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Team-based home rehabilitation after hip fracture in older adults

Effects, experiences and impact of dementia

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“I mitten av svårigheter ligger möjligheter”

Albert Einstein

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Abstract

BACKGROUND: For an older adult a hip fracture may be a traumatic and life-changing event and has shown to be associated with reduced health-related quality of life, disability and increased mortality. Previous rehabilitation studies have often excluded older adults with cognitive impairment and those living in residential care facilities, groups with an additional risk of poor outcome. Moreover, there are few randomized controlled trials that have evaluated interdisciplinary home rehabilitation after hip fracture. These studies did not include older adults with severe cognitive impairment or dementia, those with serious medical conditions, or those living in residential care.

OBJECTIVE: The aim of the thesis was to investigate the effects of early discharge followed by geriatric interdisciplinary home rehabilitation (GIHR) for older adults with hip fracture, and specifically among those with dementia, compared to in-hospital geriatric care according to a multifactorial rehabilitation program. An additional aim was to explore how older adults experienced their rehabilitation and recovery during the year following the fracture.

METHODS: The thesis evaluated a randomized controlled trial that included 205 participants with hip fracture, 70 years or older, living in ordinary housing or residential care facilities. In hospital, both the GIHR and control groups received care and rehabilitation according to a multifactorial rehabilitation program, but with the aim of early discharge for the GIHR group. The individually designed GIHR intervention focused on walking ability indoors and outdoors, independence in activities of daily living (ADL), and multifactorial fall prevention during a maximum period of 10 weeks. Participants were assessed in-hospital and at 3- and 12-month follow-up visits. Independence in walking and use of walking aids was assessed via an interview along with gait speed tests. Independence in ADL was measured using the Barthel ADL Index, and the ADL Staircase including the Katz ADL Index, and hospital length of stay (LOS) was recorded from medical charts. The effects of GIHR intervention among participants with dementia were investigated in a *post hoc* subgroup analysis where additional outcomes were falls, mortality and readmissions between discharge and 12 months. Individual interviews were conducted with 20 selected participants just after the 12-month follow-up. Data were analysed using qualitative content analysis.

RESULTS: The postoperative hospital LOS was significantly reduced by a median of six days in the GIHR group compared to the control group, although not significantly reduced in the GIHR group for participants with dementia. Binary logistic regression analyses revealed no significant differences between the GIHR and control groups regarding independent walking ability, the ability to walk

without a walking device, or independence in ADL at 3 and 12 months. Gait speed was comparable between the two groups at 3 and 12 months. At 12 months, 56% in the GIHR group and 58% in the control group had recovered their prefracture walking ability, and 41% vs. 42% in GIHR and control groups, respectively, had regained their prefracture Barthel ADL Index score. Interaction analyses showed that the GIHR group vs. the control group had comparable effects on walking ability and ADL at 3 and 12 months, and on falls and mortality between discharge and 12 months, regardless of whether the participants had dementia or not ($P \geq 0.05$ for all). The number of readmissions and hospital days after discharge was comparable between GIHR and control groups for participants with dementia. Overall, dementia was associated with significantly impaired walking ability and greater dependence in ADL at 3 and 12 months and with increased risk of falling and increased mortality between discharge and 12 months compared to participants without dementia. The interviews revealed that access to rehabilitation, provided by skilled staff, and support from others were important for participants' well-being and recovery. Participants experienced a fundamental change in their self-image after the fracture, and faced a number of difficulties, but strove for independence and used adaptive strategies to find contentment in their lives.

CONCLUSIONS: In older adults with hip fracture, early discharge followed by interdisciplinary home rehabilitation significantly reduced postoperative hospital LOS. Functional recovery during the year following the fracture was nevertheless comparable to in-hospital geriatric care according to a multifactorial rehabilitation program. The GIHR intervention seems to be appropriate also for older adults with dementia since the effects were not different in this subgroup, except for postoperative hospital LOS, which was not significantly reduced in the GIHR group for participants with dementia. Further studies with larger samples are needed to validate these results. Overall, dementia was associated with a substantial negative impact on the outcomes. According to participants' experiences, receiving rehabilitation and support after the hip fracture seems crucial for successful recovery. Negative psychological reactions were common, suggesting that future interventions should consider both physical and psychological aspects. Different rehabilitation alternatives were appreciated by the participants. Rehabilitation should thus be customised to suit wishes and needs of older adults and may accordingly be carried out in different settings, where rehabilitation in the home can be one suitable alternative. The findings of this thesis indicate that geriatric interdisciplinary home rehabilitation after hip fracture can be an alternative and a complement to in-hospital care and rehabilitation for older adults with and without dementia.

Sammanfattning på svenska

Andelen äldre i befolkningen förväntas öka i framtiden. Med stigande ålder ökar risken för fallolyckor, vilket kan leda till en höftfraktur. Konsekvenserna av en höftfraktur är ofta allvarliga. Äldre personer som har drabbats av en höftfraktur har beskrivit det som en traumatisk händelse som drastiskt förändrat deras liv och tidigare forskning visar att en höftfraktur har en negativ påverkan på äldre personers livskvalité. En stor andel återfår inte heller sin tidigare gångförmåga eller förmåga att klara aktiviteter i dagliga livet (ADL) efter frakturen. En höftfraktur innebär även en risk för medicinska komplikationer i efterförloppet som förvirring, infektioner och död. En stor andel av äldre personer med höftfraktur bor på ett särskilt boende och har en demenssjukdom. Dessa grupper har emellertid ofta uteslutits från tidigare rehabiliteringsstudier, trots att de har en ytterligare ökad risk att inte återfå sina förmågor efter en höftfraktur. Som en följd av minskade vårdplatser på sjukhusen har teambaserad hemrehabilitering utvecklats. Det finns dock få randomiserade kontrollerade studier som har utvärderat rehabiliteringsformen och dessa studier har inte inkluderat personer med svår multisjuklighet, uttalad kognitiv nedsättning eller demens eller de som bor på särskilt boende.

Syftet med avhandlingen var därför att utvärdera effekterna av teambaserad hemrehabilitering för äldre personer med höftfraktur och med ett särskilt fokus på personer med en demenssjukdom jämfört med vård och rehabilitering på sjukhus enligt ett multifaktoriellt vårdprogram. Ett ytterligare syfte var att utforska äldre personers upplevelse av sin rehabilitering under året efter höftfrakturen och hur de upplevt återhämtningsprocessen.

Avhandlingen baseras på en randomiserad kontrollerad studie som omfattade 205 deltagare, 70 år eller äldre med en nytillkommen höftfraktur. Deltagarna lottades till vård och rehabilitering på en geriatrisk rehabiliteringsavdelning på sjukhus enligt ett multifaktoriellt vårdprogram (Kontrollgrupp) eller till hemrehabilitering. Hemrehabiliteringsgruppen fick också vård enligt vårdprogrammet under tiden på sjukhus, men vårdtiden påskyndades och fortsatt vård och rehabilitering utfördes därefter i deltagarnas egna- eller särskilda boende av ett team med flera olika professioner. Insatserna anpassades utifrån deltagarnas behov och mål med rehabiliteringen, men pågick inte längre än 10 veckor. Skattning av gång- och ADL-förmåga utfördes under vårdtiden på sjukhuset och genom uppföljande bedömningar i hemmet vid tre och tolv månader. Efter studiens slut inhämtades även information från deltagarnas medicinska journaler avseende vårdtid på sjukhus. För deltagare med en demenssjukdom registrerades även fall, mortalitet och antal återinläggningar mellan utskrivning från sjukhus och 12 månader. I nära anslutning till

ettårsuppföljningen intervjuades 20 utvalda deltagare om sina upplevelser av rehabiliteringen och sin återhämtning under året efter frakturen.

Hemrehabiliteringsgruppen hade i median sex dagar kortare vårdtid på sjukhus efter frakturen jämfört med kontrollgruppen. Deltagare med en demenssjukdom hade dock inte en statistiskt kortare vårdtid. Gångförmåga, behov av gånghjälpmedel, gånghastighet och ADL-förmåga skilde sig inte mellan hemrehabiliterings- och kontrollgruppen vid tre och tolv månader. Bland deltagarna med demenssjukdom noterades inte heller några signifikanta skillnader mellan hemrehabiliterings- och kontrollgruppen avseende gångförmåga eller förmåga att utföra ADL och inte heller avseende fall, död eller antal återinläggningar. Att ha en demenssjukdom var emellertid förknippat med generellt sämre gång- och ADL-förmåga, samt en ökad risk för fall och död jämfört med deltagare utan demenssjukdom.

De 20 deltagare som intervjuades efter ettårsuppföljningen betonade vikten av att ha tillgång till rehabilitering och stöd från familj och vänner för välbefinnandet och för att uppnå en så bra återhämtning som möjligt. De beskrev att deras personlighet hade förändrats och att de hade kämpat med en rad svårigheter under året efter höftfrakturen. Trots det strävade de efter att bli så självständiga som möjligt. Det framkom att de använde olika strategier för att bemästra vardagen och för att kunna känna sig tillfreds med sina liv.

Sammanfattningsvis visar avhandlingen att hos äldre personer med höftfraktur kunde vårdtiden på sjukhus kortas, men deltagarna återfick trots det gång- och ADL-förmåga i samma utsträckning som kontrollgruppen som rehabiliterades på sjukhus enligt ett multifaktoriellt vårdprogram. Teambaserad hemrehabilitering verkar vara lämpligt även för personer med en demenssjukdom även om vårdtiden inte kunde kortas i den gruppen. Dessa resultat behöver dock bekräftas i studier med ett större antal deltagare. Generellt sett visar resultaten dock att en demenssjukdom har en stor negativ påverkan på utfallen efter en höftfraktur. Utifrån deltagarnas erfarenheter och upplevelser verkar det viktigt att rehabiliteringen anpassas till varje individs önskningar och behov. Flera olika rehabiliteringsalternativ var uppskattade, där hemrehabilitering var ett av dem. Eftersom negativa psykologiska reaktioner var vanliga efter frakturen bör framtida interventioner beakta både fysiska och psykologiska aspekter. Resultaten i avhandlingen stödjer att teambaserad hemrehabilitering efter en höftfraktur kan vara ett alternativ och ett komplement till sjukhusbaserad vård och rehabilitering för äldre personer med eller utan en demenssjukdom.

Abbreviations

ADL	Activities of daily living
CGA	Comprehensive Geriatric Assessment
CI	Cognitive impairment
CI (95%)	Confidence interval
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, 4th edition
FoF	Fear of falling
GDS	Geriatric Depression Scale
GIHR	Geriatric Interdisciplinary Home Rehabilitation
HRQOL	Health-related quality of life
HR	Home rehabilitation
IADL	Instrumental ADL
IQR	Interquartile range
LOS	Length of stay
MMSE	Mini Mental State Examination
OBS	Organic Brain Syndrome Scale
OR	Odds ratio
OT	Occupational therapist
PADL	Personal ADL
PT	Physiotherapist
RCT	Randomized controlled trial

RN	Registered nurse
SD	Standard deviation
QCA	Qualitative content analysis
WHO	World Health Organization

Original papers

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

I. Effects of Geriatric Interdisciplinary Home Rehabilitation on walking ability and length of hospital stay after hip fracture: a randomized controlled trial. Karlsson Å, Berggren M, Gustafson Y, Olofsson B, Lindelöf N, Stenvall M. J Am Med Dir Assoc. 2016;17(5): 464.e9-464.e15.

II. Effects of Geriatric Interdisciplinary Home Rehabilitation on independence in activities of daily living in older people with hip fracture: a randomized controlled trial. Karlsson Å, Lindelöf N, Olofsson B, Berggren M, Gustafson Y, Nordström P, Stenvall M. Arch Phys Med Rehabil. 2020;101(4):571-578.

III. Geriatric interdisciplinary home rehabilitation after hip fracture in people with dementia – a subgroup analysis of a randomized controlled trial. Karlsson Å, Berggren M, Olofsson B, Stenvall M, Gustafson Y, Nordström P, Lindelöf N. Clin Interv Aging. 2020;15:1575-1586.

IV. "*It´s only thanks to rehab that I´m back on my feet*": older adults' experiences of rehabilitation and recovery after hip fracture. Karlsson Å, Olofsson B, Stenvall M, Lindelöf N. Manuscript.

Preface

I feel grateful when looking back at several years in the clinic working in the field of geriatric rehabilitation. All the older adults I have met and the joy of working in a team with other rehabilitation professionals. I have had a special interest in orthopaedics for some time and I was lucky to be involved as a clinician in the development and implementation of a multifactorial in-hospital care and rehabilitation program for older adults with hip fracture at our clinic. After some time working according to the program, my physiotherapy- and occupational therapy colleagues and myself felt that the program had proven to be working well, but there was a lack of appropriate rehabilitation alternatives after discharge to maintain the positive effects of the program. At that time, the clinic had an outpatient rehabilitation unit where the patients could receive additional rehabilitation. Despite being in need of further rehabilitation, we learned that some patients declined to go there because they experienced it as being too hard to leave home, being, as they were, weak after the fracture and also had other medical conditions that limited their capabilities. Given these experiences and the command from the hospital management to reduce the hospital length of stay, we were thrilled when we had the opportunity to start and develop a home rehabilitation team. The team was a welcome complement to the in-hospital rehabilitation program and an alternative to rehabilitation at the geriatric outpatient unit. Since home rehabilitation is close to my heart, it also felt important to evaluate its effectiveness scientifically. So, here I am…

Introduction

Hip fracture epidemiology

Worldwide the population is aging, and for the first time in history, most people can expect to live into their 60s and beyond.[1] The same pattern can be seen in Sweden where the proportion of people aged 65 years or older is projected to increase from 20% in year 2020 to 25% by 2070 as a result of increased life expectancy.[2] Moreover, it is estimated that in 2045 1 million people will be aged 80 years or older.[2] With an older population the number of hip fractures is also expected to increase and it has been suggested that about one-third of women living to the age of 80 will sustain a hip fracture.[3] However, the risk of hip fracture varies between different countries and changes over time.[4] The reasons for this is not well understood and could not entirely be explained by different age structures of the studied populations.[5] The Nordic countries are known to have a high incidence of hip fractures.[4,5]

In Sweden, the age-standardized hip fracture rate continued to decrease in women but was stable in men between 1987 and 2011.[6] Still, an increase in the annual number of hip fractures can be expected in the future, according to the study authors, because of a higher hip fracture risk in more recently born cohorts and increasing numbers of old and very old individuals in the population.[6] Furthermore, a Swedish population-based study has reported an increased hip fracture incidence among women aged 90 or older.[7] According to register data from Socialstyrelsen, 15,000-16,000 of the fragility fractures in 2018 were hip fractures.[8] Hip fractures are more common among women (66%) who have a mean age of 83 years, while men are somewhat younger, at 80 years.[9] Besides great personal suffering, every hip fracture is a major expense for society with costs associated with hospitalization, rehabilitation and short and long-term care services.[3] In Western nations, 10-20% are institutionalized following the fracture,[10] and in Sweden, older adults with hip fracture are considered to be one of the most resource-intensive groups within the health care sector, with costs of 1.5 billion Swedish Crowns every year.[11]

Surgical treatment

The concept 'Hip fracture' includes fractures of the proximal part of the femur, and the most common types are cervical fractures and trochanteric fractures, which are equally common.[9] The cervical or intracapsular fracture runs through the femoral neck, whereas the trochanteric or extracapsular fracture is located below the femoral neck, where major muscle attachments are located.[11] In trochanteric fractures, intertrochanteric- and subtrochanteric fractures are

included. Intermediate types are called basocervical fractures. The different fracture types are shown in Figure 1. The cervical fractures may be further divided into undisplaced fractures (Gardens I and II) or displaced fractures (Gardens III and IV) and the trochanteric fractures into two fragmentary (stable) or multi-fragmentary fractures (instable).[9] The treatment options for the different fractures are either osteosynthesis or hip replacement. All cervical fractures were until the mid-1990s fixated by nailing or screwing, but this method is nowadays generally used only for undisplaced cervical fractures, although it has been suggested that hemiarthroplasty might be a superior method for undisplaced fractures as well.[12] The main methods of choice for displaced cervical fractures are hemiarthroplasty, where the femoral part is replaced, or a total hip replacement, which also includes an acetabulum component. However, the evidence for the best method of choice has been contradictory,[13] but guidelines suggest that total hip replacement rather than hemiarthroplasty should be used for those without cognitive impairment (CI) who could walk independently outdoors before the fracture.[14] Trochanteric fractures are most commonly fixated by intramedullary nailing, but a sliding hip screw and plate fixation is also an alternative.[9] During the study period of this thesis, undisplaced cervical fractures were fixated by nailing, and hemiarthroplasty was used for displaced fractures, while a sliding hip screw was used for basocervical and trochanteric fractures. Some participants with multi-fragmentary trochanteric fractures received an intramedullary nail.

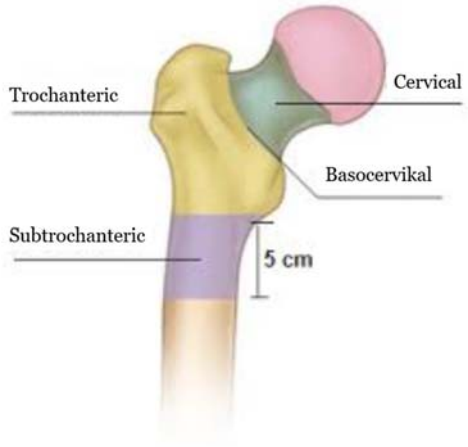


Figure 1. Fracture types (Reproduced with permission from RIKSHÖFT)

Outcomes in relation to fracture type and method of surgery

Fracture type seems to affect outcome after hip fracture. A Swedish study based on the RIKSHÖFT database reported that walking ability at four months was best among those with undisplaced cervical fractures and worst among those with multi-fragmentary trochanteric fractures.[15] Further, health-related quality of life (HRQOL) has shown to be significantly lower for those who experience fracture healing complications.[16] In addition to the effects of the fracture type, the method of surgery may also influence the outcome. Those with undisplaced cervical fractures who underwent hemiarthroplasty presented with better walking ability[12,15] and fewer major reoperations[12] than those who had received internal fixation. Furthermore, in displaced cervical fractures, a total hip replacement seems to improve long-term function and reduce reoperation rates compared to hemiarthroplasty, although the risk for dislocation is increased and surgery is longer and more invasive.[14]

Risk factors for hip fracture

A hip fracture should not only be viewed merely as a surgical condition, but rather as a complex geriatric condition, since those who sustain a hip fracture usually have other medical problems and physical limitations interacting with one another.[17] This is also referred to as "frailty" in the literature, and it involves a state of accelerated biological aging where the ability to handle physical, mental and social stress is reduced, although there is no international consensus definition.[18] Several studies have shown a strong association between frailty and adverse perioperative and postoperative outcomes.[19]

The fracture is, in 95% of cases, caused by a fall[20] from standing height or lower, that is, a so-called low-energy trauma, and this reflects a low bone mineral density, or osteoporosis. These fractures are usually defined as fragility fractures. The risk of sustaining a fragility fracture is multifactorial, since several risk factors influence the fall risk or bone quality or both. Risk factors such as age, sex, low bone mineral density, ethnicity, low body weight, smoking, previous fragility fracture, family history of fracture, and long-term immobilization have been reported to be associated with fragility fractures.[21] In addition, older adults with disabilities are considered to be at high risk for sustaining a hip fracture, and those living in residential care present with the highest risk.[5] Furthermore, because of an increased risk of falling, some diseases such as Parkinson's disease, stroke and dementia are associated with a greater risk of hip fracture,[5] of which dementia will be described more in detail below. In very old adults (≥85 years), however, risk factors have been reported to differ from those reported for adults <80 years. In a population-based cohort study, Wiklund et al.[22] showed that indoor walking with no more than one person, Parkinson's disease, age, delirium in the previous month, currently smoking and being underweight were associated

with a higher risk of incident hip fracture. Nevertheless, several of the risk factors for hip fracture are modifiable, and in clinical practice they should be detected, and fracture prevention strategies should be carried out.

Dementia and hip fracture

Dementia develops as a result of damage or death of brain cells.[23] Dementia is not a single disease; rather, it is an umbrella term for several symptoms caused by different medical conditions and injuries. The symptoms that emerge vary according to type of dementia, and symptoms may change as the disease progresses.[24] In addition, individual variations are also common. Dementia affects all aspects of life, including memory and other cognitive abilities,[23] and has been reported to be the leading cause of dependency in activities of daily living (ADL).[24]

Older adults with dementia disorders are frail by definition[25] and have an increased risk of sustaining a hip fracture.[5] An individual with Alzheimer's disease is about three times more likely to sustain a hip fracture than an age- and sex-matched control who is cognitively intact.[26] The prevalence of CI in previous cohort studies of older adults with hip fracture has been reported to be about 40%, and the prevalence of dementia approximately 19%,[27] whereas previous randomized controlled trials (RCTs) have found that approximately 30% of the participants had dementia.[28]

The relationship between dementia and hip fracture is complex and the increased risk for hip fracture in this population seems to involve several mechanisms such as older age, high risk of falls, osteoporosis, physical inactivity, and medications that increase the risk of falls and fractures.[29] In addition, impaired balance and gait disturbances, such as decreased gait speed and stride length, and an increased gait variability, are often seen, which contributes to an increased fall risk for those with dementia.[30] Moreover, an impaired executive function, i.e., difficulties in planning, organising, and maintaining focus, and impaired judgement also add to the risk of falls.[31] Gait seems to be particularly affected in non-Alzheimer's dementia forms, such as vascular dementia, Parkinson's disease dementia, and dementia with Lewy bodies, although gait disorders are also present in Alzheimer's disease.[32] The gait disturbances are most apparent under dual task conditions, where a cognitive task is added to a motor task,[31] which is demanded in many situations in everyday life.

Dementia is usually diagnosed according to criteria in the Diagnostic and Statistical Manual of Mental Disorders (DSM). In the DSM-V, dementia disorders are classified as *major neurocognitive disorders*; however, as the Papers

included in this thesis used the previous version (DSM-IV),[33] the term dementia will be used throughout.

Complications after hip fracture

Postoperative complications are common among older adults with hip fracture,[34] and among those who receive orthogeriatric rehabilitation as well.[35] The complications concern both hip related (orthopaedic) and medical (general) problems where medical complications such as delirium, anaemia, catheter-associated urinary tract infections and pneumonia have been reported to dominate during hospital stay.[35] The knowledge about complications after discharge is not well researched, but one study reported that the most common complications in the first six months after the fracture were falls, fractures and pneumonia.[36] We have previously evaluated complications after discharge in the present RCT, in a study that is not included in this thesis, and found that complications were common.[37] Between discharge and the 12-month follow-up about 50% of the study participants had at least one complication (medical or orthopaedic), and the most common complications were falls and infections.

Malnutrition should also be mentioned. A previous systematic review reported that older adults with hip fracture are often malnourished, which has shown to be associated with postoperative complications, including mortality.[38] According to the review, nutritional interventions play an important role in the prevention of complications after the fracture, in preventing new fractures, and for improving functional recovery from a short- and long-term perspective.

Older adults with dementia have an additionally higher risk of suffering from postoperative complications after a hip fracture[39,40] along with older adults with a score of 3 or more on the American Society of Anaesthesiologists (ASA) classification of medical comorbidities.[35] In this section, I will focus on falls and mortality.

Falls and fall risk assessment

Falls, i.e., an unexpected event in which the individual comes to rest on the ground, floor or a lower level,[41] are a major problem among old community-dwelling adults since one-third fall at least once every year[42] and the figures are even higher among those living in residential care.[43] About 1-2% of accidental falls may result in hip fracture.[44,45] Furthermore, those who have sustained a fracture have a 2.5-fold increased risk of a subsequent fracture.[46] The aetiology of falls is complex, with multifactorial contributing factors. As reported in a Cochrane review,[47] known intrinsic factors for falls include, for instance, old age, previous falls, gait and balance problems, muscle weakness, morbidity and impaired vision, whereas extrinsic fall-related factors include environmental

factors such as lack of hand rails, poor lighting and poor foot wear. Infections and delirium disorders have also been reported as precipitating factors for falls.[45,48] Among those who fell during postoperative hospital stay in a prospective study, as many as 45% suffered from delirium.[49] Moreover, fear of falling (FoF)[50] and use of drugs[51,52] are also known as risk factors for falls.

Strategies to prevent falls and fractures are important, although fall prevention is a difficult task due to the multifactorial interacting factors. Risk assessments in clinical practice should be carried out by healthcare professionals with appropriate skills and experience, and should include fall history, assessment of functional ability and FoF, osteoporosis risk, assessment of cognitive function, comorbidity and a medication review.[42] The risk assessments should be regularly updated, and an active approach should be applied to detect, prevent and treat complications that may emerge after the fracture.[53]

Fall prevention interventions

In hospital, multifactorial fall prevention intervention should be performed, which includes two or more categories of intervention that are linked to the older adult´s risk profile.[43] According to a Cochrane review,[43] multifactorial fall prevention interventions in hospital may reduce the rate of falls, especially in sub-acute settings, although the effects on the risk of falling and the risk of sustaining a fracture is uncertain as well as the effects of fall prevention among those that has recently been discharged from hospital. Among community-dwelling people in general, multifactorial interventions may reduce the rate of falls, although they have little or no effect on other fall-related measures.[47] A multicomponent intervention, however, where two or more categories of intervention are given to all participants, may be a better alternative and may reduce both the rate of falls and the risk of falling, although there is insufficient evidence on the risk of sustaining a fall-related fracture. Fall prevention in care facilities has shown to be less successful, since the effects of exercise interventions and multifactorial interventions on the rate of falls have shown to be uncertain and to make little or no difference to the risk of falling.[43]

Exercise has proven to be a key component and should be included in both multifactorial and multicomponent fall prevention interventions.[47] Other commonly used components are home hazard assessments and modifications, medication reviews, education, and psychological interventions.[47] In addition, for community-dwelling older adults, evidence is strong that exercise as a single intervention can reduce the rate of falls and the number of people who falls, and there is some evidence that exercise can reduce the risk of sustaining a fracture.[54] It seems important, though, that exercise is progressed and performed with a high dose and intensity, so that the balance is fully challenged to achieve positive

effects.[54] Further, performing multiple types of exercise, e.g., balance, strength and functional exercises seems more effective.[54] There are few studies reporting about the effects of exercise on falls in older adults with dementia.[25,47] A previous systematic review and meta-analysis reported that exercise interventions in different settings may reduce falls and number of fallers among community-dwelling older adults with dementia.[55] Another systematic review concluded, however, that the effect of exercise on falls was inconclusive.[56]

Mortality

Mortality is higher among older adults with hip fracture than could be expected in the age group, since one third die within the first year after the fracture, compared with an expected annual mortality of about 10%.[34] An excess mortality between 8.4% and 36% has been reported during the year after the fracture.[57] A large population-based study on all-cause mortality after hip fracture reported that the fracture was associated with excess short- and long-term mortality in both sexes, and the highest risk of dying occurred during the first year after the fracture.[58] Postoperative complications such as pulmonary and cardiac complications, infections and comorbidity contributes to excess short-term mortality, although the mechanisms behind excess long-term mortality are more unclear.[58]

The hospital length of stay (LOS) seems also to be of importance for mortality. Two previous studies have reported that an LOS of 10 days or less was associated with increased risk of death within 30 days after hospital discharge,[59] and the risk was particularly high among those who had a combination of LOS of 10 days or less and discharge to a short-term residential care facility.[60] In view of these results, it was worrying when the geriatric clinic received a demand to reduce hospital LOS during the study period of the RCT.

Functional recovery after hip fracture

Functional recovery after hip fracture is usually defined as a return to prefracture level of functional mobility, as used in this thesis, but can also be defined as achievement of a pre-specified functional target, for instance, the ability to climb a flight of stairs.[61] Auais et al. advocated the use of a functional target as a measure of recovery, because when using the traditional definition, those with a low prefracture functional ability tend to have the best recovery rate, which may not reflect the actual amount of functional improvement and their HRQoL.[61]

Previous research has established that many will fail to regain their former levels of mobility, they will become more dependent in ADL,[10,62,63] and may have to move to residential care.[64] According to a review of cohort studies, 40-60% of the participants regained their prefracture level of mobility, 40-70% their ability to

perform personal ADL (PADL), and 50% or less regained their prefracture ability to perform instrumental ADL (IADL).[10] Functional recovery was also poor among older adults who had been healthy before the fracture, since 21% of the participants reported themselves to be fully recovered at 4 months.[65] Although they had returned to their own homes, they reported impaired mobility and difficulty performing activities in the same manner as they had before the fracture. Some subpopulations have shown to be at high risk for having a worse functional recovery, for example, those with high levels of dependence before the fracture,[10] those with CI[39,66,67] and those residing in residential care.[68] Contrary, functional recovery has been reported to improve for those with high levels of social support.[69] Most functional improvements occur within the first 6 months, but improvements related to the lower extremities and IADL may occur after that period, although rarely to prefracture levels.[70]

Many factors have shown to predict a poor functional outcome. A systematic review of 81 cohort studies reported that the presence of low hand grip strength and frailty had been highlighted in the recent literature, but factors such as older age, male sex, poor prefracture functional status, CI, comorbidity and depression were also found to predict poor functional outcome and mortality.[71]

Hip fracture rehabilitation

Rehabilitation is defined by the World Health Organization (WHO) as "a set of interventions designed to optimize functioning and reduce disability in individuals with health conditions in interaction with their environment".[72] In the 2030 rehab report,[72] WHO maintain that rehabilitation interventions in the 21st century should have a holistic view of health and the core of rehabilitation should be a person-centred care that includes empowerment and goal setting. Rehabilitation after hip fracture aims to improve mobility, maximize physical function and prevent functional decline.[73] Older adults who sustain hip fractures have a high mean age and multi-morbidity, suggesting a need for an interdisciplinary team approach to meet with the WHO's core features.[74]

Orthogeriatric care models

The current recommendation after hip fracture is an orthogeriatric care model with structured multi- or interdisciplinary team rehabilitation,[17,75,76] although the evidence concerning the key components of rehabilitation are still insufficient,[77] especially for older adults with CI or dementia.[39]

Interdisciplinary rehabilitation is a holistic and patient-centred approach characterized by a high level of collaboration, communication and joint decision-making among the rehabilitation professionals.[74] Comprehensive geriatric assessment (CGA) is used to conduct assessments in order to identify the

problems as well as the resources of the individual. It is an established approach that has shown to improve outcomes in older adults admitted to hospital for medical problems[78] and surgery.[79] CGA has been defined as a "multidimensional interdisciplinary diagnostic process focused on determining a frail older persons medical, psychological and functional capability in order to develop a coordinated and integrated plan for treatment and long term follow up".[80] Accordingly, the rehabilitation professionals develop individual rehabilitation plans based on goals that are composed together with the patient and the next of kin. The professionals meet regularly to evaluate the individual plan and to coordinate further interventions. Examples of other team approaches are a multidisciplinary team model where skills from different professionals are used, but members work within their own professional limits, with low levels of communication between members and are usually led by a physician. In a transdisciplinary team model, the professional boundaries are blurred, and the team members may assume responsibility in any team role.[74,81]

In Sweden, the clinical guidelines after hip fracture include surgery as soon as possible; interdisciplinary rehabilitation, including early mobilization, to promote recovery and prevent postoperative complications; pain control and specialized training provided by physiotherapists (PT) and occupational therapists (OT).[11] Further, individual care plans should be set up and include a thorough discharge plan for further care and rehabilitation after discharge.[11]

The benefits with rehabilitation performed by an interdisciplinary geriatric team after hip fracture were summarized in a previous meta-analysis of RCTs and showed an increase in ADL performance and mobility after the fracture compared to usual care, although it did not increase survival or the chances of remaining in own home.[75] Similar results were reported in another meta-analysis, which found that comprehensive in-hospital geriatric rehabilitation improved recovery in ADL and walking ability during the year after discharge, but not mortality, compared to usual orthopaedic care.[82] However, a greater proportion of those who received comprehensive geriatric care was discharged to the same place of residence as before the fracture compared to usual orthopaedic care. Regarding the effects on hospital LOS, the results have been contradictory, as some studies have showed a reduced LOS compared with orthopaedic care,[83,84] whereas others have reported a longer LOS.[82] Heterogeneity between studies and in the organization of health care and rehabilitation after the hip fracture may have contributed to these differences. Orthogeriatric care models using CGA have been suggested to be cost effective, since they seem to provide better care after hip fracture at a lower cost.[85]

Hip fracture research in Umeå

At the University Hospital of Umeå, research aiming to improve care and rehabilitation after hip fracture has been conducted since 1979 in collaboration between the orthopaedic and the geriatric departments. This collaboration is still ongoing. One of these studies was an RCT that evaluated a multifactorial in-hospital rehabilitation program after hip fracture for 199 older adults, aged ≥70 years. The program resulted in fewer postoperative complications, a shorter hospital LOS and improvements in mobility and performance of ADL, from both short- and long-term perspective compared with usual care.[86-88] Beneficial effects over usual care were also seen among those with dementia.[89] The program was implemented in the geriatric clinic after study completion and is still used. Accordingly, this rehabilitation program constituted the in-hospital intervention (control intervention) in the RCT evaluated in this thesis.

Interdisciplinary home rehabilitation

Multi- or interdisciplinary home rehabilitation (HR) after hip fracture is not well described in the literature. Hospital LOS after hip fracture has been reduced in recent decades; in Sweden, for example, the mean LOS after hip fracture was reduced by 20% between 2006-2012.[59] The shorter hospital LOS has contributed to the establishment of HR teams to enable early discharge and continuation of rehabilitation in older adults' own homes.[90] HR teams may be connected to hospitals, which are usually directed towards specific diagnoses, but they could also be part of rehabilitation services in the community. In hospital-based HR, the team is specialized, and the rehabilitation could be continued directly after hospital discharge, avoiding delays that can lead to additional declines in physical function.

A systematic review concluded that hospital stays can be decreased through team-based HR, but that patient outcomes such as independency, quality of life, ability to retake social activities and costs were comparable to other types of rehabilitation.[90] Further, Donohue et al.[91] found a trend to support team-based HR after hip fracture, but called for more studies with high methodological quality to enable stronger conclusions. Positive effects on ADL performance and physical function with interdisciplinary teams in the home setting were also reported in a systematic review that included both in-hospital and in-home interventions.[11] In addition, a previous observational study reported that specialized team-based HR for geriatric patients with orthopaedic conditions resulted in ADL performance comparable to in-patient geriatric rehabilitation, but the HR group had a shorter rehabilitation intervention, suggesting that rehabilitation efficiency was better.[92] In the study, 62% of the participants had hip fracture and CI and living in residential care facilities were not exclusion criteria.

Crotty and co-authors[93] compared early discharge from hospital and team-based HR with conventional hospital care for 66 participants with hip fracture. The tailored rehabilitation program focused on short-term goals relevant to ADL. The participants received on average 14 home visits from the team comprising of a team coordinator, a PT, an OT, a speech pathologist, a social worker, and a therapy aid. The result showed no differences in quality of life outcomes, but independence and confidence to perform ADL without falling improved in the group with HR. In a follow-up study 12 months after the hip fracture, no significant differences between the groups were found, although caregivers in the HR-program experienced a significant reduction in burden.[94] In Sweden, Zidén and co-authors[95] evaluated geriatric multi-professional HR in a RCT soon after the hip fracture compared to conventional care. The HR program focused on a safe discharge, personal goals and enhancing physical activity and independence in ADL. The intervention gave special priority to improvement of the participants' confidence in performing physical activity such as outdoor walking and ADL. The team comprised of a PT, an OT, a nurse, and an assisting nurse and the participants received a mean of 5 home visits. In the early phase after the fracture, the HR program improved balance confidence, independence and physical activity. This result also remained at six months and at one-year follow-up.[96] It turned out that the participants in the HR program regained their balance confidence and independency faster than the group that received conventional care, and the main recovery for both groups took place during the first six months after the fracture. There were, however, only one of three in the HR program and one of ten in the group with conventional care, who reported being fully recovered one year after the fracture, which shows that long-term consequences after hip fracture are substantial.

Positive long-term effects on PADL, recovery of prefracture walking ability and the number of falls were also shown in an HR intervention delivered by a geriatric nurse and a PT compared to a control group that received usual postoperative care in hospital.[97] Participants in that study received on average 10 home visits from the nurse and 3 from the PT. Another study compared the effects of a 12-month HR intervention that also included management of nutrition, depression, and fall prevention with those of a 4-month HR intervention and usual care.[98] The 12-month HR intervention was reported to be more beneficial than the 4-month intervention or usual care, since it reduced the risk of depression and malnutrition. However, there were no significant differences regarding ADL performance between the two HR interventions. Similarly, a 6-month multicomponent HR intervention showed no significant differences in outcomes such as ADL, leg strength or balance over usual care at either 6 or 12 months.[99]

Effects of a multicomponent, but not team-based, HR intervention have also been reported.[100-102] The participants received 5-6 home visits from a physiotherapist

during the year-long intervention. The results showed a reduction in perceived difficulties in negotiating stairs[100] and increased physical activity in the HR group, particularly among those with high physical activity also before the fracture,[102] compared to standard care. The study did, however, not improve ADL over standard care.[101]

The generalizability of the results in previous RCTs on team-based HR is limited, however, since older adults with severe CI or dementia, those with serious medical conditions, and those living in residential care were not included in the HR studies, despite their representing large groups among older adults with hip fracture.

Exercise interventions

Besides interdisciplinary interventions there is evidence for different types of structured exercise interventions after hip fracture delivered at various stages of rehabilitation and in different settings.[73,77,103-105] This highlights the importance of physiotherapy as an important part of team rehabilitation after hip fracture. Because of long-lasting physical impairments after a fracture, there is need for rehabilitation for a longer period, and different approaches may be suitable for different individuals. Unfortunately, current evidence may not be generalized to all older adults with hip fracture since those with CI have, to a great extent, been excluded from previous post-discharge interventions.[77]

Auais and co-authors[103] reported that an extended rehabilitation program after the regular rehabilitation period, community- or home-based, had significant effects on physical function such as knee extension strength, balance and gait speed, although the effects on ADL were not significant. Further, structured exercise interventions that included moderate to high doses of progressive resistance training were reported to be significantly associated with small but significant improvements in mobility compared to interventions without strength training, and the effects seemed to be better when delivered after hospital discharge.[73] Another systematic review and meta-analysis that included 587 participants verified the positive effect on mobility with progressive lower-limb resistance training, but positive effects on ADL performance, balance, lower limb strength, and performance tasks, such as the Timed Up-and-Go test, were also found.[106] Moreover, balance training has been shown to improve balance and to have positive effects on walking ability, lower limb strength, ADL and HRQOL.[107]

Home-based exercise programs with different degrees of supervision from a PT have been shown to be feasible, to have good compliance and to have the potential to lead to improvements in mobility and physical functions,[108-110] also when

starting some months after the fracture.[111] One RCT study, evaluating a home-based exercise program starting four months after the fracture, found that the intervention group, which received an additional 20 sessions of physiotherapy targeting gait and balance, improved self-chosen gait speed and functional leg strength.[112] In addition, there was not an increase in cost of care. However, most studies have been small and heterogeneous in the design. A previous systematic review and meta-analysis on the effectiveness of supervised home-based exercise after hip fracture reported that home-based exercise did not seem to be superior to usual care or to a non-exercise control intervention.[113] Only one trial described the content, intensity and adherence to the exercise program. According to the study authors, this may indicate that the interventions were not optimal to achieve effects. Moreover, it has been reported that community-based exercise programs had larger effect sizes than home-based programs, which may be explained by a higher exercise intensity,[103] since duration, frequency and intensity of exercise have been shown to be important for improving physical function among older adults.[114]

Impact of dementia on the outcome

Overall, dementia has a large negative impact on outcomes after hip fracture.[39] Mortality is higher,[26,66,115,116] postoperative complications more common,[39,40] and the negative impact on mobility and ADL is greater in people with dementia than in people who are cognitively intact.[39,66,67,116] In addition, dementia is an independent risk factor for postoperative admission to long-term residential care.[40]

Despite dementia being common among older adults with hip fracture and the population having complex care needs, they have been under-represented in earlier studies.[117] It has been shown that older adults with dementia are less likely to receive rehabilitation after a hip fracture than people without dementia, and when they do receive rehabilitation it is shorter.[40] However, in older adults with mild to moderate dementia, supervised exercise can improve physical function.[56] There is also promising evidence that exercise programs may improve the ability to perform ADL.[118] These results indicate that older adults with dementia should not be excluded from exercise interventions. The literature also supports that older adults with dementia benefit from multi- or interdisciplinary rehabilitation after hip fracture in-hospital,[89,119] combined in-hospital and in-home rehabilitation,[120-123] and from rehabilitation in residential care facilities.[124] Effects such as improved functional ability,[89,119,122] a reduction in postoperative complications, including mortality,[89,120] and prevention of admission to long-term care settings have been shown.[120,123] According to a systematic review, rehabilitation of older adults with CI can be challenging, but evidence supports that they should be offered rehabilitation with as high intensity as possible, and

preferably from an interdisciplinary team.[121] Furthermore, comorbidities and postoperative complications as well as behavioural problems connected to the dementia diagnosis should be addressed, and rehabilitation should be person-centred and delivered in settings that are adapted to the needs of older adults with dementia,[39,125] involving also family and caregivers.[126] In addition, there is need for education to change attitudes among care staff and health care management.[125]

Experiences of recovering from a hip fracture

The main focus in previous rehabilitation studies after hip fracture have concerned the physical aspect of recovery. However, there is a growing knowledge on the far-reaching psychological consequences after the fracture, which severely reduces older adults' HRQOL.[127,128] There are, however, few rehabilitation interventions that have focused on improving psychosocial functioning after hip fracture.[129]

Older adults who have been interviewed after their hip fracture described it as a life-breaking event with consequences both socially and existentially,[130-132] and regardless of their being healthy before the fracture.[133] These consequences also remained in the long term.[134] A hip fracture may contribute to older adults feeling vulnerable, helpless and dependent,[131,132,135] and having fears of becoming a burden for others.[134] A previous observational study, which took place in an orthopaedic hospital ward, explored how three older adults with Alzheimer's disease experienced recovering from a hip fracture.[136] Participants expressed that they wanted to be engaged in their care during their hospital stay and to have something meaningful to do. However, the study revealed that staff must improve knowledge transfer between shifts to be able to include older adults in daily activities. In addition, information must be tailored to the individuals in order to increase their participation. In the attempt to "get to know" older adults, next of kin could provide valuable information to the staff.[136]

Psychological factors and recovery

Some psychological factors and individual characteristics appear to be of particular importance for a successful rehabilitation outcome, such as the older adults' own beliefs in success.[137] Those who have a strong *locus of control* engage in rehabilitation to a higher extent, and this influences coping strategies and behaviours during the rehabilitation process.[138] Older adults who have control over their health will be more likely to perform health-promoting activities and especially those with a strong internal locus of control who believe that they are responsible for their own outcome.[137] Another factor that has shown to be important for recovery is *self-efficacy*, i.e., the belief individuals have about their ability to do certain tasks. Self-efficacy was a central concept in Bandura´s Social

Cognitive Theory.[139] Self-efficacy is affected by the actual performance of an activity, but is also affected by vicarious experiences or role models, by reliable verbal encouragement or other social influence, and by positive and negative psychological or emotional reactions.[139] A systematic review and meta-synthesis on well-being after hip fracture reported that self-efficacy for recovery may increase when older adults experience success during rehabilitation, are actively involved in planning and goal setting, and manage everyday activities.[140] In contrast, negative thoughts may reduce self-efficacy and lead to activity avoidance.[137]

FoF is common after a hip fracture.[50,141,142] In the study of Visschedijk et al.,[50] 63% of the older adults who underwent in-hospital geriatric rehabilitation reported to have FoF, and it was at its highest four to eight weeks after the fracture. FoF may hinder participation in everyday activities[140] and lead to activity avoidance.[141] Bower et al.[142]reported in a prospective observational study of 241 participants that FoF after the fracture was associated with poorer functional recovery at 12 months. Falls and FoF have shown to be correlated, i.e., an individual who develops one of these outcomes is at greater risk of developing the other. This may cause a spiralling effect of increasing falls, FoF and functional decline.[143]

Recovery is an individual process of regaining health[144] and can be seen as a process of healing where the individuals find an identity apart from the illness and experience having control over their lives.[145] Rehabilitation professionals need to have knowledge about psychological consequences after a hip fracture and an understanding about how they might affect rehabilitation.[137] To date, there are few studies exploring older adults' experiences of recovery in relation to an intervention and I have found only two qualitative studies where the participants received a team-based HR intervention.[130,134]

Rationale

Worldwide the population is aging, and as a consequence more people are at risk of falling, which can lead to more hip fractures. Sustaining a hip fracture has been described as a disruptive and life-changing event. A hip fracture has a negative impact on mobility and on the ability to perform ADL, and many who experience hip fracture fail to regain their former abilities, despite participation in rehabilitation programs. Older adults with hip fracture have complex care needs, and these fractures should be treated as geriatric conditions rather than as orthopaedic injuries. The current rehabilitation recommendation is an orthogeriatric care model with an interdisciplinary team, although evidence regarding the most optimal rehabilitation strategies is still uncertain. A major concern is that previous rehabilitation interventions after hip fracture may not be generalizable to the whole group of older adults with hip fracture, since in many studies a representative sample has not been included.

During the last few decades, the number of hospital beds has decreased, and there has been a shift towards shorter hospital LOS after hip fracture. To deal with this change, HR teams have been established to facilitate early discharges and provide continued rehabilitation in the home setting. The evidence for interdisciplinary HR after hip fracture is, however, limited. In addition, older adults with severe comorbidity, those who live in residential care facilities, as well as those with severe CI or dementia were excluded in previous RCTs, despite these groups representing a large proportion of older adults with hip fracture. Indeed, there is an urgent need to further evaluate the effectiveness of interdisciplinary HR after hip fracture in the entire group of older adults with hip fracture.

In striving to optimize quality of care after hip fracture, it is essential that rehabilitation professionals take a broad perspective and focus not only on the physical aspect after the fracture, but also have knowledge about psychological reactions that may emerge. To be able to provide support during the recovery process, rehabilitation professionals need to understand how psychological aspects may facilitate or hinder older adults from participating in their rehabilitation. Additionally, it is important to attain more knowledge about how older adults perceive their rehabilitation following a hip fracture, including their experiences receiving rehabilitation in the home setting.

Aims

The overall aim of this thesis was to evaluate early discharge followed by geriatric team-based home rehabilitation for older adults with hip fracture compared to in-hospital geriatric care and rehabilitation at a geriatric ward according to a multifactorial rehabilitation program. The specific aims for the research conducted for this thesis were:

I: To evaluate the effects of geriatric interdisciplinary home rehabilitation on walking ability and postoperative hospital length of stay.

II: To evaluate the effects of geriatric interdisciplinary home rehabilitation on independence in activities of daily living.

III: To evaluate the effects of geriatric interdisciplinary home rehabilitation specifically for the subgroup of participants with dementia, with regard to walking ability, activities of daily living, postoperative hospital length of stay, and mortality, falls, and readmissions after discharge. A secondary aim was to describe the overall outcome after hip fracture in older adults with dementia.

IV: To explore older adults' experiences of their rehabilitation after hip fracture and of the recovery process one year after their fracture.

Methods

This thesis reports on data from an RCT, which was conducted between May 2008 and June 2011, in collaboration between the Orthopaedic Department and the Geriatric Department of the University Hospital of Umeå, Sweden (Table 1). Of the four Papers included, three have a quantitative study design, whereas the fourth Paper is a qualitative study based on interviews performed after the last follow-up in the RCT study.

Table 1. Overview of studies included in the thesis

	Paper I	Paper II	Paper III	Paper IV
Sample size, n	205	205	Subgroup analysis of participants with dementia n = 103	20
Data collection	Interview and assessments during hospital stay and follow-up visits at 3 and 12 months; medical charts			In-depth interviews after 12-month follow-up
Outcome	Walking ability, hospital LOS	Independence in ADL	Impact of dementia on walking ability, ADL, hospital LOS, and on falls, mortality, and readmissions after discharge	Participants' experiences
Measurement	Independence in walking, recovery of walking ability, use of walking aids, gait speed 2.4 m, median LOS	Barthel ADL Index, ADL Staircase including Katz Index, recovery of ADL	Independence in walking and recovery (as in Paper I), ADL (as in Paper II), median LOS. Falls, mortality, and readmissions after discharge	NA
Data analysis	Binary logistic regression, Pearson chi-square test /Fisher exact test, Student *t* test, Mann-Whitney *U* test	Binary logistic regression, Mann-Whitney *U* test, Pearson chi-square test/Fisher exact test	Interaction analysis; binary logistic regression, Mann-Whitney *U* test, Pearson chi-square test/Fisher exact test	Qualitative Content Analysis

Abbreviations: ADL, activities of daily living; LOS, length of stay

The study protocol for the RCT (Papers I-III) was published at Current Controlled Trials Ltd (ISRCTN 15738119), and the study, including the interviews after study completion, was approved by the Regional Ethical Review Board of Umeå in 2008 (DNR 08-053M).

Participants

In total, 205 older adults with hip fracture were included in the RCT study. The inclusion criteria were: aged 70 years or older, acute hip fracture surgery for a cervical or trochanteric fracture, and living in the municipality of Umeå. Presence of CI, having a dementia diagnosis or living in residential care were not obstacles for inclusion. Of the 466 people who were screened for eligibility, 257 were excluded because they lived outside the municipality of Umeå (n = 152), had a pathologic fracture (n = 4), sustained the fracture in-hospital (n = 13), or were younger than 70 years (n = 18) (Figure 2). In addition, 37 people declined to participate and 33 were not included due to failure of inclusion routines. Those who declined participation did not differ significantly in terms of age or sex from the participants included in the study. Furthermore, after randomization four additional participants were excluded before the first in-hospital assessment took place, leaving 205 participants who were included in the study (Papers I-II). In Paper III, we focus on the 103 participants who fulfilled the criteria for dementia at baseline, according to the DSM-IV criteria,[33] and in the fourth Paper, 20 of the participants in the RCT were interviewed soon after the 12-month follow-up.

Randomization

The participants were consecutively randomized to the Geriatric Interdisciplinary Home Rehabilitation (GIHR) group, comprising in-hospital geriatric care and rehabilitation and GIHR after discharge, or to the control group, i.e., in-hospital geriatric care and rehabilitation. An independent researcher prepared sequentially numbered lots in opaque, sealed envelopes to be drawn by a nurse on duty who was not involved in the study. In order to obtain comparable groups, the randomization was stratified in two categories according to type of housing (community-dwelling or residential care facilities) and type of fracture (cervical or trochanteric).

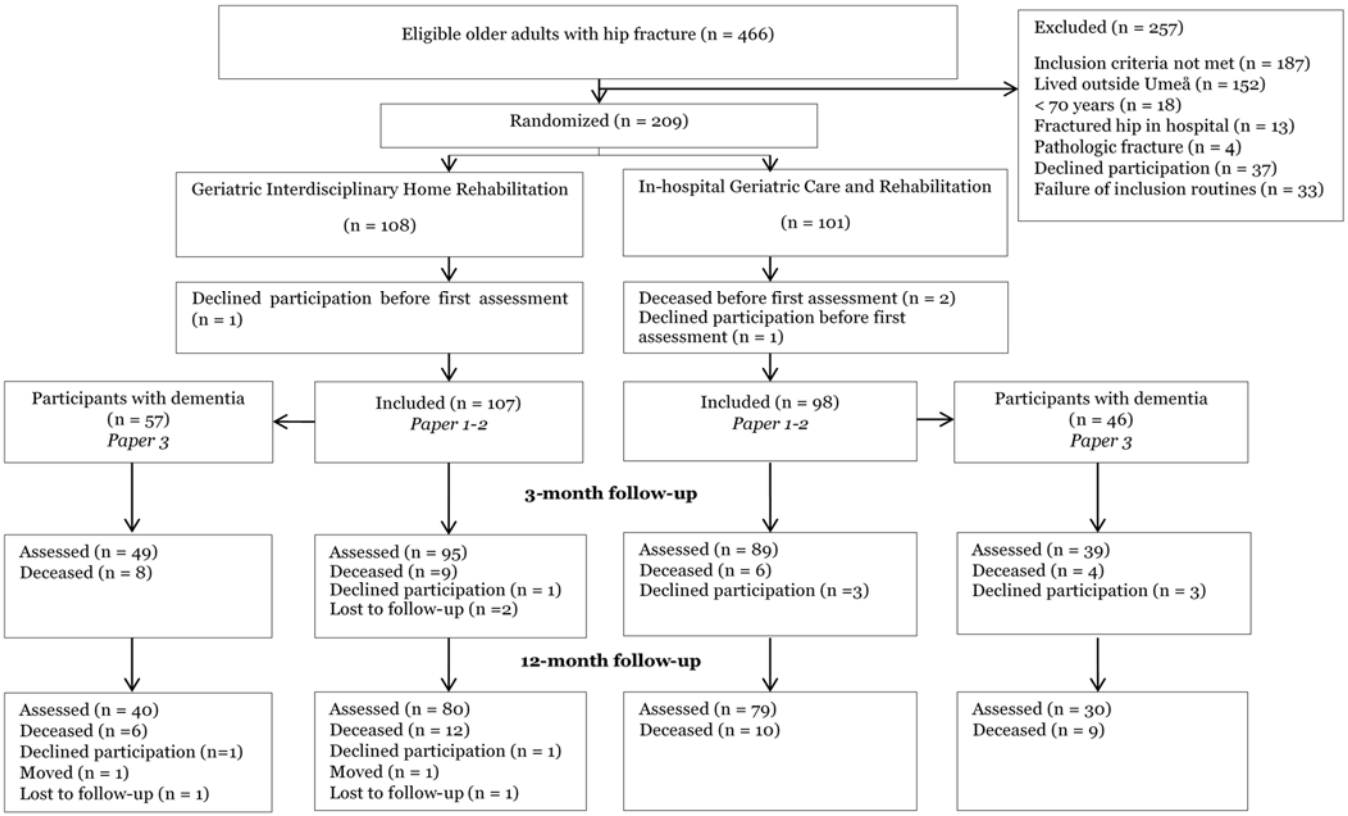


Figure 2. Flow chart of study participants in Papers 1-3.

Study context and procedure

Papers I-III

The usual clinical pathway was followed during the study period. All participants were treated in the orthopaedic department before surgery. After surgery, those with cervical fractures were referred to a ward in the geriatric department with special competence in orthopaedics, while those with trochanteric fractures returned postoperatively to the orthopaedic department. They could be included in the study later if they were referred to the geriatric ward for a rehabilitation period. In order to make it clear to the staff at the geriatric ward and to facilitate an early discharge from hospital for the HR group, the ward was divided with the HR group in one wing and the control group in the other, of which each wing had separate care staff.

Since the randomization for those with cervical fractures was carried out before admission to the geriatric ward, the participants were asked for participation in the study on arrival, usually by the geriatrician. Those with trochanteric fractures gave their consent for participation before the randomization was performed. Study information was given both orally and in written form. In cases when the participants could not give informed written consent, for instance, in the presence of CI, their next of kin was also consulted. Both the participants and their next of kin were informed that withdrawal from the study was possible at any time without any negative repercussions.

Paper IV

In connection with the 12-month follow-up, 20 of the study participants were asked by the assessors to participate in an interview that took place in the participants' homes shortly thereafter. Purposive sampling was applied to achieve variation in age, gender, living conditions, type of rehabilitation, and functional and cognitive ability. Twenty participants were chosen, which was considered enough to be able to answer the research question in a credible way.[146] A prerequisite for participation in the interviews was that the participants were expected to remember the time after the fracture and the following rehabilitation, as well as to be able to verbally express their experiences. Due to this demand, only one of the included participants had a dementia diagnosis.

Data collection

Papers I-III

The participants were assessed during hospital stay, within five days after randomization. The assessments in hospital were performed in a neutral room at the geriatric ward in order to keep the assessors blinded to group allocation. Follow-up assessments were carried out at 3 months after randomization and 12 months postoperatively. They were held in the participants' homes to make it as easy as possible for them and thereby reduce the number of drop-outs. The assessors, two experienced and trained researchers, one PT and one registered nurse (RN), had no other contact with the ward or access to the participants' medical charts during the study period. In the presence of CI, the next of kin and/or care staff at the facilities were also interviewed. After study completion, data was also registered from the participants' medical charts. This was performed by an experienced geriatrician who was not blinded to group allocation using a pre-set protocol. Sometimes the group allocation was revealed in connection with the 3-month follow-up. On such occasions, the actual assessment was completed, but at 12-month follow-up the other assessor performed the assessment.

Paper IV

One of the assessors in the RCT study who had experience in qualitative methods performed the semi-structured interviews. The interview started with an open question whereby the participants were asked to describe their experiences of sustaining a hip fracture and of the following rehabilitation. During the interview, additional questions were available in a thematic interview guide. The interviews were audio recorded and transcribed verbatim by an independent person. They lasted on average 37 minutes with a range of 15-76 minutes.

Outcomes

The RCT included several assessments using established outcome measures and data was also collected from the participants' medical charts. Table 2 provides an overview of the measurements included in this thesis, which are further described below.

Table 2. Overview of outcome measures in Papers I-III and time points of measurement

Measurements	Pre-fracture*	Discharge	3 months	12 months	Discharge-12 months
Independence in walking (I, III)	X	-	X	X	-
Recovery of walking ability (I, III)	-		X	X	-
Walking aids use (I)	X		X	X	-
Gait speed, 2.4 m (I)	-		X	X	-
Independence in ADL (II, III) (Barthel, ADL Staircase)	X	-	X	X	-
Recovery of ADL (II, III)	-	-	X	X	
Hospital LOS (I, III)	-	X	-	-	X
Mortality (I, III)	-	-	-	-	X
Falls (III)	-	-	-	-	X
Readmissions (III)	-	-	-	-	X

*Information was retrospectively collected.

ADL, activities of daily living; LOS, length of stay in hospital

Walking ability (Papers I and III)

Walking ability indoors and outdoors was assessed using two items (need for assistance when walking and need for walking device) from the Swedish version of Physiotherapy Clinical Outcome Variables (S-COVS).[147] The 13-item outcome measure is originally from Canada and contains seven levels, where 1 indicates no functional ability or the need for the assistance of two people and 7 indicates normal function. The scale was developed for patients with neuromuscular and musculoskeletal impairments and has shown to be a valid and reliable instrument for older adults.[148,149] Data was collected via an interview and the assessments during hospital stay concerned the participants' walking ability prior to the fracture. Recovery of at least the same walking ability as before the fracture was evaluated at the two follow-ups.

Self-chosen and maximum gait speed calculated in meters per second (m/s) and over a distance of 2.4 meters was assessed. The distance was chosen to comply with a limited space in the participants' homes at the follow-up assessments.[150] The set distance was marked on the floor with coloured tape. The test was performed from a standing still start position with the participants' feet behind

the tape and with their usual walking aids. The participants were instructed to cross the finish line. For self-chosen gait speed, the participants were instructed to walk at their usual pace, and for maximum speed to walk as fast as they could without losing balance. The stopwatch was started on the command "Go" and was stopped when the first foot crossed the finish line. Self-chosen gait speed was calculated using the mean of two tries calculated, whereas the fastest value of the two tries was used for maximum gait speed. Gait speed has shown to be a valid and reliable instrument for older people, although the reliability of maximum gait speed need to be further explored.[151] It can be used to predict different health-related outcomes such as hospitalization, mobility decline and death.[151,152]

ADL (Papers II and III)

Dependence in ADL was assessed with an interview using the Barthel ADL index,[153,154] along with the ADL Staircase including the Katz ADL Index.[155,156] The 10-item Barthel ADL Index is a valid and well-established measure of functional independence.[157] The instrument covers PADL and mobility, and ranges from 0 to 20 with higher numbers indicating better status. The Katz ADL-Index measures independence in six PADLs (feeding, continence, transfer, toilet use, bathing, dressing), and in the ADL Staircase, the Katz Index is extended by an additional four IADL activities (cooking, cleaning, shopping, public transport). In the ADL Staircase, the activities are numbered hierarchically from 0-10, where 10 is the lowest level, indicating dependence in all 10 activities. Both the Katz Index and the ADL Staircase are widely used for evaluating functional changes in ADL and long-term prognosis in older people[155] and have been reported to be valid and reliable measures.[158] However, previous research has shown that the Katz Index, as well as the Barthel Index, has a limited ability to detect small changes.[159] Recovery of prefracture ADL performance according to the ADL measurements described above was evaluated at the two follow-ups and was defined as a score at least as high as before the fracture or at the same level.

Hospital LOS (Papers I and III) and readmissions (Paper III)

Hospital LOS was reported in a median number of days. In paper I, LOS was recorded in three different ways. Total LOS included the time spent in all departments in the hospital from directly after surgery until discharge. Additionally, LOS from admission to the geriatric ward until discharge was measured as well as LOS from admission to the geriatric ward until the discharge-ready date, that is, where the inpatient rehabilitation was completed but the participant remained in the hospital for other reasons, such as waiting for an accommodation in a residential care facility. In paper III, LOS from admission to the geriatric ward until discharge was reported for the subgroup of older adults with dementia.

In paper III, the number of readmissions and the total number of hospital days between discharge and 12 months were registered after study completion.

Falls (Paper III) and mortality (Papers I and III)

The number of participants who fell at least once and the total number of falls between discharge and 12 months were registered after study completion in the subgroup of older adults with dementia. Data was obtained by interviewing the participants at the follow-ups, as well as by information from next of kin, care staff and medical charts.

The one-year mortality rate and mortality between discharge and 12 months specifically in the subgroup of older adults with dementia were registered after study completion.

Baseline assessments

All participants were interviewed during hospital stay by the assessors regarding their social situation, medical history and prescribed drugs prior to the fracture. When CI was present, the next of kin or a nurse in the residential care facility were also consulted. Cognitive function was assessed using the Mini Mental State Examination (MMSE), which is a screening test that scores from 0-30.[160] A score less than 24 indicates CI and a score less than 17 severe CI.[161] To assess delirium the Organic Brain Syndrome Scale (OBS)[162] was used and depressive disorders were assessed using the 15-item Geriatric Depression Scale (GDS).[163] The GDS scores from 0-15, where a score between 5-9 indicates mild depression, while a score of 10 or more indicates moderate to severe depression. After the study was completed, an experienced geriatrician, who was unaware of the study group allocation, analysed medical data and assessments to determine if the participants fulfilled the criteria for dementia, delirium and depressive disorders according to the DSM-IV criteria.[33]

Interventions

In-hospital rehabilitation (Control intervention)

In-hospital care and rehabilitation in the geriatric ward was based on a multifactorial rehabilitation program for hip fracture patients that has previously been evaluated in an RCT and was implemented at the ward in 2000.[86-88] In accordance with the program, the team worked interdisciplinary; individual rehabilitation plans were set up based on CGA, and a thorough discharge planning was carried out. The program focused on detection, prevention, and treatment of postoperative complications, such as delirium, pain, falls, malnutrition, and decubitus ulcers. Moreover, to facilitate functional recovery,

early mobilization, participation of the whole staff in the participants' everyday activities, and retraining with the PT and the OT were included. The specific training provided by the PT aimed at improving transfers and walking ability. In addition, strength and balance training were performed according to the High Intensity Functional Exercise Program (HIFE).[164,165] As the name indicates, the HIFE Program consists of functional exercises performed in weight-bearing positions with the aim of being carried out with as high intensity as possible, i.e., with increasing load for strength training and the postural control fully challenged when performing balance training. The OT focused on PADL training and did an inquiry about the participants' home environment. When needed, the OT and sometimes the PT made a home visit before discharge together with the participant. If there was a further need for rehabilitation after discharge the participants who lived in ordinary home were referred to primary health care, and at three months post-hip fracture, they could also receive rehabilitation at a geriatric outpatient rehabilitation unit connected to the geriatric department. The residential care facilities had their own rehabilitation staffs, and they were contacted before discharge regarding the residents need for continued rehabilitation after discharge.

The GIHR intervention

Participants randomized to the GIHR intervention were also treated according to the multifactorial rehabilitation program during their hospital stay, but with the aim of reducing the number of hospital days and continuing the rehabilitation in their homes with the support of the GIHR team. Discharge was possible when the participants were not in need of hospital medical care, could manage basic transfers, and had the care they required at home. The participants were introduced to someone in the GIHR team before discharge in order to get information about the team, to reduce possible anxiety about leaving hospital, and to inquire whether the participant needed to be accompanied home by one of the team members. The interdisciplinary team consisted of a RN, an OT, and two PTs who visited the participants regularly. A geriatrician was medically responsible, and a social worker and a dietician were available for consultation.

The in-home rehabilitation was individually designed according to the participants' own goals, i.e. team actions and number of home visits differed for each participant. During the first days after discharge, all participants received nearly daily home visits from someone on the GIHR team, and later according to the participants' needs. All team members encouraged the participants to increase their level of activity to resume their prefracture activities. Special priority was given to multifactorial actions in order to prevent falls. The PT intervention was quite similar to the one in the control intervention, but was adjusted to the demands of the home environment and had extra focus on out-

door ambulation, on the assumption that the participant had been able to walk outside before the hip fracture. Besides exercises for indoor and outdoor walking ability, functional strength and balance training, according to the HIFE Program, were included.[164,165] Further, exercise programs were designed for participants who had the capacity to exercise on their own or with support from others. The OT paid special attention to independence in PADL and IADL, tried out assistive devices, and initiated modifications of the home environment with the objective of making everyday activities safer.

The nurse and geriatrician were jointly responsible for medical issues, such as evaluation of pain, healing of the operation wound, and the participants' ability to handle their medicines safely. Interventions for other medical problems besides the hip fracture were planned together with the primary health care. The nurse also evaluated the participants' nutrition. Different aspects that might have an effect on the nutrition were considered, for example, constipation, pain or oral problems. All team members worked together in order to improve the participants' nutritional status, and in some cases a dietician was consulted. The GIHR team worked in close contact with the next of kin, home social services or with the staff at the residential care facilities. The maximum duration in GIHR was 10 weeks. If additional rehabilitation was needed after that time, then colleagues in primary health care or in the residential care facilities were contacted. The participants could also be referred to the geriatric outpatient rehabilitation unit. A summary of the GIHR and control intervention is provided in Table 3.

Table 3. A summary of the main content of the in-hospital rehabilitation program and the home rehabilitation intervention

	In-hospital rehabilitation (*control intervention*)	**Home rehabilitation (HR)**
Team members	- RN, OT, PT, Licensed Practical Nurses, Geriatricians, Dietician, Social Worker - Close cooperation with the orthopaedic surgeons in the medical care of the participants	- As control group during hospital stay HR: RN, OT, 2 PTs, Geriatrician, and Dietician and Social Worker on consultation
Individual care planning	- Early assessment of the participants, usually within 24 hours, to start individualized care planning based on CGA - Team meetings twice a week for evaluation of the individual care plans - Thorough discharge planning	- As control group during hospital stay but with the aim of an early discharge HR: - Individual care planning based on updated assessments and the participants' own goals. - Team meeting once a week for evaluation.
Prevention, detection and treatment of complications	- Active and systematic screening to detect, prevent and treat postoperative complications - Active fall prevention: analysis of internal and external risk factors, which were regularly updated - Calcium and vitamin D, and other pharmacological treatments for osteoporosis if indicated	- As control group during hospital stay HR: - Continued focus on prevention, detection and treatment of postoperative complications - Assessment of how participants handled their drugs - Cooperation with primary health care in medical care
Nutrition	- Food and liquid registration, and protein-and energy enriched meals the first four days, longer if necessary - Nutritional and protein drinks served every day - Consultation with dietician when needed	- As control group during hospital stay HR: - Nutritional assessment and advice by the RN - Consultation with dietician when needed - Team members jointly tried to improve the participants nutritional status

Rehabilitation actions to improve physical function and to prevent falls	- Mobilization within the 24 postoperative hours - Focus on functional retraining with a special focus on fall-risk factors - PADL training around the clock by care staff to increase activity and facilitate recovery - Specialized training and other rehabilitation actions by PT and OT - Home visit before discharge by OT and/or PT -Referral by PT/OT to primary health care, a geriatric outpatient unit, or contact with rehabilitation staff in the facilities if need for follow-up and rehabilitation after discharge.	- As control group during hospital stay HR: - Continuation of rehabilitation in own home when no need of in-hospital treatment - Varying team actions and number of home visits for each participant according to their goals - Rehabilitation for a maximum of 10 weeks - Multifactorial fall prevention -PT: Specialized training of in- and outdoor walking ability, functional strength and balance training according to HIFE - OT: Specialized training in P- and IADL, assessment and use of assistive devices, modifications of the home environment - Collaboration with the next of kin, home social services or staff at the facilities - If additional need for rehabilitation after GIHR, referral by PT/OT to primary health care, geriatric outpatient unit or contact with rehabilitation staff in the facilities

Analyses

All statistical analyses in Papers I-III were performed using IBM SPSS software version 22-25 (Statistics for Windows, Armonk, NY: IBM Corp.) with a two-tailed significance level of $P<0.05$. In the first three Papers, binary logistic regression analyses were used. In Papers I and II, adjustments were made for possible confounding variables. Selection of covariates to include in the models were based on previous research and clinical experience of the authors. Before performing multivariable regression analyses, multi-collinearity between independent variables were investigated using Pearson and Spearman's coefficients.

The analyses were based on the intention-to-treat principle using available data from all participants, according to their original allocation, and regardless of level of attendance. In the RCT study, seven of the participants randomized to the

GIHR intervention did not get the intervention since six of them were judged not to need HR because of long hospital stays with continued in-hospital rehabilitation and one participant was missed. However, according to the intention-to-treat principle they are included in the analysis. Additionally, the number of participants included in analyses of GIHR data (i.e., number of visits from the GIHR team and number of days in GIHR) was n = 105 in Paper I, which was corrected in Paper III to n = 106. This minor correction did not change any of the results.

Paper I

Descriptive statistics were used to analyse group differences in prefracture characteristics and for some of the outcomes. Data on physical assistance when walking and use of a walking device were dichotomized, and a binary logistic regression was used to analyse the odds ratio (OR) of independent walking ability indoors and outdoors, and OR of not having to use a walking device. The regressions were adjusted for age, sex and prefracture status of the outcome variable and for significant differences between the groups at baseline (antidepressants, analgesics). For postoperative LOS, the Mann-Whitney U-test was used because the data were not normally distributed and because of differences between the groups in the extreme outliers.

Paper II

Differences between the GIHR and control groups were analysed with the Student's *t*-test for independent samples for normally distributed continuous variables, the Pearson chi-square test (with Yates continuity correction) or Fisher's exact test for dichotomous data, and for ordinal data and data that were not normally distributed the Mann-Whitney *U*-test was used. Category A in the Katz ADL Index indicated independence in PADL. A binary logistic regression method was used to analyse the OR of independence in each item of the ADL Staircase according to group allocation. The first model was adjusted for age, sex and prefracture status of the outcome variable, and in the final model, significant differences between the groups at baseline (antidepressants, analgesics and Parkinson' s medication) were also added.

Paper III

Descriptive statistics were used in comparisons between participants with and without dementia and between treatment groups, i.e., GIHR vs. control, among the participants with and without dementia. Student's *t*-test for independent samples was used for normally distributed continuous variables, and the Mann-Whitney *U*-test was used for ordinal data and for non-normally distributed

continuous variables. Binary data were analysed with Pearson' s chi-square test (with Yates continuity correction) or Fisher's exact test.

To evaluate the impact of dementia on the outcomes, irrespective of type of treatment, binary logistic regression was used to analyse the associations (OR) between dementia and the risk of falling and mortality after discharge, and between dementia and performance in ADL and walking ability at 3 and 12 months. Analysis using Cox regression was considered for the outcomes related to falls and mortality, but this was considered inappropriate because the proportional hazard assumptions were not fulfilled. The regression models were unadjusted, except for the analysis of falling after discharge, which was adjusted for observation time. Observation time was registered as the time from discharge until the end of the study or until the participant died, declined participation, or left the study for other reasons. The total score on the Barthel ADL Index was dichotomized at the median value (<18, ≥18), and category A in the Katz ADL Index was considered as an independent PADL performance. To investigate if the treatment effect on the outcomes was different among participants with dementia, we also used binary logistic regression in separate models where an interaction term was added to each model between dementia (yes/no) and type of treatment (GIHR or control), and the *P*-value of the interaction was reported.

Paper IV

Data from the individual interviews were analysed by qualitative content analysis (QCA) in accordance with Graneheim et al.[146] According to the method, data is analysed and interpreted in a stepwise and systematic way, resulting in categories and themes that are based on similarities and differences throughout the data.[146] The unit of analysis consisted of all 20 interviews. In the role of first author, I (ÅK) read through the transcribed interviews several times and also listened to the audio recordings in order to be familiar with the data and to obtain a sense of the whole. Next, the interviews were divided into meaning units, i.e., words, sentences, or paragraphs that were related to the same central meaning. The meaning units were thereafter condensed and labelled with codes describing the manifest content. The codes were compared regarding similarities and differences and were then sorted into subcategories that were abstracted and merged in several steps into nine categories that were further abstracted into four themes. During this interpretative process, I had regular discussions with one of the researchers (NL). The analysis was performed using an inductive approach and the software package MAXQDA 2020 was used.

To ensure trustworthiness, we used triangulation between researchers,[166] and some parts of the analysis were performed by all co-authors (NL, BO, MS). I singled out three interviews of different nature, which the co-authors

independently read, divided into meaning units and coded, and their analyses were jointly discussed until consensus was achieved. In addition, at meetings with all authors the classification of the interview data as well as how categories and subthemes were organized and formulated were discussed and changes were made until consensus was achieved. Three of the researchers were PTs (NL, MS and me) and the forth was an RN (BO). All of us were experienced in working with older adults with hip fracture within the field of orthopaedics (BO) and geriatric medicine (ÅK, NL, MS) and also within different settings: in-hospital (ÅK, NL, BO, MS), in a geriatric outpatient unit (ÅK, NL, MS), and on a HR team (ÅK, MS). Two of the researchers (NL, BO) had been involved as assessors in the study and were also experienced in using QCA.

Results

The RCT that this thesis is based on comprised 205 participants (107 in the GIHR group and 98 in the control group). Description of the baseline population is presented in Table 4. The mean age was 82.9 ± 6.7 years, 147 (71.7%) were women, and 142 (69.3%) lived in ordinary housing. Before the fracture, 180 (87.8%) were walking independently indoors with or without a walking aid, though only 92 (44.9%) were independent in PADL. More than half of the participants had three or more comorbidities (58.5%), 153 (74.6%) had delirium during their hospital stay, and 103 (50.2%) of the participants fulfilled the DSM-IV criteria[33] for dementia, where Alzheimer's disease (47.6%) was the most common type of dementia. Most participants had a cervical fracture (72.2%), and 35 (17.1%) of the participants had previously sustained a hip fracture. The use of antidepressants, analgesics and medications for Parkinson's differed between the GIHR and control group at baseline, but no other differences were observed. In the subgroup of older adults with dementia a larger proportion in the control group were prescribed analgesics compared to the GIHR group.

Table 4. Baseline characteristics

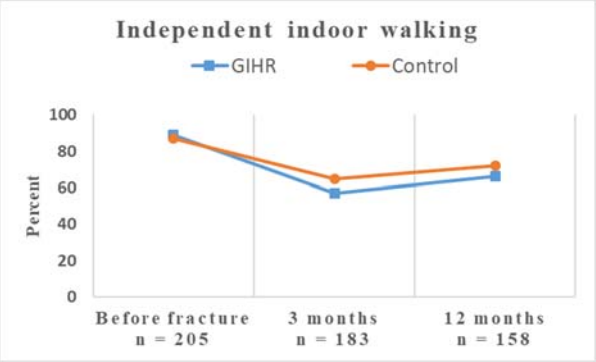
	GIHR n = 107	Control n = 98	D n = 103	ND n = 102
Age (y), mean ± SD	83.2 ± 7.0	82.6 ± 6.4	83.9 ± 6.8	81.9 ± 6.6*
Females, n (%)	79 (73.8)	68 (69.4)	72 (69.9)	75 (73.5)
Living in ordinary home, n (%)	71 (66.4)	71 (72.4)	46 (44.7)	96 (94.1)*
Dementia type, n (%)				
Alzheimer			49 (47.6)	
Vascular			14 (13.6)	
Other			40 (38.8)	
Cervical fracture, n (%)	78 (72.9)	70 (71.4)	79 (76.7)	69 (67.6)
Trochanteric fracture, n (%)	29 (27.1)	28 (28.6)	24 (23.3)	33 (32.4)
Operative methods, n (%)				
Internal fixation	26 (24.3)	22 (22.4)	27 (26.2)	21 (20.6)
Hemiarthroplasty	43 (40.2)	43 (43.9)	44 (42.7)	42 (41.2)
Sliding hip screw	23 (21.5)	18 (18.4)	20 (19.4)	21 (20.6)
Other methods	15 (14.0)	15 (15.3)	12 (11.7)	18 (17.6)
Diagnoses and medical conditions				
Previous hip fracture, n (%)	20 (18.7)	15 (15.3)	22 (21.4)	13 (12.7)
Depressive disorders, [a] n (%)	47 (44.3)	30 (30.9)	55 (53.9)	22 (21.8)*
Delirium during hospitalization, n (%)	84 (78.5)	69 (70.4)	100 (97.1)	53 (52.0)*
Stroke, n (%)	21 (19.6)	24 (24.5)	21 (20.4)	24 (23.5)
Heart disease, n (%)	53 (49.5)	52 (53.1)	59 (57.3)	46 (45.1)
Number of comorbidities ≥3, n (%)	66 (61.7)	54 (55.1)	82 (79.6)	38 (37.3)*
Medications at discharge, n (%)				
Analgesics (not ASA)	87 (81.3)	90 (91.8)*	90 (87.4)	87 (85.3)
Antidepressants	49 (45.8)	26 (26.5)*	56 (54.4)	19 (18.6)*
Benzodiazepines	15 (14.0)	12 (12.2)	17 (16.5)	10 (9.8)
Beta-blockers	42 (39.3)	34 (34.7)	30 (29.1)	46 (45.1)*
Diuretics	36 (33.6)	34 (34.7)	35 (34.0)	35 (34.3)
Neuroleptics	10 (9.3)	13 (13.3)	15 (14.6)	8 (7.8)
Parkinson medications	10 (9.3)	1 (1.0)*	7 (6.8)	4 (3.9)
Assessments				
GDS (0-15),[a, b] median (IQR)	4 (2-6)	4 (2-6)	5 (2-8)	3 (2-5)*
MMSE(0-30),[a, c] median (IQR)	18 (11-25)	19 (11-25)	11 (6-17)	24 (21-26)*
Independent in PADL, [d] n (%)	45 (42.1)	47 (48.0)	16 (15.5)	76 (74.5)*
Barthel Index (0–20),[c] median (IQR)	18 (13-20)	18 (13-20)	15 (10-18)	20 (18-20)*
ADL Staircase (0-10),[a, b] median (IQR)	5 (1-7)	4 (1-7)	7 (5-8)	2 (0-4)*
Walking independently indoors, n (%)	95 (88.8)	85 (86.7)	83 (80.6)	97 (95.1)*
Walking independently outdoors, n (%)	70 (65.4)	71 (72.4)	55 (53.4)	86 (84.3)*

[a] Measurements available when values were missing. [b] Lower scores indicate better status. [c] Higher scores indicate better status. [d] Category A according to Katz ADL Index.
*Indicates a significant difference between GIHR vs. Control or between D vs. ND.
ADL, activities of daily living; ASA, acetylsalicylic acid; D, participants with dementia; GDS, Geriatric Depression Scale; GIHR, geriatric interdisciplinary home rehabilitation; IADL, instrumental ADL; IQR, interquartile range; MMSE, Mini Mental State Examination; ND, participants with no dementia; PADL, personal ADL

Walking ability (Papers I, III)

In Paper I, it was shown that walking ability deteriorated in both groups post-hip fracture as presented in Figure 3. At the three-month follow-up, 54 (56.8%) participants in the GIHR group and 57 (64.8%) in the control group could walk independently indoors with or without a walking aid (P = 0.273), and at 12 months the totals were 53 (66.3%) vs. 56 (71.8%) in the GIHR and control groups, respectively (P = 0.451).

A.



B.

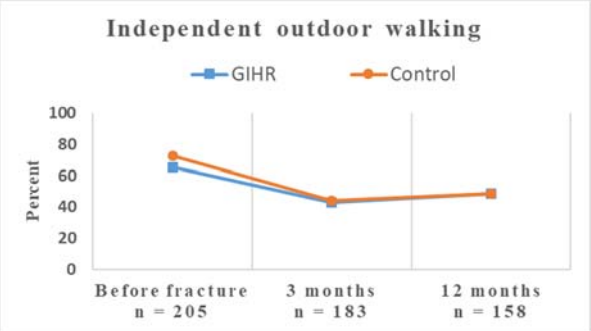


Figure 3. Proportion of participants walking independently indoors and outdoors, before fracture, and at the 3- and 12-month follow-up visits.

Binary logistic regression analyses showed that the OR of being independent in walking indoors or outdoors, or being able to walk without a walking device, at 3 and 12 months did not differ between the GIHR and control groups. Two participants in the GIHR group and one participant in the control group were not able to walk before the fracture. These numbers increased to 8 (8.4%) vs. 3 (3.4%) at 3 months for the GIHR and control groups, respectively, and to 9 (11.3%) vs. 8 (10.3%) at 12 months, although there were no significant differences between the groups. There were no differences between the GIHR and control groups in any of the gait speed tests at 3 or 12 months (Table 5).

Table 5. Self-chosen and maximum gait speed over 2.4 m for the two groups at the 3- and 12-month follow-up visits

	GIHR	Control	*P-value*
Self-chosen gait speed, m/s ± SD			
At 3 months, (n = 156)	0.43 ± 0.19	0.43 ± 0.20	0.899
At 12 months, (n = 138)	0.49 ± 0.19	0.48 ± 0.17	0.945
Maximum gait speed, m/s ± SD			
At 3 months, (n = 149)	0.70 ± 0.31	0.69 ± 0.29	0.845
At 12 months, (n = 135)	0.74 ± 0.30	0.75 ±0.27	0.846

GIHR, geriatric interdisciplinary home rehabilitation

In Paper III, interaction analysis of the treatment effect (GIHR or control) on independent indoor and outdoor walking ability showed no difference in the dementia subgroup at 3 and 12 months ($P > 0.05$ for all). Binary logistic regression analyses showed that the dementia subgroup, irrespective of type of treatment, had significantly impaired walking ability at the 3- and 12-month follow-ups compared with participants without dementia (Table 6).

Table 6. Odds ratios of independent walking ability and ADL performance at the 3- and 12-month follow-ups for participants with dementia compared to those without dementia

	N	3 months OR*	95% CI	N	12 months OR*	95% CI
Independent indoor walking ability	183	0.15	0.08-0.29	158	0.08	0.04-0.19
Independent outdoor walking ability	183	0.17	0.09-0.32	158	0.08	0.04-0.17
Barthel Index, [a] (median ≥18)	184	0.08	0.04-0.17	159	0.11	0.05-0.23
Independent in PADL	184	0.06	0.02-0.16	159	0.09	0.04-0.21

*Unadjusted binary logistic regression analysis. [a] Score of ≥18 indicates better status.
CI, confidence interval; OR, odds ratio; PADL, personal activities of daily living

Independence in ADL (Papers II and III)

In Paper II, the total median score of the Barthel ADL Index, the Katz ADL Index or the ADL Staircase did not differ significantly between the groups at 3 and 12 months. Similarly, there was no difference between the groups regarding independence in PADL at the 3- and 12-month follow-ups. At 3 months, 28 (29.5%) participants in the GIHR group and 26 (29.2%) in the control group (P = 0.99) were independent in PADL, with some improvement at 12 months: 31 (38.8%) vs. 29 (36.7%) for the GIHR and control groups, respectively (P = 0.919). The proportions of participants who were independent according to the items in the ADL Staircase at 3 and 12 months are presented in Table 7, along with the ORs for each item of those being treated in the GIHR group. Binary logistic regression analyses, adjusted for age, sex, prefracture status of the outcome variable and baseline differences (antidepressants, analgesics, Parkinson's medications), showed that participants in the GIHR group were more likely to be independent in bathing at three months (OR 3.39; 95% CI: 1.09-10.59), but no other significant differences between the groups were found.

In Paper III, interaction analysis of the treatment effect (GIHR or control) on ADL (having a Barthel Index score of ≥18 or being independent in PADL) showed no difference in the dementia subgroup at 3 and 12 months (P>0.05 for all). Among those with dementia, 4 (8.2%) in the GIHR group and 1 (2.6%) in the control group (P = 0.381) were independent in PADL at 3 months, and at the 12-month follow-up the totals were 6 (14.6%) vs. 2 (6.9%) in the GIHR and control groups, respectively (P = 0.455). When comparing participants with and without dementia, and irrespective of type of treatment, binary logistic regression analyses showed that dementia was associated with impaired ADL performance at 3 and 12 months compared to those without dementia (Table 6).

Table 7. Independence in the items of the ADL Staircase at 3 and 12 months, and odds ratios of being treated in the GIHR group

	GIHR n = 107	Control n = 98	Adjusted odds ratio†	95% CI
Independent in dressing, n (%)				
Before fracture, (n = 204)	66 (62.3)	61 (62.2)		
At 3-month follow-up, (n = 182)	38 (40.4)	43 (48.3)	1.35	0.54 -3.35
At 12-month follow-up, (n = 158)	43 (53.8)	45 (57.0)	1.96	0.71 – 5.43
Independent in bathing, n (%)				
Before fracture, (n = 204)	46 (43.4)	49 (50.0)		
At 3-month follow-up, (n = 181)	28 (30.1)	26 (29.2)	3.39*	1.09 -10.59
At 12-month follow-up, (n = 158)	31 (38.8)	29 (36.7)	2.87	0.98 – 8.43
Independent in toilet use, n (%)				
Before fracture	84 (78.5)	71 (72.4)		
At 3-month follow-up, (n = 183)	54 (57.4)	52 (58.4)	1.08	0.44 - 2.66
At 12-month follow-up	52 (65.0)	53 (67.1)	1.17	0.41 – 3.30
Independent in transfer, n (%)				
Before fracture	94 (87.9)	84 (85.7)		
At 3-month follow-up	59 (62.1)	59 (66.3)	1.06	0.47 – 2.39
At 12-month follow-up	53 (66.3)	58 (73.4)	0.72	0.28 – 1.87
Independent in continence, n (%)				
Before fracture	74 (70.5)	67 (68.4)		
At 3-month follow-up, (n = 180)	56 (60.2)	60 (67.4)	0.96	0.42 – 2.21
At 12-month follow-up, (n = 156)	49 (62.0)	55 (69.6)	1.05	0.40 – 2.77
Independent in feeding, n (%)				
Before fracture	97 (90.7)	84 (85.7)		
At 3-month follow-up	81 (85.3)	78 (87.6)	1.00	0.35 - 2.84
At 12-month follow-up	63 (78.8)	68 (86.1)	0.46	0.15– 1.35
Independent in cooking, n (%)				
Before fracture	39 (36.4)	36 (36.7)		
At 3-month follow-up, (n = 183)	20 (21.3)	27 (30.3)	0.47	0.17 – 1.31
At 12-month follow-up, (n = 158)	22 (27.8)	25 (31.6)	1.23	0.45 – 3.36
Independent in cleaning, n (%)				
Before fracture	29 (27.1)	20 (20.4)		
At 3-month follow-up, (n = 181)	13 (14.0)	8 (9.1)	1.61	0.49 – 5.30
At 12-month follow-up, (n = 158)	17 (21.3)	11 (14.1)	2.51	0.87 - 7.23
Independent in shopping, n (%)				
Before fracture	29 (27.1)	28 (28.6)		
At 3-month follow-up, (n = 183)	10 (10.6)	7 (7.9)	1.85	0.54 – 6.36
At 12-month follow-up, (n = 158)	14 (17.5)	15 (19.2)	1.27	0.46 – 3.55
Independent in public transport, n (%)				
Before fracture, (n = 200)	35 (33.7)	32 (33.3)		
At 3-month follow-up, (n = 180)	16 (17.4)	10 (11.4)	2.10	0.70 – 6.35
At 12-month follow-up, (n = 149)	12 (16.2)	10 (13.2)	1.40	0.44 – 4.49

Numbers reported after covariates indicate number of measurements available when values were missing. *$P<0.05$

†Binary logistic regression analysis adjusted for age, sex, prefracture status of the outcome variable and significant differences between the groups at baseline (antidepressants, analgesics, Parkinson's medications)

Recovery of walking ability and ADL (Papers I - III)

Recovery of the participants' prefracture walking ability (Paper I) and ADL performance (Paper II) were analysed and showed no significant differences between the groups at the two follow-ups, nor in the subgroup of older adults with dementia (Paper III, n = 103) (Table 8). At 12 months, 45 (56.3%) participants in the GIHR group and 45 (57.7%) in the control group had recovered or improved their prefracture walking ability (P = 0.982), whereas the figures among those with dementia were 12 (29.3%) vs. 7 (25.0%) in the GIHR and control groups, respectively (P = 0.908). The proportion of participants who had recovered their prefracture ADL performance was somewhat lower. At 12 months, 33 (41.3%) in the GIHR group vs. 33 (41.8%) in the control group had regained their prefracture total score, according to the Barthel Index (P = 0.99). Corresponding numbers in the subgroup of older adults with dementia were 10 (24.2%) vs. 6 (20.7) in GIHR and control groups, respectively (P = 0.941).

In Paper III, binary logistic regression analyses showed that the dementia subgroup, irrespective of type of treatment, had poorer recovery of walking ability and ADL performance at the 3- and 12-month follow-ups compared to the participants without dementia. Compared to those without dementia, the OR at 12 months of recovery of prefracture indoor walking ability was 0.10; 95% CI:0.05-0.20 (P<0.001), and the figures for recovery of the Barthel Index score were 0.23; 95% CI:0.12-0.46 (P<0.001), for the participants with dementia.

Table 8. Recovery of prefracture walking ability and ADL performance for the groups at 3 and 12 months and specifically for the subgroup of older adults with dementia

Outcome	GIHR n (%)	Control n (%)	*P*	D in GIHR n (%)	D in Control n (%)	*P*
Walking ability						
3 months [a]	49 (51.6)	48 (54.5)	0.800	16 (32.7)	12 (32.4)	0.99
12 months [a]	45 (56.3)	45 (57.7)	0.982	12 (29.3)	7 (25.0)	0.908
Barthel Index						
3 months	38 (40.0)	38 (42.7)	0.825	11 (22.4)	9 (23.7)	0.99
12 months	33 (41.3)	33 (41.8)	0.99	10 (24.2)	6 (20.7)	0.941
ADL Staircase						
3 months [a]	27 (30.7)	33 (39.8)	0.279	14 (30.4)	13 (35.1)	0.827
12 months [a]	27 (37.0)	36 (48.6)	0.207	9 (23.7)	13 (44.8)	0.118

Recovery was defined as a score at least as high or at the same level as before the fracture. [a] Available measurements when values were missing.
D, participants with dementia; GIHR, geriatric interdisciplinary home rehabilitation

Hospital LOS (Papers I, III)

In Paper I, we found a significantly shorter postoperative hospital LOS for the GIHR group compared to the control group no matter how LOS was calculated. The postoperative LOS from admission to the geriatric ward until discharge was a median of 17 days (IQR 12-26) vs. 23 days (IQR 17-32) for the GIHR and control groups, respectively (P = 0.003).

However, among the participants with dementia (Paper III), we found no significant difference between the groups in postoperative LOS from admission to the geriatric ward until discharge. LOS was a median of 18 days (IQR 14-30) vs. 23 days (IQR 15-30) for the GIHR and control groups, respectively (P = 0.254). Moreover, the postoperative hospital LOS was comparable between participants with and without dementia: 20 days (IQR 14-29) vs. 21 days (IQR 13-32) respectively ($P = 0.928$).

Falls (Paper III)

In Paper III, falls after discharge were evaluated in the subgroup of participants with dementia. We found no statistically significant interaction between dementia and type of treatment (GIHR or control) for the risk of having one or more falls during the year after discharge (P = 0.100). The proportion of participants that sustained a fall and the number of falls during the period are presented in Table 9. Binary logistic regression analysis showed that participants with dementia, irrespective of type of treatment, had a higher risk for falls after discharge (OR 3.86; 95% CI: 2.05-7.27, P<0.001) compared to those without dementia.

Mortality (Papers I and III)

The 1-year mortality rates (Paper I) were 19.6% for the GIHR group and 16.3% for the control group (P = 0.666).

In Paper III, mortality between discharge and 12 months was analysed in the dementia subgroup. Interaction analyses revealed a statistically significant interaction (P = 0.035) between dementia (yes/no) and type of treatment (GIHR or control) for mortality. Further subgroup analyses according to dementia showed that the OR for death for participants with dementia in the GIHR group (compared with the control group) was 0.67; 95% CI: 0.27-1.66 (P = 0.392), whereas the OR for participants without dementia in the GIHR group was 8.14; 95% CI: 0.96-68.81 (P = 0.054). The number of participants who were deceased is shown in table 9. Binary logistic regression analysis showed that dementia was associated with increased mortality overall (OR 4.20; 95% CI: 1.79-9.82, P = 0.001) compared to those without dementia.

Health care utilization after discharge (Papers I and III)

The GIHR team made a median of 13 visits (IQR 5-20) in the participants' homes, and the number of days in the GIHR team was a median of 22 days (IQR 13-35). For the participants with dementia (Paper III), however, the GIHR intervention was significantly shorter, with a median of 17 days (IQR 7-30) vs. 29 days (IQR 22-43) for those without dementia ($P<0.001$), and also involved less frequent home visits, with a median of 10 visits (IQR 4-17) for the participants with dementia vs. 16 visits (IQR 10-22) for the participants without dementia ($P<0.001$).

In Paper I, 33 (33.7%) of the participants in the control group received additional rehabilitation actions in primary health care, in a geriatric outpatient rehabilitation unit, or by another HR team connected to the geriatric clinic during the year after discharge. In the GIHR group, 12 (11.3%) of the participants received additional rehabilitation after the intervention ended, in primary health care, in a geriatric outpatient rehabilitation unit, or in an outpatient rehabilitation unit connected to a residential care facility.

In Paper III, the number of readmissions and hospital days after discharge were evaluated. Analyses showed no significant differences regarding these outcomes between the GIHR and control groups in the dementia subgroup or between participants with and without dementia (Table 9).

Table 9. Postoperative use of health care, falls and mortality between discharge and 12 months

	D n = 103	ND n = 102	*P*	D in GIHR n = 57	D in Control n = 46	*P*	ND in GIHR n = 50	ND in Control n = 52	*P*
Readmissions after discharge, n, (n = 199)	40	71	0.059	26	14	0.373	32	39	0.631
Days in hospital after discharge, n, (n = 199)	389	673	0.086	235	154	0.330	325	348	0.556
Sustained one or more falls after discharge, n (%), (n = 199)	53 (54.1)	31 (30.7)	0.001	28 (50.0)	25 (59.5)	0.465	18 (36.0)	13 (25.5)	0.353
Falls, n, (n = 199)	225	51	<.001	131	94	0.434	32	19	0.239
Deceased in hospital, n, (n = 199)	2	1	0.99	1	1	0.99		1	0.99
Deceased after discharge, n (%), (n = 199)	26 (26.5)	8 (7.9)	0.001	13 (23.2)	13 (31.0)	0.530	7 (14.0)	1 (2.0)	0.031

Numbers reported after covariates indicate number of measurements available when values were missing.
D, participants with dementia; GIHR, geriatric interdisciplinary home rehabilitation; ND, participants with no dementia

Experiences of sustaining a hip fracture (Paper IV)

The 20 participants who were interviewed had a mean age of 81 years, and the majority were women. They had a median MMSE score of 28 (range 22-30), and only one of the participants had dementia. The majority were independent in PADL, and all participants were able to walk independently indoors with or without a walking aid. All but one managed independent outdoor walking. Ten of the participants had received the GIHR intervention, and 10 had received the control intervention. During the year following the fracture, some of the participants had received additional rehabilitation at an outpatient geriatric rehabilitation unit, rehabilitation by another HR team connected to the geriatric clinic, or rehabilitation actions from the community or primary health care.

The analysis of the participants' experiences of their rehabilitation and recovery after hip fracture revealed four themes: *Having support is vital for recovery*; *Getting to know a new me; Striving for independence despite obstacles; and Living an* altered *but acceptable life*. The four themes and the underlying categories are shown in Table 10.

Table 10. An overview of categories and themes

Categories	Themes
To have access to rehabilitation and professional expertise is essential To be involved and treated with respect Support brings well-being and confidence	Having support is vital for recovery
From independent and strong to vulnerable To be changed as a person	Getting to know a new me
A desire to be independent To struggle with difficulties during the recovery process	Striving for independence despite obstacles
To manage a restricted life situation To view change as a natural process	Living an altered but acceptable life

Having support is vital for recovery

Participants expressed the importance of receiving rehabilitation during the year after the hip fracture. They emphasized the need for staff support and expertise, which motivated them and improved their recovery. Further, they voiced that rehabilitation should be individually tailored to their preferences and needs. Participants perceived themselves as being well treated by the staff during the rehabilitation period, although descriptions of disrespect from staff also emerged. The experience of being involved in their own care and discharge planning varied and depended on the amount of information that was provided. Besides the in-hospital rehabilitation, different types of supervised outpatient rehabilitation were appreciated by the participants. They expressed that exercise classes, exercise with the PT in the community, HR, and rehabilitation at a geriatric outpatient unit were suitable alternatives for their needs. Participants who received HR appreciated that they did not have to leave home to receive rehabilitation and expressed feeling safe and in better health, which facilitated their being more active. Contrary, participants who had attended the geriatric

outpatient rehabilitation unit emphasized the benefits of getting out of the home and meeting others in connection with the rehabilitation and also the advantage of well-equipped facilities. Regardless of the rehabilitation setting, participants voiced the importance of rehabilitation being supervised to be effective:

"*It´s only thanks to rehab that I am back on my feet…I could not have managed on my own… definitely not… because what I learned during those months at rehab would never have worked at home…never…I would never have been able to think up all those things… [exercises]… I could never do that.*" (I 29)

Support from family members, friends and home social services were crucial during the recovery process. Having support from the family was also described as a prerequisite for accepting HR, although participants expressed a fear of putting too much burden on their loved ones. They also expressed that getting out of home and meeting with family and friends was important for their well-being. They felt safe in their company and were encouraged to resume activities that they had performed before the fracture, which promoted their recovery. Having to rely on others also meant that the participants sometimes felt overprotected and had to omit some activities or accepted assistance to comply with the demands of their loved ones, even though they believed that they could have managed on their own. In contrary, some expressed that family and friends placed demands and expectations that were too high on them, which resulted in feelings of failure.

Getting to know a new me

Postoperatively, participants suffered from pain and experienced difficulties moving, and also described feeling vulnerable, dependent and out of control. The unfamiliar situation raised concerns about how they would manage on their own in the future. When being discharged, some of them felt confident, while some felt lonely and anxious, and serious psychological conditions such as depression and losing zest for life were reported. Participants voiced that the hip fracture affected their lives to a great extent, since they suddenly had to rely on assistive devices and were dependent on help from others. Losing their independence and having to ask for help was reported to be hard, and some would rather try on their own or drop some activities than ask for help.

The hip fracture was a traumatic event for the participants, and they described that the shock persisted for a long time and caused a change in their self-image. Things that had been important to them before were suddenly not desirable at all, and changing from being full of life to being unable to perform certain activities anymore had far-reaching consequences for their identity. Furthermore, the fracture induced a significant fear of falling, which they had not experienced

before. They started to have doubts about their capacity and became anxious for future negative events, which affected their everyday activities during the whole year after the fracture:

"*I really am…yes, I´m terrified of falling.*" (I 20)

Striving for independence despite obstacles

To remain as independent as possible and to return home were perceived as important by the participants. They described that succeeding with rehabilitation was up to them, to a great extent, and they took advantage of previous life experiences where they had managed to overcome difficulties. When being discharged from hospital, participants expressed that they felt capable and aimed to retake the activities that they had performed before the fracture. They had faced a number of difficulties during the rehabilitation process, such as hip-related complications, comorbidity and disappointment of not recovering to the extent that they had expected to, although they tried to stay positive and focus on the improvements they had made. Working towards a goal was given voice, in order to facilitate rehabilitation:

"*You need to have a goal…everyone should have a goal…because then you exercise more…I exercised like crazy here [at home] …I was determined not to be stuck here for the rest of my life…that´s important…really important…the most important thing in a person´s life."* (I 29)

Living an altered but acceptable life

Participants voiced that the hip fracture was a persistent injury that had dramatically changed and restricted their lives, although some did express, to the contrary, that life had not changed much after the fracture. It was described that spontaneity was gone, as they were dependent on others for transportation, and the energy to invite others to their home was limited. Thus, just staying at home was easier, but some participants described that life had become boring and they perceived themselves as isolated. To manage everyday life, participants adapted step-by-step to the new circumstances, for example, by performing activities in an alternative way, using assistive devices or adopting modifications of the home environment. Despite being less mobile outdoors, participants emphasized that the outdoor environment was important for recovery of their walking ability and also an opportunity to meet others. They described that they tried to remain active, to include exercise in their everyday activities, and found their recommended exercises to be important and doable.

It was also expressed that it was expected that life had changed because of the fracture and their old age. Participants described that they had accepted the fact

that they would not regain their prefracture abilities and tried instead to be grateful for the things they still could carry out:

"*Every morning, I´m so happy that I can get out of bed…that I can get dressed…that I can make my own cup of coffee…not have to stay in bed waiting for someone to help me…that in itself…" (I 28)*

Additional results

The median number of home visits performed by each professional on the GIHR team was: 7 (IQR 3-10) by the PT, 3 (IQR 1-5) by the OT, and 3 (IQR 2-6) by the RN.

Analyses of the number of participants who still lived in ordinary housing at the follow-ups revealed no significant differences between the GIHR and control groups. At 3 months, 45 participants (68.2%) in the GIHR group and 51 (77.3%) in the control group still lived in their own home ($P = 0.328$), and at 12 months the numbers were 42 (72.4%) vs. 48 (80.0%) in GIHR and control groups, respectively ($P = 0.452$). A significantly lower proportion of the participants with dementia still lived in ordinary housing at the follow-ups compared to those without dementia ($P<0.001$ at 3 and 12 months). However, no differences were found between the GIHR and control groups in the subgroup of participants with dementia.

Discussion

This thesis provides new knowledge about the effects of a geriatric interdisciplinary HR intervention and how dementia impacts the outcomes of older adults with hip fracture. In addition, we have explored experiences with rehabilitation and recovery after a hip fracture. Participants who received GIHR had significantly reduced postoperative hospital LOS, and their functional recovery did not differ from that of the control group, who received in-hospital geriatric care according to a multifactorial rehabilitation program. Moreover, the effects of the GIHR intervention did not differ in the dementia subgroup. We could, however, not demonstrate a significantly reduced postoperative hospital LOS in the GIHR group among the participants with dementia, which could have been affected by limited power. It was evident, though, that dementia had a substantial negative impact on the outcomes in both groups following the hip fracture. Participants who were interviewed about their experiences after the one-year follow-up underlined the importance of having access to rehabilitation expertise and support from others for well-being and recovery. They experienced a fundamental change in their self-image after the fracture, and faced a number of difficulties, but they strived for independence and used adaptive strategies to find contentment in their lives.

Recovery of walking ability and activities of daily living

Despite a shorter hospital LOS, outcomes regarding walking ability and ADL performance did not differ between the GIHR and control groups at the two follow-ups. A deterioration in walking ability and ADL was seen in both groups during the year after the fracture, which confirms the long-term negative impact of a hip fracture.[10] Gait speed was almost identical between the groups at the follow-ups. Gait speed is known to be reduced after a hip fracture,[167] and both physical factors, such as lower extremity strength, and psychological factors, such as perceived health and balance confidence, may affect gait speed.[168] The self-chosen gait speed at 12 months for both GIHR and control groups in Paper I was comparable to a previous study of healthy community-dwelling women aged ≥70 with hip fracture who had a usual gait speed of 0.52 m/s measured over 3m.[169] In comparison, normative values for self-chosen gait speed suggested for community-dwelling older adults above the age of 80 are 0.94m/s.[170]

At 12 months, 56% in the GIHR group and 58% in the control group had recovered or improved their prefracture walking ability, and 53% vs. 64% in GIHR and control groups, respectively, had regained their prefracture Katz ADL Index score. In comparison, a previous RCT evaluating a multifactorial in-hospital rehabilitation program, which was the control intervention in the

present RCT, reported that 62% in the intervention group and 53% in the usual care group had regained or improved their prefracture walking ability at 12 months.[88] Furthermore, 58% vs. 36% in intervention and control groups, respectively, had regained their prefracture ADL performance according to the Katz ADL Index at 12-month follow-up. Similar to the present RCT study, participants with dementia and those living in residential care could be included in the study, although the prevalence of dementia was lower (32%), and they did not include those who had a trochanteric fracture.

Previous team-based HR studies have reported better functional performance than the present RCT. Two previous HR studies with a comparable number of home visits as the GIHR intervention reported improved ADL performance and balance confidence[93] and better recovery of walking ability[97] compared to the control group. Other HR studies with only five to six home visits showed positive effects on ADL and mobility compared to the control group.[95,100,108] An essential difference in these studies compared to the present RCT was that they included a healthier sample of community-dwelling older adults with no serious medical conditions, or severe CI or dementia. These groups have complex care needs and an appropriate rehabilitation is more difficult to carry out.

Influence of psychological factors on recovery

Participants in a previous qualitative study described that "there is life after fracture" but described it as a long-term process in which they had to adopt new life perspectives.[171] Participants in Paper IV seemed to have a strong inner driving force to return home after the fracture and to remain as independent as possible. Although they struggled with pain, physical limitations and a slow recovery, they expressed that they tried to look ahead and focus on the improvements during the rehabilitation process. To maintain a positive outlook throughout the rehabilitation may positively affect recovery. A previous study showed that older community-dwelling adults who had a positive outlook during hospitalization had better functional recovery at two years,[172] and a positive approach could also contribute to positive recovery experiences.[173]

The use of adaptive strategies may also facilitate recovery and help older adults to move towards well-being.[140] Strategies like seeing humour in frustration and viewing age as a strength have been reported to be successful adaptive approaches.[174] Acceptance could mean adaptation to a life with disability, but could also be used as a legitimacy to slow down.[175] Those who view functional limitations as a natural symptom of being old may be less motivated to engage in rehabilitation.[137] Similar to other studies,[171,176] participants in Paper IV described using adaptive strategies to still be able to perform everyday activities, although in an alternative manner. According to the Continuity theory of aging, one of the

first adaptive strategies older adults use when circumstances in life are changing is to strive to achieve continuity. Continuity can be defined as the maintenance of general patterns of thoughts, actions and lifestyle.[177]

To obtain a person-centred care, the older adult should be involved as a collaborator in planning the rehabilitation.[131] To set and work towards a goal may facilitate recovery and can be a strategy to overcome difficulties and maintain motivation through the rehabilitation process,[178] which was also emphasized in the interviews in Paper IV. When individual goals are formulated and achieved, the progress becomes visible to the individual, and self-efficacy may be increased.[178] Self-efficacy has been reported to be crucial for the initiation and maintenance of goal-oriented behaviour, since it could give a sense of personal control and empowerment.[139] Goal-setting has been described as an essential part of rehabilitation of adults and may improve self-efficacy and HRQoL,[179] although according to two systematic reviews, the included studies showed no significant positive effects on physical functioning.[179,180] In the present RCT study, participants were involved in goal-setting both during their hospital stay and during the HR intervention. My clinical experience is, however, that the rehabilitation goals could be tailored in more detail specific to the individual in the home setting. When participants returned home, it became more evident for them what had changed after the fracture and also what they considered most important to achieve. In addition, it was easier to involve next of kin or informal caregivers when formulating the rehabilitation goals.

Some of the reported experiences in Paper IV may have affected recovery negatively. It was expressed, for example, that participants felt vulnerable and had doubts about their own abilities. These experiences could lead to a reduced physical activity level, which in turn may lead to an additional functional decline. This was described in a previous study where 12 community-dwelling older adults who had undergone in-hospital and outpatient rehabilitation were interviewed about 12 weeks after their fracture.[181] They expressed that psychological factors, such as fear and lack of confidence, contributed to their impaired mobility in the home and in the community. Prolonged sedentary behaviour has been reported to be a problem among older adults post-hip fracture, with more than 75% of waking hours spent sedentary and low levels of physical activity.[182] Additionally, loneliness and social isolation have been reported to be common.[183] In Paper IV, participants emphasized the importance of support after discharge from family and friends for their well-being, to be able to get out into the community and to resume activities that they had performed before the fracture. In addition, support from the rehabilitation professionals, for instance, on the HR team and at the outpatient rehabilitation unit was highly valued. A previous scoping review reported that social support as well as socioeconomic status may influence functional recovery, although evidence is limited.[69] The authors maintain that

social interaction may lead to better psychosocial health. When the individual receives feedback and adequate information, self-efficacy may improve.[140] This suggests that support from loved ones, the community and from rehabilitation professionals is needed in a long-term perspective to encourage older adults to engage in rehabilitation during the recovery process as well as to increase their social participation and physical activity levels.

Hospital length of stay

In the present RCT study, the hospital LOS was reduced for the GIHR group compared to the control group. A previous HR study reported a reduced hospital LOS, with a median of one day, compared to the control group, although LOS was only eight days for the HR group.[93] Another study with a mean hospital LOS for the HR group of 18 days showed no reduction. [95] Hospital LOS could, however, be a difficult outcome for comparison across studies since it depends on the organization of different health care systems.[82] Hospital LOS after hip fracture has continued to decrease during recent decades and is now a median of six days in Sweden among the hospitals that report to the RIKSHÖFT database.[9] Hospital LOS varies, however, between 4 and 12 days depending on how post-fracture rehabilitation is organized in the different municipalities.[9] LOS may involve only the acute care after the fracture, but could also include in-hospital rehabilitation as in the present RCT. Furthermore, available rehabilitation options in the community after discharge differ across the country, which may also affect LOS. According to records of the University Hospital of Umeå, the current median LOS for individuals with hip fracture at the geriatric ward where the RCT study was conducted has been somewhat reduced compared to the study period between 2008 and 2011.

The shorter hospital LOS for the GIHR group did not increase the number of complications after discharge compared to the control group, as we have reported in a previous work of the research group.[37] A large register study showed that the risk of short-term mortality and readmissions was lower when the participants received in-hospital care in a geriatric ward after the fracture.[60] Reducing the hospital LOS but with access to a specialized HR team after discharge seems to be a comparable alternative. In Sweden, those who live in residential care before the fracture often have a very short hospital LOS, despite limited rehabilitation resources in the facilities.[11] According to an SBU report, rehabilitation for those with short LOS who are discharged to short-term care facilities or return home to residential care need to improve.[11] Rehabilitation should be structured and better organized and performed in collaboration between the community and primary health care. Staff in the facilities may have insufficient medical competence to care for older adults who have recently undergone hip fracture surgery and to handle postoperative complications that may emerge. This was expressed in a

qualitative study, performed in parallel with an RCT, where a rehabilitation program for nursing home residents with hip fracture was evaluated.[184] Staff expressed lack of competence, resources and confidence for performing the rehabilitation and also poor transfer of information from the hospital. Support from a hospital team during the first four weeks, however, improved the recovery experience of the nursing home staff as well as for the family members. Moreover, the intervention had positive short-term effects on mobility, nutritional status, and mortality compared to the control group.[124]

Experiences of being discharged

Participants in Paper IV described the importance of receiving information from hospital staff, of being involved in discharge planning and of having time to prepare themselves for discharge. To comply with these needs it seems that LOS should not be too short. The need to participate in discharge planning was also described in the work of Segevall et al.,[132] where participants expressed that the recovery process, which began in hospital, was supported when being involved in the discharge planning. In Paper IV, some participants expressed that they had not been involved in the planning and that the notification of being discharged came totally unexpected. Although, their knowing that they would receive follow-up, for instance, by the GIHR team, made them feel more confident and prepared to leave the hospital. The value of follow-up and continued rehabilitation after the in-hospital rehabilitation was also described in a previous HR study.[176] Participants in the study expressed that, due the support they received, they regained more confidence in performing activities that were important to them.

One potential benefit with a shorter hospital LOS and continued care and rehabilitation in the home may involve a reduced health care cost. However, evidence of the impact on healthcare costs is insufficient and may depend on how the HR intervention is implemented.[185] Another benefit may be an adaptation to the decreasing amount of hospital beds available.[1] Moreover, participants who were allocated to the GIHR group described that they preferred to receive rehabilitation at home and would gladly leave their hospital beds to someone else. They expressed that they became more active in their home environment since they could perform meaningful activities. To return home to a familiar environment in a residential care facility may be perceived as positive for some older adults.[186] We have, however, not explored the experiences of a shorter hospital LOS among those living in residential care, since we interviewed only participants living in ordinary homes in Paper IV.

Falls, mortality and readmissions

The risk of falling, the number of falls, mortality and readmissions after discharge were evaluated in the subgroup of participants with dementia in Paper III. These analyses build upon our previous work evaluating complications after discharge in the whole sample.[37] Similarly, among those with dementia, the GIHR intervention did not increase the risk for falls, mortality or readmissions compared to the control group. Instead, we were surprised to find that mortality in the GIHR group during the year after discharge seemed higher among those without dementia, although not significantly higher. We cannot explain this finding, but we believe that it should be interpreted with caution and should indeed be further evaluated in future studies with larger samples. Furthermore, with reference to a high rate of hospital readmissions among older adults with hip fracture,[187] we were surprised to find an overall trend of fewer readmissions and hospital days among the participants with dementia than among those without dementia. We believe that this was mainly a consequence of a large number of the participants with dementia living in residential care, where many medical conditions could be treated within the facility, reducing the number of hospital admissions. A previous HR study reported, however, that participants with CI in the HR group were more likely to be readmitted to hospital in the first two years after the fracture compared to the control group.[122] The study authors discuss that frequent home visits could contribute to the detection of health problems that need hospital care.

Falls were common among the participants during the year following the fracture and particularly among those with dementia. In addition, participants in Paper IV expressed that the hip fracture had induced a substantial FoF**,** which they had not experienced before, and that still affected and restricted their everyday life one year after the fracture. FoF is a well-known consequence after a hip fracture,[50,134,176] and once it develops it tends to persist.[143] FoF may lead to a vicious circle of activity avoidance and an additionally impaired physical function.[142] In light of this, it seems very important to try to prevent falls and fractures, but it is indeed a challenge. Despite that the HR intervention in the present study gave special priority to multifactorial fall prevention actions and included an exercise component, the number of falls after discharge were comparable to the control group among participants with and without dementia. The exercise component in the GIHR intervention was likely not optimal to have an effect on falls when considering that the exercise interventions included in the Cochrane review by Sherrington et al.[54] lasted 12 weeks or more.

Previous interventions aiming to reduce falls have seldom been designed specifically for older adults with dementia, which may have contributed to the limited evidence on successful fall prevention among older adults with

dementia.[25] A multifactorial rehabilitation program (i.e., the control intervention in this study) has, however, proven to reduce in-patient falls also among those with dementia.[86] Contrary, previous HR interventions where some participants had mild to moderate dementia have not been able to show any significant differences regarding falls between HR and control groups.[93,96,99] Shyu et al.[122] reported that participants in the HR group without CI were less likely to fall during the first two years after the fracture compared to the control group, although this was not seen among participants with CI.

Outcomes in older adults with dementia

Previous rehabilitation interventions after hip fracture including older adults with dementia are few, and they have not been tailored specifically for those with dementia.[39,188] Functional recovery is worse among older adults with dementia than among their counterparts without dementia, indicating an urgent need for rehabilitation in this subgroup.[39] This is consistent with our findings in the present RCT study where we found that dementia was associated with an overall negative impact on the outcomes. The results from the subgroup analysis of participants with dementia (Paper III) suggest, however, that participants with dementia should not be excluded from HR interventions, since outcomes were comparable between GIHR and control groups among those with dementia. This is supported by two subgroup analyses of HR interventions, which found that participants with mild to moderate dementia benefited from the interventions. They improved ADL and recovered walking ability to a greater extent than those who received routine care in hospital.[122] The other study reported a shorter LOS for HR group and less need of residential care at 12 months compared to rehabilitation in local hospitals.[123] In-hospital, a multifactorial rehabilitation program has shown to reduce postoperative complications for participants with dementia, and a larger proportion recovered their prefracture walking ability and PADL performance compared to usual care.[89]

It has been shown that older adults with dementia do not have the same access to subacute rehabilitation after the fracture,[186] and particularly not those living in residential care.[189] Barriers for receiving rehabilitation may involve resource availability, insufficient management of comorbidity and postoperative complications such as delirium, and attitudes among rehabilitation professionals.[186] Health professionals, experienced in working with older adults with dementia and hip fracture, expressed in in-depth interviews that access to rehabilitation should not be based on the presence of dementia, but they called for education to better understand how dementia affects rehabilitation.[190] This is in agreement with a narrative review, which reported that health care staff need education to be able to adapt person-centred approaches, which those with dementia need.[125] Family members and informal caregivers are an important

resource to enable an individualized care. Health-care staff should involve them in care planning and support them throughout the rehabilitation process, as they have a key role in facilitating social participation of older adults and the resumption of previous activities after discharge.[188]

The GIHR intervention was not specifically tailored for individuals with dementia, but for vulnerable old adults with comorbidity, including dementia. The intervention seems, however, to include many of the important features mentioned above. However, analyses revealed that participants with dementia received fewer home visits, and the HR intervention was shorter compared to participants without dementia. This was a surprising result for us, since the clinical experience is that the intervention is feasible also for those with dementia. I believe this result is more related to the fact that the HR team experienced it being difficult to work in the residential care facilities where a high proportion of those with dementia lived. The team found it difficult to coordinate the team actions with the staff at the facilities and with regard to the different organizational routines at the facilities. This meant that it was hard to carry out the rehabilitation and to accomplish and maintain successful teamwork. This might have affected the magnitude of the intervention and may have resulted in the team members finding it more appropriate for the participants to receive further rehabilitation with the support of the usual rehabilitation professionals connected to the facilities. In clinical practice, when the RCT study was completed, the GIHR team focused solely on community-dwelling older adults where they felt that they could operate more usefully. Undoubtedly, there is a need for enhanced rehabilitation after a hip fracture in the facilities also, but I believe a better alternative is to increase competence and rehabilitation resources within the facilities.

Pros and cons of interdisciplinary home rehabilitation

Rehabilitation in the home setting has its benefits. When being in a vulnerable situation, such as after a hip fracture, the home environment may support the self, since it is connected to previous experiences and a sense of being part of family and neighbourhood.[191] This is consistent with our findings. Participants expressed feeling exposed and out of control after the fracture and experienced a change in their self-image. Those who had received HR expressed that home was the right place for rehabilitation, since they felt more secure and in better health there than in hospital. To practice everyday activities in one's own home environment makes exercise functional, task-specific and purposive. Furthermore, to perform activities that are important to the individual in a supervised and safe manner may increase self-efficacy and thereby improve performance of everyday activities. This is supported by the literature where HR studies have shown improved balance confidence to avoid a fall when performing

ADL, both from short- and long-term perspectives.[93,95,96] In addition, adherence to exercise activities has shown to be better when integrated into daily routines.[192] In the present RCT study, we unfortunately did not assess self-efficacy, which would have been interesting, and I believe that the content of the GIHR intervention seems appropriate for improving that outcome. For older adults with CI or dementia, exercise in an environment that is similar to the one in which the skill will be used has been reported to be beneficial because of an impaired ability to transfer skills.[193] This could facilitate that they experience success during the rehabilitation, which has shown to be particularly important for participants with dementia.[194] This may be applied to the group of older adults with hip fracture, comprising individuals who often have CI or dementia. HR may also be a suitable alternative when individuals have physical limitations after the fracture and are restricted by pain and thereby have difficulties leaving their home. This was one contributing factor to why we started the HR team in the geriatric clinic, since we found that further outpatient rehabilitation was often declined because of this. Being in the older adults' homes also enables a close collaboration with next of kin and care staff in home social services or in the facilities, which may increase their participation in the rehabilitation.[188]

Disadvantages with HR may involve fewer rehabilitation sessions and less supervision, which might be needed especially in the presence of CI or dementia. The GIHR team had more frequent home visits during the first week after discharge from hospital for safety reasons and assisted the participants in making contact with the community if additional help from home social services was needed. Other disadvantages may be not having access to well-equipped facilities and missing opportunities to get out of the home to socialize in connection with rehabilitation, like at the geriatric outpatient unit. A previous study has also reported that receiving HR may restrict integrity and could be experienced as being monitored and having to take too much own responsibility.[195] Working in older adults' own homes means that the rehabilitation professionals have to act very careful when suggesting, for example, adaptations to the home environment. On the other hand, when the older adult is in charge and the collaboration is based on mutuality and respect, it may enable a good therapeutic alliance, which may increase motivation and understanding of the rehabilitation.[196] To facilitate recovery, the rehabilitation setting should be characterized by empathy, respect and trust.[145] The importance of being respectfully treated was voiced also by the participants in Paper IV as well as the importance of tailoring all rehabilitation actions to their unique situations and needs.

The present RCT was a pragmatic intervention study where all rehabilitation actions were tailored to the individual. This means that the team actions varied between the participants according to their individual rehabilitation plan. When a multifactorial team approach is used it is also difficult to know which

rehabilitation actions had the best result. Besides exercise and ADL training, important team actions were to give information and to provide support regarding nutrition and the use of medications. The GIHR intervention was relatively short. The participants received in median seven visits from the PT, three from the OT, and three from the RN. When considering previous research, it seems clear that the exercise part of the intervention was too limited to expect improvement in walking ability and ADL performance. A previous meta-analysis reported that these outcomes can be improved after hip fracture with structured exercise.[73] However, the mean dose of the included interventions was 37 hours, and the average follow-up period was 12 weeks. The study also showed better effect when the exercise included progressive resistance training or was performed in other settings than in hospital, suggesting that a delayed exercise intervention may be more effective.[73]

There is strong evidence that structured exercise can improve physical functions in older adults with mild CI, or mild to moderate dementia,[56] which could possibly be applicable also to those with hip fracture. To obtain positive effects on physical function, the exercise should be multi-modal, supervised and performed for about 60 minutes, 2-3 times a week for 9 to 16 weeks.[56] In addition, continuous exercise programs may be needed to maintain effects.[56] A feasibility study of nursing home residents with moderate to severe dementia showed that 30 exercise sessions after the hip fracture, performed for about 40 minutes, 3 times a week for 10 weeks, improved locomotion at 3 months compared to usual care.[197] Moreover, the improvement in locomotion was sustained to 12 months after the fracture. This highlights the need for extended and ongoing outpatient rehabilitation with an appropriate dose and duration. Different rehabilitation options should be provided and the professionals included in the interdisciplinary team should be tailored to the individual. This seems to be particularly important for those with complex problems, such as dementia. However, in Umeå today, there is a lack of rehabilitation options after hip fracture, especially team-based rehabilitation. The geriatric outpatient rehabilitation unit has been closed for some years now and access to rehabilitation in the community and in primary health care is very limited.

Methodological considerations

Strengths of the study include the RCT design and that we included a representative sample of older adults with hip fracture in the studied geographical area, since we also included those with severe CI or dementia and those living in residential care facilities. This strengthens the external validity of the study. In addition, the control group received a multifactorial rehabilitation program that could be considered to be best practice,[86-88] which may have contributed to comparable results between the GIHR and control groups. The

intention-to-treat principle was used in order to reduce selection bias, and seven of the participants allocated to the GIHR group did not receive the intervention but are included in the analyses. Among the participants with trochanteric fractures, there may, however, be a risk of selection bias. They were only referred to the geriatric ward if they needed a longer rehabilitation period, suggesting that they presumably were frailer. This may limit the external validity among the population with trochanteric fractures. Furthermore, about 70% of the participants included in the RCT study were women, reflecting that hip fracture is more common among women, but does limit the generalizability of the results with respect to older men with hip fracture. Considering the high age and morbidity of the participants, losses were expected before the follow-ups. Most drop outs occurred because the participants were deceased, and only a few were due to participants declining to continue in the study. The fact that the follow-ups were performed in the participants own homes may have contributed to this low drop-out rate.

The randomization was stratified according to type of fracture and type of housing in order to obtain a good balance between the participants' characteristics in each group. The RCT study included a thorough data collection with structured interviews and assessments. The assessments during hospital stay and at the follow-ups were performed by experienced and independent researchers who were blinded to group allocation. Data obtained from the assessments was complemented with a structured review of the participants' medical records, which was retrospectively performed. This was carried out by a geriatrician who was not blinded to group allocation, which might have introduced some bias. A strength, though, is that the dementia diagnosis at baseline was based on the DSM-IV criteria[33] and not only according to the MMSE score as in previous HR studies.[122,123] Information from medical records as well as the follow-up assessments regarding the MMSE score, the OBS and GDS scale were used to be able to differentiate between dementia, delirium and depressive disorders.[33] This was performed by an experienced geriatrician, unaware of group allocation.

The RCT study was designed and conducted some years ago, guided by the 2001 CONSORT guidelines,[198] and the trial protocol was published to increase transparency in conduct and reporting. Power was calculated on one of the planned primary outcomes, LOS, since the overall purpose with this clinical trial concerned the demand from hospital management to reduce hospital LOS. It would have been useful to perform a power calculation also on walking ability or ADL performance, which were also planned primary outcomes, but that was unfortunately not done. Moreover, the study was designed to be a superiority study and may have insufficient power to show equivalence between the groups, as we have found in Papers I-III. Another limitation is that the subgroup analysis

of participants with dementia (Paper III) was a *post-hoc* analysis, which might reduce the credibility of the results. We considered it important, though, to evaluate the GIHR intervention among the participants with dementia, since half of the study participants had dementia at baseline, and older adults with severe CI or dementia have been excluded from previous team-based HR studies. The results could also be a valuable help in the clinic when considering different rehabilitation alternatives for those with dementia.

Multiple analyses on the same data were conducted in Papers I-III, which increases the risk of false positive results, i.e., Type I errors.[199] It is likely that this could have occurred. Furthermore, we did not adjust the significance level. This should be considered when interpreting the results. In the subgroup analysis (Paper III), interaction analyses were used as recommended, but the statistical power was likely insufficient to detect true differences between the groups, which means an increased risk for Type II errors.[199]

Established and validated outcome measures were used in Papers I-III, although in terms of walking ability, only two items (need for physical assistance when walking and need of a walking device) from the Swedish version of Physiotherapy Clinical Outcome Variables (S-COVS) was used.[147] The original scale has shown to be sensitive to change and a good alternative for evaluating different interventions in older adults,[149,200] although this might not be the case when the whole scale is not used. Because of the extensive assessments in the RCT study, it was not appropriate to use the whole scale, but we thought that using these two items would enable us to describe walking ability in a structured way. Baseline data on walking ability and ADL performance concerned the participants' abilities before the fracture, suggesting a risk for recall bias. However, in the presence of CI, the assessors also consulted next of kin to verify the data, which was also done at the follow-ups where participant interview data were complemented by information from next of kin or care staff at the facilities. Involving several different people is of course not optimal, but it was the best method available for us, as we wanted to also include those with CI. This may have influenced the results since proxy respondents may report more disabilities.[201] The Barthel ADL Index can be assessed through observation or by interviewing the participant, next of kin or care staff, whereas the Katz ADL Index should preferably be assessed in observation by a health care professional.[159]

Gait speed over 2.4m was measured, but only at the follow-ups, since the first assessments took place shortly after the fracture. We used a standing still start position, which may give a slower gait speed, especially since we used a short distance. However, a previous systematic review of gait speed in geriatric patients found no significant differences between tests with a static start or steady state gait speed.[202] The review, however, did not include participants from residential

care settings who most often have CI and have shown to need a longer time to initiate gait.[203] In the present RCT study, the participants were allowed to use their usual walking aids during the test. According to a previous study, the use of a walker improves gait performance, although it might limit the ability to detect changes in gait speed over time[204] and might conceal exercise effects.[205] Data on falls was based on information collected in connection with the follow-up assessments along with participants' medical charts. No fall calendars were used, suggesting that falls are probably underreported.

This thesis includes both quantitative and qualitative approaches that may complement each other and could enable a broad knowledge but also a deeper understanding. I believe it is of great importance to give older adults a voice regarding their experiences of different rehabilitation alternatives. The individual interviews varied in duration between 15-76 minutes. Interviews were shorter when participants found it difficult to put their experiences into words, but overall the interviews provided rich interview data. They were performed after the 12-month follow-up and because of this the participants could have had difficulty remembering how things were one year prior, which may involve a risk of recall bias. Furthermore, those who were interviewed were healthier than the average older adult with hip fracture, since only one participant was diagnosed with dementia, and no participants lived in residential care facilities, which limits transferability to these groups. The assessors in the RCT study selected the participants in connection with the 12-month follow-up and selection was based on how they perceived contact with the participant, and assessments, including the MMSE score, were also considered. One of the assessors performed the interviews. The interviewer was experienced in the field of geriatric rehabilitation and also in qualitative method and had not been involved in the GIHR or control intervention. This could be important in order to allow the participants to speak freely. The interview data was analysed with QCA, which is an appropriate method when aiming to explore variation in the data,[146] and during the analyse process, we used triangulation between researchers to increase trustworthiness. All co-authors met to discuss and agree on the classification and organization of the data. They were all experienced in working with older adults with hip fracture and contributed with their knowledge base and preunderstanding.

Ethical considerations

Medical research including representative samples of older adults with hip fracture is essential to improving quality of care, but requires careful consideration of whether the potential benefits of the research exceed the potential risks and burdens, according to the ethical principles outlined in the Declaration of Helsinki. The present RCT study was approved by the Regional

Ethical Review Board of Umeå, including the interviews performed after study completion.

There are few studies concerning team-based HR for older adults with hip fracture, and it is not known if previous results could be transferred also to those with severe comorbidity, severe CI or dementia, and those living in residential care. Since these groups have been underrepresented in previous studies and have a great need for rehabilitation we considered it important to include them in the present RCT study. It is important to gain knowledge about which groups should be offered team-based HR in clinical practice. We reasoned that receiving individually tailored rehabilitation in a known environment would be positive and that close collaboration with next of kin and informal caregivers could be achieved. Possible risks that were considered involved less supervision, which could, for instance, lead to an increased fall risk. Further risks, in the initial phase, includes having to accept temporary solutions at home because of functional limitations, and also that next of kin might experience increased burdens. Balancing the benefits and risks, we considered it to be more positive than connected to risks to receive some of the rehabilitation in the home environment.

Participants received both oral and written information about the study, usually by a geriatrician or an independent researcher. It was emphasized that they had right to withdraw at any time and that doing so would not affect further care. If the participants had CI and a reduced capacity to understand and consent to the research, next of kin who could provide written informed consent on their behalf was consulted. For those with cervical fractures, however, randomization was carried out before the participant had given his/her consent for participation in the study. This was done because of logistical reasons at the geriatric ward and did not affect the study information that was given to the participants.

Participation in the study also meant that all participants took part in baseline tests and two follow-ups, including interviews, cognitive tests and physical performance tests. The follow-up assessments took place in the participants' homes to make it easier for them. The assessors had medical training and were experienced in assessing older adults. During the assessments they paid attention to signs of discomfort or fatigue. If medical problems were detected in connection with the assessments, participants were recommended to contact an appropriate health care service. The assessors also had the opportunity to consult an experienced geriatrician if needed. Participating in the study also meant that those in the control group could not receive rehabilitation at the outpatient geriatric unit until three months after the fracture in order to minimize the confounding effects at the 3-month follow-up.

Clinical implications

The GIHR intervention seems to be a suitable and appreciated complement to in-hospital geriatric care and rehabilitation. The presence of severe comorbidity, CI or dementia were not obstacles for receiving the intervention, which supports the inclusion of the whole group of older adults with hip fracture in similar interventions. The shorter postoperative hospital LOS for the GIHR group did not affect functional recovery or the number of complications after discharge negatively. When hospital LOS is reduced, in-hospital rehabilitation could be offered to more old adults in need of in-hospital care. In clinical practice, it seems important, though, that the selection of older adults to an HR intervention is based on an individual and well-reasoned decision, especially if it means an early discharge.

Participants who were interviewed about their experiences expressed the need for rehabilitation during the recovery process. Their experiences support the use of an interdisciplinary approach with supervised exercise. Rehabilitation should be tailored to the needs of older adults and to the time-point in the rehabilitation process. This means that different rehabilitation options should be available, in which HR may be one alternative.

During the years since the study was conducted, the methods for hip fracture surgery have improved resulting in a reduction of fracture-healing complications.[12] This could be of major importance for the individual, since everyday activities might be less restricted by pain and mobility restrictions. Still, functional outcomes after hip fracture seem not to have improved during the recent years[15] despite the development of orthogeriatric care models, and outcomes are particularly poor for older adults with dementia.[39] It is evident that older adults with hip fracture have a greater need for rehabilitation than what is offered to them. There is a need for extended outpatient rehabilitation interventions for the whole group of older adults with hip fracture in order to improve or preserve their abilities.

Implications for future research

To our knowledge, the present study was the first RCT to evaluate team-based HR in a representative sample of older adults with hip fracture. Additional large RCTs, including the whole group of older adults with hip fracture, are needed to increase knowledge and to further evaluate the effectiveness of interdisciplinary HR. Based on our findings, interdisciplinary HR can be offered to older adults with dementia, but this needs to be further studied, as well as the effects of HR in relation to severity of the dementia disorder. Moreover, any differences in the effects of HR between women and men need to be investigated.

It would be interesting to evaluate whether an HR intervention that includes an extended exercise component would mean better results for functional recovery and reduce the number of falls. It would also be of interest to evaluate whether an HR intervention performed at a later stage after the fracture might yield better effects. In addition, future studies may want to investigate the effects on psychological aspects such as self-efficacy and FoF. In addition, we have not performed a cost-effectiveness evaluation of the GIHR intervention, which would be of the greatest interest.

Experiences receiving HR among older adults living in residential care and among more men need to be explored. In addition, in-depth interviews could be performed with older adults with dementia if interviews are performed close to a home visit. Future studies might also want to explore how an HR intervention affects the burden of care among next of kin and informal caregivers.

Conclusions

In older adults with hip fracture, early discharge followed by interdisciplinary home rehabilitation significantly reduced postoperative hospital LOS. Functional recovery during the year following the fracture was nevertheless comparable to the control group that received in-hospital geriatric care according to a multifactorial rehabilitation program. The effects of the GIHR intervention did not differ in the subgroup of older adults with dementia, except for postoperative hospital LOS, which was not significantly reduced in the GIHR group among participants with dementia. Further studies with larger samples are needed to validate these results. Overall, dementia was associated with a substantial negative impact on the outcomes.

According to participants' experiences, receiving rehabilitation after the hip fracture was crucial for successful recovery. Participants also expressed the importance of support from family members and friends for their well-being and recovery. Feelings of vulnerability and changes in self-image were described, suggesting that future interventions should consider both physical and psychological aspects.

Different rehabilitation alternatives were appreciated by the participants. Rehabilitation should thus be customised to suit the wishes and needs of older adults and may accordingly be carried out in different settings, where rehabilitation in the home can be one suitable alternative.

To conclude, the findings of this thesis indicate that early discharge followed by geriatric interdisciplinary home rehabilitation after hip fracture can be an alternative and a complement to in-hospital care and rehabilitation for older adults with and without dementia.

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