J Med. 2008;359(3):252-61.
195. Calhoun R, Meischke H, Hammerback K, Bohl A, Poe P, Williams B, et al. Older adults' perceptions of clinical fall prevention programs: a qualitative study. J Aging Res. 2011. doi: 10.4061/2011/867341
196. Calasanti T, KF S, King N. Ageism and Feminism: From "Et Cetera" to Center. Feminist Formations. 2006;18(1):13-30.
197. Herr K, Anderson GL. The action research dissertation: a guide for students and faculty. Thousand Oaks, California: Sage; 2005.
198. Domholdt E. Rehabilitation research: principles and applications. 3rd ed. St. Louis, Mo: Elsevier Saunders; 2005.
199. Rolfe G. Validity, trustworthiness and rigour: quality and the idea of qualitative research. J Adv Nurs. 2006;53(3):304-10.
200. Donaldson MG, Sobolev B, Cook WL, Janssen PA, Khan KM. Analysis of recurrent events: a systematic review of randomised controlled trials of interventions to prevent falls. Age Ageing. 2009;38(2):151-5.
201. Anaby D, Miller WC, Eng JJ, Jarus T, Noreau L, Group PR. Can personal and environmental factors explain participation of older adults? Disabil Rehabil. 2009;31(15):1275-82.
202. Barbour RS. Making sense of focus groups. Med Educ. 2005;39(7):742-50.
203. Kitzinger J. Qualitative research. Introducing focus groups. BMJ. 1995;311(7000):299-302.

Dissertations written by physiotherapists, Umeå University 1989–2014

1. Birgitta Bergman. Being a physiotherapist - Professional role, utilization of time and vocational strategies. Umeå University Medical Dissertations, New Series no 251, 1989 (Department of Physical Medicine and Rehabilitation)

2. Inger Wadell. Influences from peripheral sense organs on primary and secondary spindle afferents via gamma-motoneurones - A feedback mechanism for motor control and regulation of muscle stiffness. Umeå University Medical Dissertations, New Series no 307, 1991 (Department of Physiology)

3. Jessica Elert. The pattern of activation and relaxation during fatiguing isocinetic contractions in subjects with and without muscle pain. Arbete och hälsa 1991:47. Diss. 1992 (sammanfattning). (Departments of Clinical Physiology, National Institute of Occupational Health and Physical Medicine and Rehabilitation)

4. Gunnevi Sundelin. Electromyography of shoulder muscles - The effects of pauses, drafts and repetitive work cycles. Arbete och Hälsa, 1992:16. Diss. (sammanfattning). (Departments of Anatomy, National Institute of Occupational Health, Division of Work and Environmental Physiology, Divisions of Occupational Medicine and Applied Work Physiology and Occupational Medicine)

5. Birgit Rösblad. Visual and proprioceptive control of arm movement - Studies of development and dysfunction. Diss. (sammanfattning) 1994 (Department of Paediatrics)

6. Charlotte Häger-Ross. To grip and not to slip - Sensorimotor mechanisms during reactive control of grasp stability. Umeå University Medical Dissertations, New Series no 429, 1995 (Department of Physiology)

7. Lars Nyberg. Falls in the frail elderly – Incidence, characterics and prediction with special reference to patients with stroke and hip fractures. Umeå Medical Dissertations, New Series no 483, 1996 (Department of Geriatric Medicine)

8. Margareta Barnekow-Bergkvist. Physical capacity, physical activity and health -A population based fitness study of adolescents with an 18-year follow-up. Umeå University Medical Dissertations, New Series no 494, 1997 (Departments of Physiology and Technology, National Institute for Working Life and Epidemiology and Public Health)

9. Britta Lindström. Knee muscle function in healthy persons and patients with upper motor neurone syndrome. Umeå University Medical Dissertations, New Series no 505, 1997 (Departments of Physical Medicine and Rehabilitation and Clinical Neuroscience)

10. Monica Mattsson. Body Awareness - applications in physiotherapy. Umeå University Medical Dissertations, New Series no 543, 1998 (Departments of Psychiatry and Family Medicine)

11. Hildur Kalman. The structure of knowing. Existential trust as an epistemological category. Umeå studies in the humanities. 145, 1999 (Department of Philosophy and Linguistics)

12. Hamayun Zafar. Integrated jaw and neck function in man: studies of mandibular and head-neck movements during jaw opening-closing tasks. Umeå University Medical Dissertations, New series no 74, 2000 (Departments of Odontology, Clinical Oral Physiology and Centre for Musculoskeletal Research, National Institute for Working Life, Umeå)

13. Lillemor Lundin-Olsson. Prediction and prevention of falls among elderly people in residential care. Umeå University Medical Dissertations, New Series no 671, 2000 (Department of Community Medicine and Rehabilitation, Physiotherapy and Geriatric Medicine)

14. Christina Ahlgren. Aspects of rehabilitation – with focus on women with trapezius myalgia. Umeå University Medical Dissertations, New Series no 715, 2001 (Department of Public Health and Clinical Medicine, Occupational Medicine)

15. Ann Öhman. Profession on the move - changing conditions and gendered development in physiotherapy. Umeå University Medical Dissertations, New series No 730, 2001 (Departments

of Community Medicine and Rehabilitation, Physiotherapy and Public Health and Clinical Medicine, Epidemiology)

16. Kerstin Söderman. The female soccer player – Injury pattern, risk factors and intervention. Umeå University Medical Dissertations, New series no 735, 2001 (Departments of Surgical and Perioperative Sciences, Sports Medicine, and Community Medicine and Rehabilitation, Physiotherapy)

17. Lena Grönblom-Lundström. Rehabilitation in light of different theories of health. Outcome for patients with low-back complaints – a theoretical discussion. Umeå University Medical Dissertations, New series no 760, 2001 (Departments of Public Health and Clinical Medicine, Epidemiology, and Community Medicine and Rehabilitation, Social Medicine)

18. Kerstin Waling. Pain in women with work-related trapezius myalgia. Intervention effects and variability. Umeå University Medical Dissertations, New series no 762, 2001 (Departments of Public Health and Clinical Medicine, Occupational Medicine, and Community Medicine and Rehabilitation, Physiotherapy)

19. Eva-Britt Malmgren-Olsson. Health problems and treatment effects in patients with non-specific musculoskeletal disorders. A comparitson between Body Awareness Therapy, Feldenkrais and Individual Physiotherapy. Umeå University Medical Dissertations, New series no 774, 2002 (Department of Community Medicine and Rehabilitation, Physiotherapy and Department of Psychology)

20. Jane Jensen. Fall and injury prevention in older people living in residential care facilities. Umeå University Medical Dissertations, New series no 812, 2003 (Department of Community Medicine and Rehabilitation, Physiotherapy and Geriatric Medicine)

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24. Karin Wadell. Physical training in patients with chronic obstructive pulmonary disease – COPD. Umeå University Medical Dissertations, New series no 917, 2004 (Departments of Community Medicine and Rehabilitation, Physiotherapy; Public Health and Clinical Medicine, Respiratory Medicine and Allergy, Surgical and Perioperative Sciences, Sports Medicine)

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