Hip Fractures - Functional assessments and factors influencing in-hospital outcome of patients with hip fracture, a physiotherapeutic perspective

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2010

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From the Department of Health Sciences, Faculty of Medicine,
Lund University, Sweden 2010

Hip fractures

Functional assessments and factors influencing in-hospital outcome, a physiotherapeutic perspective

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Layout and printing by Media-Tryck, Lund University, Sweden

ISSN 1652-8220

ISBN 978-91-86443-46-7

Lund University, Faculty of Medicine Doctoral Dissertation Series:

2010:31

Contents

List of publications

This thesis is based on the following seven papers, which are referred to by their respective Roman numerals.

Study I
Kristensen MT, Bandholm T, Foss NB, Ekdahl C, Kehlet H.
High inter-tester reliability of the New Mobility Score in patients with hip fracture.
Journal of Rehabilitation Medicine 2008; 40: 589-91.

Study II
Kristensen MT, Andersen L, Bech-Jensen R, Moos M, Hovmand B, Ekdahl C, Kehlet H.
High inter-tester reliability of the Cumulated Ambulation Score for the evaluation of basic mobility in patients with hip fracture. *Clinical Rehabilitation* 2009; 23: 1116-1123

Study III
Kristensen MT, Foss NB, Ekdahl C, Kehlet H.
Prefracture functional level evaluated by the New Mobility Score predicts in-hospital outcome after hip fracture surgery.
Acta Orthopaedica 2010; 81: 296-302

Study IV
Kristensen MT, Foss NB, Kehlet H.
Factors with independent influence on the 'timed up and go' test in patients with hip fracture.
Physiotherapy Research International 2009; 14 (1): 30-41

Study V
Kristensen MT, Bandholm T, Holm B, Ekdahl C, Kehlet H.
The Timed Up & Go test score in patients with hip fracture is related to the type of walking aid.
Archives of Physical Medicine and Rehabilitation 2009; 90:1760-1765

Study VI
Kristensen MT, Ekdahl C, Kehlet H, Bandholm T.
How many trials are needed to achieve performance stability of the Timed Up & Go Test in patients with hip fracture?
Archives of Physical Medicine and Rehabilitation 2010; In press

Study VII
Kristensen MT, Bandholm T, Bencke J, Ekdahl C, Kehlet H. Knee-extension strength, postural control and function are related to fracture type and thigh edema in patients with hip fracture. *Clinical Biomechanics* 2009; 24: 218-224.

Some additional data not previously published are added in the sections of methods and results in this thesis.

Permission to reprint the published papers was obtained from the respective journals.

Abstract

A hip fracture is probably one of the most fatal fractures for the elderly and estimated worldwide to reach 5 million cases annually by the year 2050. Thus, continuing efforts in preventing fractures, with more research and improved treatment strategies for those who do fracture, seem crucial.

The primary aims of this thesis, which comprises seven original papers, including a total of 656 patients, were to examine the reliability and validity of functional assessments used by physiotherapists of patients with different types of hip fracture, and to evaluate pre-surgery factors influencing in-hospital performances and outcome.

Specifically, the ordinal-scaled prefracture functional level; New Mobility Score (NMS, 0-9), the basic mobility; Cumulated Ambulation Score (CAS, 0-6), and the continuous functional mobility, Timed Up & Go (TUG) test, were evaluated. Furthermore, the focus was on the influence of prefracture function and fracture type in addition to age, gender, mental and health status, on in-hospital performances and discharge destination.

The relative intertester reliability of the NMS, and the CAS were, respectively, 0.98 and 0.95, while findings of the absolute reliability expressed by the smallest real difference indicate that a change of one point for both scores signifies a real change for a single person.

The prefracture NMS functional level, in addition to age and fracture type, independently predicts or influences the in-hospital CAS-outcome and TUG-scores. Thus, a patient with a low prefracture level (NMS $\leq$ 6) and/or an inter- or subtrochanteric fracture was, respectively, 18 and 4 times more likely not to regain independency in basic mobility during admittance, compared to a patient with a high prefracture level and a cervical fracture, while

the odds against mobility independency increased with 5% for every additional year of age.

Correspondingly, patients with a low prefracture NMS and an inter- or subtrochanteric fracture, on average took, respectively, 9 and 6 seconds more to perform the TUG, while scores increased with 0.4 seconds per additional year.

TUG scores were strongly influenced by the walking aid used during testing, as patients who performed the TUG with a rollator (a standardised walking aid), required on average 13.6 (95% CI, 11.2-16.1) seconds less than when using their discharge walking aid, a walker. Furthermore, TUG-scores of six subsequent timed trials, performed with a rollator, improved significantly up to and including the third trial.

Finally, patients with intertrochanteric fractures presented significantly larger thigh oedema (11% increase) in the fractured limb compared with cervical fractures (4%), and the oedema was significantly correlated to scores of basic CAS-mobility ($r = -0.61$), postural control (sway, $r = 0.67$), and fractured limb knee-extension strength (% non-fractured, $r = -0.77$) explaining between 32% and 59% of the variance (r^2) in performances.

In conclusion, the NMS, and CAS seem highly reliable with small changes needed to indicate real changes. Findings of the TUG-test indicate that the original TUG-manual needs modification, the fastest of three timed trials performed with a rollator is recommended for testing. The prefracture NMS level, in addition to age and fracture type, provides clinicians with a valid prediction of in-hospital outcome. Finally, our results indicate that the fracture type and the corresponding thigh oedema strongly influence physical performances, including maximal knee-extension strength of the fractured limb. Future research and rehabilitation programmes of patients with hip fracture should accommodate these findings.

Description of contributions

Study I

Study idea	Morten Tange Kristensen
Study design	Morten Tange Kristensen, Nicolai Bang Foss
Data collection	Morten Tange Kristensen, Sanne Busk, Marc Hemmingsen
Data analysis and/or interpretation	Morten Tange Kristensen, Thomas Bandholm, Nicolai Bang Foss, Charlotte Ekdahl, Henrik Kehlet
Manuscript writing	Morten Tange Kristensen
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Study II

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Data collection	Morten Tange Kristensen, Rie Bech-Jensen, Lene Andersen, Malene Moos, Elisabeth Ginnerup Nielsen, Fakhri Quyamudin
Data analysis and/or interpretation	Morten Tange Kristensen, Rie Bech-Jensen, Bente Hovmand, Charlotte Ekdahl, Henrik Kehlet
Manuscript writing	Morten Tange Kristensen

Manuscript revision	Bente Hovmand, Rie Bech-Jensen, Derek Curtis, Thomas Bandholm, Charlotte Ekdahl, Henrik Kehlet

Study III

Study idea	Morten Tange Kristensen
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Manuscript writing	Morten Tange Kristensen
Manuscript revision	Thomas Bandholm, Nicolai Bang Foss, Charlotte Ekdahl, Henrik Kehlet

Study IV

Study idea	Morten Tange Kristensen
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Data collection	Morten Tange Kristensen, Kajsa Lindberg, Lene Abildgaard Frederiksen, Sara Henriksen, Malene Mourier, Anne Hjeresen
Data analysis and/or interpretation	Morten Tange Kristensen, Nicolai Bang Foss, Henrik Kehlet
Manuscript writing	Morten Tange Kristensen
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Study V

Study idea	Morten Tange Kristensen
Study design	Morten Tange Kristensen, Bente Holm, Thomas Bandholm, Henrik Kehlet
Data collection	Morten Tange Kristensen, Berit Jakobsen, Fakhri Quyamudin, Christina Ørtenblad
Data analysis and/or interpretation	Morten Tange Kristensen, Thomas Bandholm, Bente Holm, Charlotte Ekdahl, Henrik Kehlet
Manuscript writing	Morten Tange Kristensen
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Study VI

Study idea	Morten Tange Kristensen, Thomas Bandholm
Study design	Morten Tange Kristensen, Thomas Bandholm
Data collection	Morten Tange Kristensen, Berit Jakobsen, Elisabeth Ginnerup Nielsen, Fakhri Quyamudin
Data analysis and/or interpretation	Morten Tange Kristensen, Thomas Bandholm, Charlotte Ekdahl, Henrik Kehlet
Manuscript writing	Morten Tange Kristensen
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Study VII

Study idea	Morten Tange Kristensen, Thomas Bandholm

Study design	Morten Tange Kristensen, Thomas Bandholm, Jesper Bencke, Henrik Kehlet
Data collection	Morten Tange Kristensen, Berit Jakobsen, Fakhri Quyamudin, Christina Ørtenblad
Data analysis and/or interpretation	Morten Tange Kristensen, Thomas Bandholm, Jesper Bencke, Charlotte Ekdahl, Henrik Kehlet
Manuscript writing	Morten Tange Kristensen
Manuscript revision	Thomas Bandholm, Charlotte Ekdahl, Henrik Kehlet

Thesis at a glance

Papers	Question	Answer	Methods
I	Was the inter-tester reliability of the New Mobility score (NMS) in patients with hip fracture acceptable?	Yes, the relative reliability of the prefracture functio-nal NMS-score is very high, and a change of one NMS-point indicates a real change for a single patient.	The NMS of 48 patients, at a median age of 84 years, recorded by two independent physiotherapists was compared.
II	Was the inter-tester reliability of the Cumulated Ambulation Score (CAS) in patients with hip fracture acceptable?	Yes, the relative reliability of the basic mobility CAS-score is very high, and a change of one CAS-point indicates a real change for a single patient.	CAS-scores of 50 patients, at a median age of 83 years, obtained by an experienced and an in-experienced CAS-score user were compared.
III	Did prefracture functional level evaluated by the NMS predict in-hospital outcome of patients with hip fracture, when adjusted for previously established predictors?	Yes, the prefracture NMS functional level, in addition to age and fracture type is a major predictor of the basic mobility in-hospital outcome and discharge destination after hip fracture surgery.	The influence of the NMS to in-hospital outcome of basic mobility in 280 patients, at a median age of 81 years, when adjusted for age, gender, prefracture functional level, mental and health status, and fracture type, were analysed.
IV	Did individual and clinical factors influence scores of the Timed Up & Go (TUG) test in patients with hip fracture upon discharge from hospital?	Yes, the functional mobility TUG-scores are related to age, prefracture functional level, fracture type, day of testing, and the type of walking aid used during testing.	The influence of age, gender, prefracture functional level, type of walking aid used, fracture type, and postoperative day of testing to TUG-scores in 196 patients ≥ 60 years of age were analysed.

V	Were TUG-scores related to the type of walking aid used during testing upon discharge from an acute orthopaedic ward?	Yes, patients with hip fracture who performed the TUG with a walker or crutches are significantly faster when tested using a rollator.	126 patients, at a mean age of 75 years performed the TUG with a rollator in addition to their discharge walking aid, a walker (n=88) or crutches (n=38).
VI	Was one practice trial followed by one timed trial as recommended in the original TUG-manual enough to ensure stable TUG-scores in patients with hip fracture?	No, a minimum of three timed trials are needed to achieve performance stability of TUG-scores when testing upon discharge from an acute orthopaedic ward.	Performances of six successive timed TUG-trials with up to one-minute seated rest intervals in 122 patients, at a median age of 80 years, were analysed.
VII	Were knee-extension strength, postural control, functional performances, fracture type and thigh oedema in the fractured limb associated after hip fracture surgery? Did pain in the fractured hip influence results?	Yes, patients with intertrochanteric fractures and a corresponding larger thigh oedema in the fractured limb performed poorer than patients with cervical fractures. Knee extension strength in the fracture limb (% non-fractured) is strongly correlated to the amount of thigh oedema No, performances were independent of hip-pain scores.	Subjects: 20 patients, 10 with a cervical and 10 with an unstable inter-trochanteric fracture, at a mean age of 77 years, participated. The association between all variables and between fracture types were analysed.

Abbreviations

AOR	Adjusted odds ratio
ASA	American Society of Anaesthesiologists
CAS	Cumulated Ambulation Score
CI	Confidence interval
FWB	Full weight bearing
ICC	Intraclass correlation coefficient
ICF	International Classification of Functioning, Disability and Health
MVT	Maximal voluntary torque
NMS	New Mobility Score
OR	Odds ratio
SEM	Standard error of measurement
SD	Standard deviation
SRD	Smallest real difference
TUG	Timed Up & Go test

Introduction

Approximately 30% of community-residing people aged 65 years or older fall each year, with higher numbers in institutions[1]. About 53% of women and 21% of men over 50 years of age will have a fragility fracture in their remaining lifetime[2] and of these, a hip fracture is considered to be the most fatal.

The total worldwide number of hip fractures was estimated to be between 1.26 million[3] and 1.7 million[4] in 1990 and estimated to be between 4.5[3] and 6.3[4] million by the year 2050. Thus, patients with hip fracture seem to represent an increasing challenge for clinicians, including physiotherapists, and the health care system worldwide.

Hip fractures, which are primarily caused by accidental falls,[5] have been related to pre-existing mobility, balance, osteoporosis, and visual or other health problems.[6-8] In addition, predictors of mortality or rehabilitation outcome after hip fracture surgery include age,[9-15] gender,[13-20] the prefracture functional and/or ambulatory level,[9, 10, 12, 13, 21-25] cognitive function,[9, 14, 15, 24-27] the American Society of Anaesthesiologist's (ASA) rating or co-morbidities,[12, 14-16, 19, 20, 25] fracture type,[11, 13, 28, 29] more physiotherapy post-surgery,[30, 31] and the postoperative early mobility level.[32-34]

Of the above-mentioned, the prefracture functional level seems to be one of the most consistent predictors of rehabilitation outcome; morbidity or mortality is high (up to 33% at one year),[2, 35-37] and some patients do not regain their prefracture functional level.[38-40] To regain this functional level, independence in basic mobility is an essential first step for patients aiming to return to their prefracture living situation and is associated with a better outcome after hip fracture surgery.[30, 31, 33, 41-43]

Regarding functional assessments, the latest Cochrane review of mobilisation strategies after hip fracture surgery conclude that "development of a standard portfolio of validated and patient-orientated outcome measures would enable meta-analysis of the results of future trials".[44] Further, a critical review of literature regarding the effectiveness of physiotherapy management of hip fracture in elderly persons recommends that, "future research should focus on specific locations of the hip fracture as opposed to merely a universal "hip fracture", including an operational definition of functional recovery after hip fracture".[45]

At the present time, different definitions and assessments are commonly being used. Thus, physiotherapists involved in clinical practice or research concerning patients with hip fracture need a set of easily applicable measurement tools. This requires that the "instruments used to measure outcomes are valid (measure what they are supposed to measure), reliable (provide consistent ratings between repeated measures in a stable population), and responsive (able to detect meaningful change)".[46]

Also, expanded knowledge of pre-surgery factors (including the fracture type) influencing the early in-hospital outcome of patients following a multimodal rehabilitation programme,[47] is considered important in order to plan research studies, and adjust expectations and rehabilitation needs for individual patients in daily clinical practice.

Epidemiology

Hip fracture incidence rates vary according to age and gender, and international developments in incidence vary. Thus, 75% of fractures occur in patients ≥ 75 years of age,[48] around 75% of fractures occur among women, while an age-adjusted decrease in hip fracture incidence rates has been reported e.g. in Northern America (1985-2005)[48, 49] and in a Danish county (1996-2003).[50] On the contrary, an increase was reported in Germany and Austria from 1994 to 2006, while a demographic change from 26% of all hip fractures occuring in Asia in 1990 to 45% in 2050 has been predicted.[3]

Overall, the worldwide increase in age cohorts, probably will lead to an increase in the total number of hip fractures in the future, despite a trend towards lower incidence.[51]

Classification of hip fractures

A hip fracture is commonly classified as intracapsular (femoral neck/cervical), or as extracapsular (intertrochanteric/pertrochanteric or subtrochanteric),[52] as presented in Figure 1. The most commonly used types of hip fracture surgery at Hvidovre Hospital, Copenhagen, Denmark, are shown in Figure 2: Hansson pins from Swemac (A), Bfx hemiarthroplasty from Biomet (B), Hiploc dynamic hip screw (DHS) from Biomet (C), and short intra medullar hip screw (IMHS) from Smith & Nephew (D).

Cervical fractures are most often subdivided into four types according to Garden´s classification, whilst Frandsen et al.[53] recommended division into just two groups, to improve classification accuracy: "undisplaced fractures or minor displacement (Garden I-II), and obviously displaced fractures (Garden III-IV)".[51]

Intertrochanteric fractures are often classified according to Jensen and Michaelsen,[54] and Jensen,[55] these being based on Evan´s original classification.[56] This classification subdivides intertrochanteric fractures into five types based on the number of fragments and their localisation, which are then usually evaluated as stable fractures (two main fragments, Evans I-II) and unstable fractures (more than two fragments, Evans III-V).[51, 52]

Subtrochanteric fractures are present in about 5% of the hip fracture population,[51] with the remaining 95% of hip fractures classified as either cervical or intertrochanteric, which in general are almost equally common, with a higher proportion of trochanteric fractures seen with increasing age, especially in women.[7, 8, 28]

Higher mortality and/or a poorer functional outcome are reported in patients with intertrochanteric fractures compared to those with cervical fractures.[13, 28, 29] Furthermore, a larger hiddden blood loss,[57] higher pain scores,[58] and a larger oedema in the fractured limb,[59] have been shown in patients with inter- and/or subtrochanteric fractures compared to patients with cervical fractures, while anaemia has been associated with a poorer mobility outcome shortly after hip fracture surgery.[60]

Still, the influence of fracture types or the corresponding fractured limb oedema on in-hospital performances and outcome, requires further investigation.

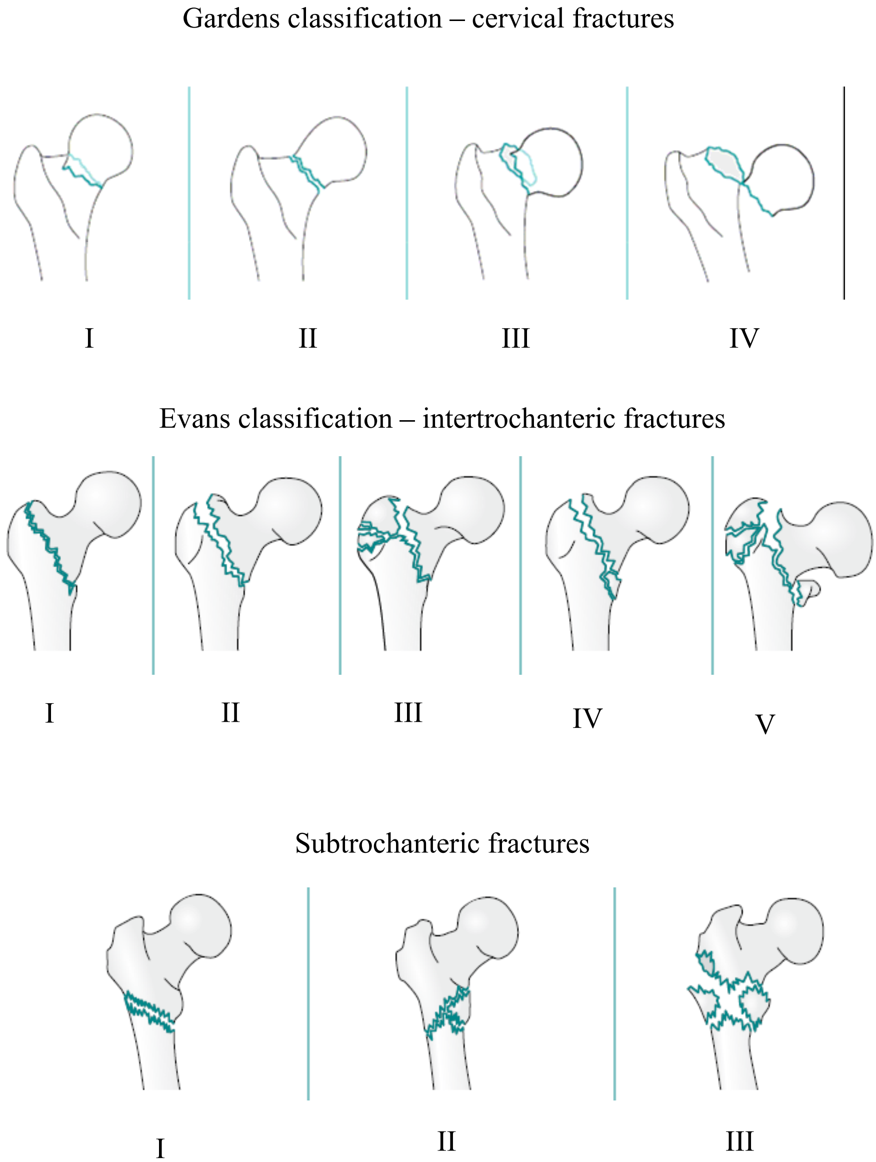

Figure 1. Reprinted from, Ortopædkirurgi for ergoterapeuter og fysioterapeuter with permission from Munksgaard, Copenhagen, Denmark, 01/2010

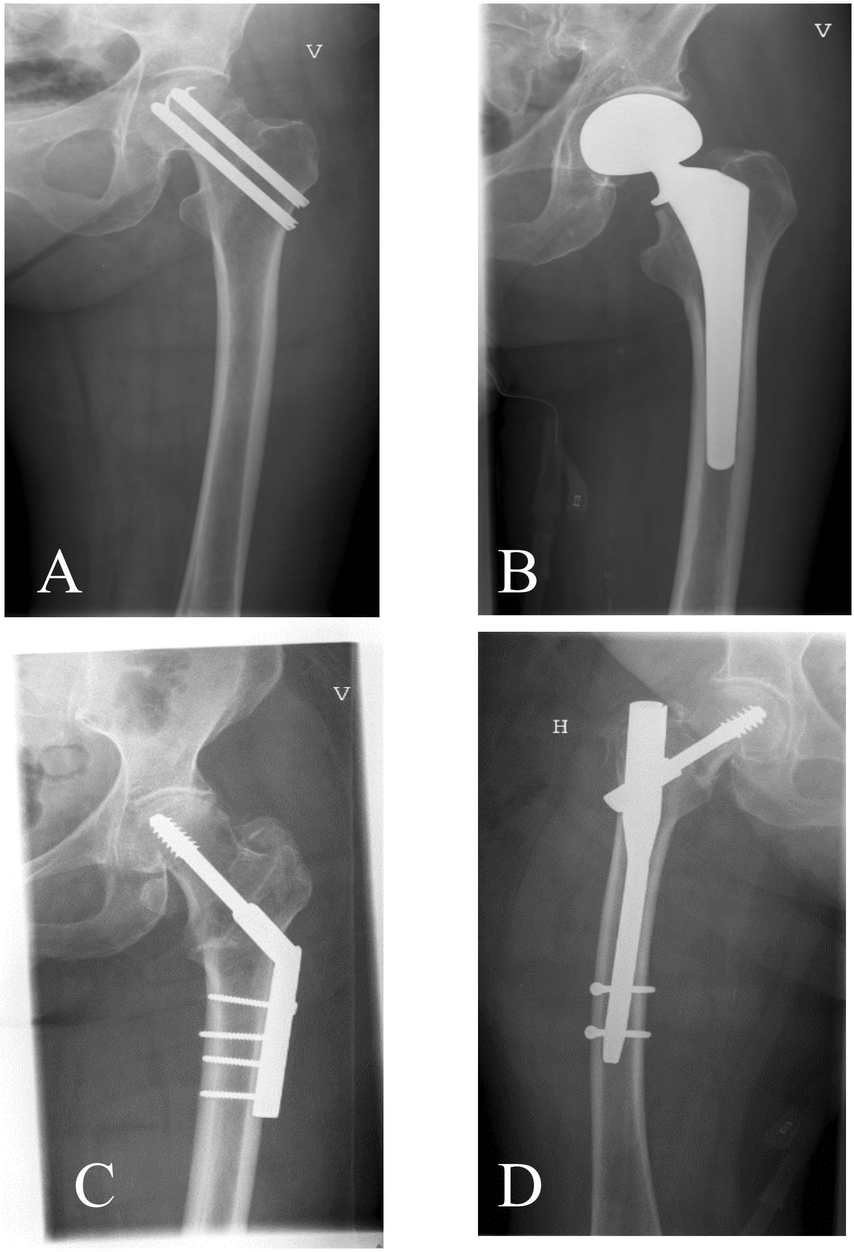

Figure 2. Types of surgery commonly used for undisplaced cervical fractures (A), displaced cervical fractures (B), stable intertrochanteric fractures (C), and unstable intertrochanteric fractures (D).

In-hospital rehabilitation

Somehow, different procedures regarding the postoperative rehabilitation of patients with hip fracture have been adopted. Thus, patients in Northern America[30, 41] are more often discharged from the acute hospital shortly after surgery to further and often long-term in-patient rehabilitation in other settings. In contrast, patients, for example, in Denmark,[33, 61] Sweden,[11, 62] and England,[63] are more often rehabilitated in, and if at all possible discharged directly from the acute hospital, to their previous residence.

Still, very different procedures do exist within the same country, although rehabilitation in the acute ward with discharge directly to the previous residence has been considered equally or more cost-effective when compared with transfer to secondary institutions with in-patient rehabilitation facilities.[64-67] Further, it has been stated that "the aim must be that as many patients as possible return directly home after discharge from a short hospitalization".[11]

Of importance, multimodal strategies,[47, 68,] within optimised programmes, and/or designated staff units,[18, 61-63, 70] have reduced length of stay markedly, without an increase in readmissions, morbidity or mortality. Also, such programmes seem to reduce the number of postoperative falls.[71] Still, some patients do not regain their prefracture level.

Physiotherapeutic in-hospital interventions are commonly aimed at improving basic ambulatory skills, including elements of balance and strengthening exercises, until a safe and independent functional level that enables discharge to the previous residence, if at all possible, are reached. Thus, physiotherapists are important members of the multidisciplinary teams, and should aim high in providing their knowledge to the other staff members in the planning of treatment and rehabilitation needs of all patients.

Physiotherapists seem to have an especially important role in identifying those patients not reaching an ambulatory level which enables a safe return directly to their own home after a short hospitalisation, as this could be fatal for the patient. This is, of course, dependent upon those physiotherapists involved being skilled in their evaluation of this particular patient group, and thereby giving the correct prognosis.

As in other professions, knowledge of the hip fracture population among physiotherapists varies. Thus, determining the factors that influence the in-hospital rehabilitation outcome, in addition to a set of reliable and valid measurements, seem highly relevant to physiotherapists, as these factors are probably more precise than clinical judgement alone.[72]

It is important that such assessments should, at the same time, be readily available and as efficient as possible, as time in an acute orthopaedic ward is limited.

Classification of outcome measures

Outcome measures can be classified according to the International Classification of Functioning, Disability, and Health (ICF),[73] which provides a standard language and framework for the description of health and health-related domains.

The ICF-model (Figure 3) identifies three levels of human functioning with a classification of domains by means of two lists; a list of body functions and structure and a list of domains of activity and participation. In ICF, "the term *functioning* refers to all body functions, activities and participation, while *disability* is similarly an umbrella term for impairments, activity limitations and

participation restrictions".[73] Environmental factors that interact with all these components also are included.
The formal definitions of these components according to the ICF are as follows: "***Body functions*** are physiological functions of body systems (including psychological functions), ***body structures*** are anatomical parts of the body (e.g. organs, limbs and their components), ***impairments*** are problems in body function or structure such as a significant deviation or loss, ***activity*** is the execution of a task or action by an individual, ***participation*** is involvement in a life situation, ***activity limitations*** are difficulties an individual may have in executing activities, ***participation restrictions*** are problems an individual may experience in involvement in life situations, while ***environmental factors*** make up the physical, social and attitudinal environment in which people live and conduct their lives (e.g. architectural characteristics, climate or terrain). As can be seen, ***personal factors*** are also included in the model but are not classified".[73]

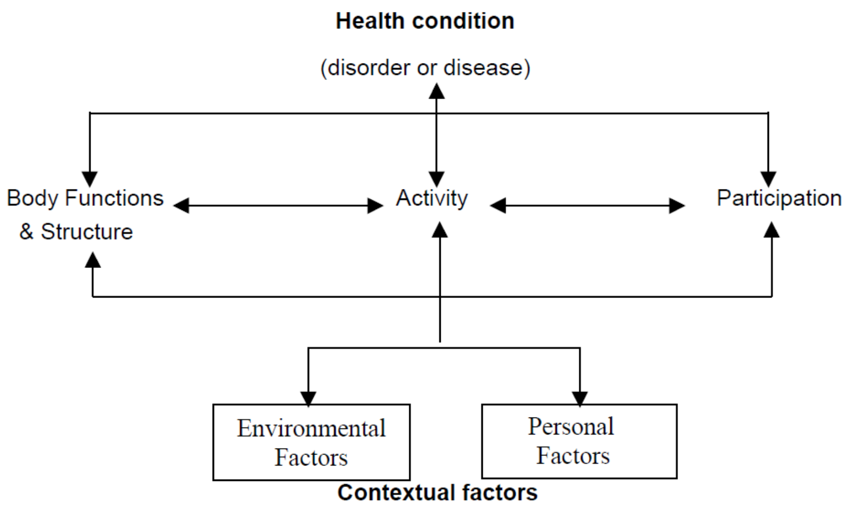

Figure 3. Model of the International Classification of Function (WHO 2002).

The interaction can be explained concisely as follows: "Having an impairment of a body structure (hip joint) or function (range of motion) may contribute to limitations in activities, including activities of daily living, walking, or driving a car that might also contribute to restrictions in participation".[46]

Functional assessments

The prefracture functional level. A number of score-systems like the Katz,[10] the Functional Independency Measure,[74] the New Mobility Score (NMS),[24] and the Functional Recovery Score[22] have been used to evaluate the prefracture functional level and as predictors of the post-fracture outcome.

Of these score-systems, the NMS is the most simple and non-time consuming, being a simple composite score of the patient's ability to perform indoor walking, outdoor walking and shopping before the hip fracture, providing a score between zero and three (0 = not at all, 1 = with help from another person, 2 = with an aid, 3 = no difficulty) for each function, resulting in a total score from 0 (no walking ability at all) to 9 (fully independent, no walking aids or other support needed).[24]

The NMS is recommended in the first and the second National Referendum Programme for patients with hip fracture in Denmark (1999, 2008) for the evaluation of the prefracture functional level and to indicate the potential of rehabilitation. Also, it is named as one of several score-systems clinicians can choose in the Danish National Indicator Project (2010) in patients with hip fracture. Previous studies have defined that a NMS cut-off point of 5 is a valid predictor of one-year mortality[24] and six-months functional level [75] in patients with hip fracture, and is used in a number of studies in the same patient group.[33, 58, 60, 76-85]

Still, no studies have examined in detail (different cut-off points) the potential of the NMS as a predictor of in-hospital performances and discharge status. Neither have the relative and absolute reliability of the score-system been examined.

The basic mobility level. The Cumulated Ambulation Score (CAS), a newly developed score which allows day-to-day measurements of basic mobility, has been found to be a reliable and valid predictor of length of hospitalisation, time to discharge status, 30-day mortality, and postoperative medical complications in patients with hip fracture [33]. Also, the basic mobility level evaluated by the CAS has been related to anaemia,[60] pain in the fractured hip,[58] and used as an outcome measure in a randomised controlled trial concerning transfusion[77] in patients with hip fracture. Further, the score-system has been used to investigate the relationship between early functional mobility and pain intensity in a fast track programme after total knee arthroplasty.[86]

The CAS is recommended for use by physiotherapists in the National Referendum Programme (2008) and as "The" score-system to be used in the National Indicator Project (2010), also in Denmark, for the evaluation of basic mobility in patients with hip fracture.

The CAS describes the patients' independency in three activities:1) getting in and out of bed, 2) sitting down and standing up from a chair, 3) walking ability with an appropriate walking aid. Each function is assessed on a 3-point ordinal scale (2 = independent of human assistance, 1 = requiring human assistance to perform function, 0 = unable to perform function despite human assistance). The score for each function is cumulated to provide a daily score between 0 and 6 (one-day CAS), with 6 indicating independent ambulation on that particular day. In addition, the cumulated scores from the first three days post-surgery can be added to give a value from 0 to 18 (three-day CAS).[33] Also, stair walking can be assessed with the CAS-system, but this is not included in the basic mobility score, not being part of the basic mobility definition.

The relative inter-tester reliability (ICC=0.97) for the total CAS-score has been determined, but this was based on "only" 20 study participants assessed by two experienced CAS-score users, [33] and the absolute reliability was not examined. Thus, the reliability of the three individual activities has not been examined, nor has the reliability between an experienced and inexperienced score-user. In addition, it is not known when a change in the three activities or in the total CAS-score (0-6) represents a real change in the basic mobility level.

The functional mobility level. The Timed Up & Go (TUG) test,[87] which quantifies the functional mobility level as the time in seconds it takes an individual to rise from a chair with arms, walk 3 metres to a line drawn on the floor, and return to the chair is probably internationally the most often used test of functional mobility by physiotherapists.

Mean performance times from 7.7 to 23.6 seconds for the TUG have previously been reported for different groups of community dwelling elderly according to gender, age, chair seat height and use of walking aids.[88-93] Higher mean performance times of 28.2 and 30 seconds[91, 94] have been reported for institutionalised elderly.

Very high intra- and inter-rater reliability[87, 95] and test-retest reliability[89, 96] have been found for the TUG, and significant correlation has been shown to scores obtained using the Barthel Index of activities of daily living, the Berg Balance Scale and gait speed testing,[87] the General Motor Function Assessment Scale,[97] the Four Square Step Test,[98] and the Tinetti Balance.[92] The TUG has also been found to be able to discriminate multiple fallers from non-multiple fallers[98] with medians of respectively, 16.7 and 12.3 seconds. Further, Shumway-Cook et al.[99] reported means of 22.2 and 8.4 seconds for fallers and non-fallers respectively, while Okumiya[100] reported a cut-off point of 16 seconds in predicting falls in older active community-dwellers.

The original TUG-manual describes one practice trial followed by one timed trial,[87] but of concern are the different assessment procedures which have been used in elderly people.[101] Thus, the procedures have varied from only one timed trial,[101] one timed trial after one practice trial (if needed),[102] the mean of two timed trials,[103, 104] the best of two timed trials after one practice trial,[105, 106] the best of three timed trials after one practice trial,[91] the mean of three timed trials after one practice trial,[107] to the time of single trial after three practice trials.[90, 108] Others have followed[94, 109] or referred to[110] the TUG-manual as originally described by Podsiadlo and Richardsson.[87] Also, the mean of three timed test trials after one practice trial was used for people after total hip replacement,[111] while the original manual described use of the instrument in persons with multiple sclerosis.[112]

In patients with hip fracture, the TUG recorded at discharge from an acute orthopaedic ward, with a cut-off point of 24 seconds, has proven useful in predicting non-fallers (negative predictive value of 93%),[80] has been used to evaluate the outcome of rehabilitation [113-117] and seems to correlate with BBS performance [118] and gait speed.[115]

Relative reliability of the TUG in patients with hip fracture has been established in Denmark with a Spearman rank order correlation coefficient of 0.91 for both inter- and intratester comparison of the two ratings, but without reports of the absolute reliability.[119] These results were based on 23 patients using different walking aids (walker, rollator, or crutches) during testing, and evaluated during admittance to an acute orthopaedic ward. Also, test-retest reliability of the TUG (ICC, 0.99), with standard error of measurement (SEM) of 1.3 seconds and minimal detectable change of 2.5 seconds, based on data from an exercise trial, have been reported in 29 subjects.[120] Still, these data are probably based on testing at a median of 6 months post hip-fracture, and except for a reference to the original TUG-manual and a standard deviation of 13 seconds for TUG-scores, no other specific details of participants and procedures were given, and it seems as if a number of different walking aids were used during testing.[120]

In an attempt to further establish the relative and absolute inter- and intratester reliability of the TUG, access was gained to these previously recorded TUG-data.[119] The ICC (2.1) was then estimated to 0.93 (95% confidence interval (CI), 0.85-0.97) and 0.98 (95% CI, 0.96-0.99), respectively for inter- and intratester reliability. The corresponding figures for the SEM were 4.1 and 2.5 seconds and 11.4 and 6.9 seconds, respectively, for the smallest real difference (SRD).

However, predictive values of poorer TUG-scores in previous studies were low[75, 80] and further examination of the influence of the type of walking aid used during testing has been recommended.[75] Also, of concern in the TUG-testing of patients with hip fracture are the varied assessment procedures which differ from the original TUG-manual.[87] Test procedures from only one timed trial to one timed trial after three practice trials are being used in patients with hip fracture.[114, 116, 121, 122] Thus, the influence of the walking aid used during testing and other factors, in addition to the number of trials needed to achieve TUG-performance stability needs to be examined.

Furthermore, and dependent on these findings, the reliability of the TUG in patients with hip fracture may need further examination, especially as the in-hospital data of the absolute reliability was not so impressive. TUG-scores of an individual scored using the method in this thesis, needs to improve by more than 11 seconds to indicate a real improvement when the test is supervised, as it often is, by different physiotherapists.

Walking aids

Walking aids or so-called assistive devices are commonly used before the hip fracture (Appendix) and prescribed for all patients after hip fracture surgery in the early period of rehabilitation. The specific walking aid chosen for a patient at different points in time after surgery depends on many factors, such as their functional level, balance, and the physical environment to which the patient is being discharged.[123]

In patients with hip fracture, a 4-wheeled high walker is often chosen for the first mobilisation, followed by a four legged standard walker, a front wheeled walker (rolling walker), a four wheeled rollator with handbreaks, axillary crutches, or forearm/elbow crutches[124] as aids commonly used during in-patient rehabilitation and upon discharge from the acute ward or rehabilitation facilities in different countries.

Different ambulatory aids potentially provide different walking patterns, where "the term "points" refers to the number of floor contacts on a line perpendicular to the direction of walking that simultaneously occurs during any part of stance phase for the lead foot",[125] the lead foot being the foot of the fractured leg in patients with hip fracture. Further, the term "delayed" should be used "when the lead foot is clearly slower than the assistive device in making floor contact",[125] while "contralateral" refers to a situation where the walking aid held in one hand and the foot of the opposite leg are

concurrently in contact with the walking surface at the same time point.
Physiotherapy students walked considerably slower when performing a delayed five-point walker gait compared to a two-point contralateral crutch gait, which again was slower than walking unassisted at a self-selected velocity.[125] Similar to this, three groups of healthy community dwelling elderly who performed the TUG without devices presented significantly slower scores when using either a cane, a rolling walker or a standard walker, and the subjects using the standard walker produced slower scores than those using the two other aids.[108] Further, use of an assistive device, together with age, was an important predictor of performance on seven functional tests, including the TUG, in community living elderly.[88] Also, older adults who used a standard walker have been shown to require 104% more oxygen per meter walked and they experienced a 98% higher heart rate compared to ambulation with a wheeled walker, and respectively 212% and 200% more than when walking unassisted.[126]

In our setting, a delayed five-point walker, a five-point rollator, or a delayed three-point crutch gait pattern are commonly used, also when performing the TUG upon discharge from hospital to their own home or further in-patient facilities. These TUG-scores are used in research[80, 116] and are also forwarded to the physiotherapist in the community, to be used as baseline figueres when evaluating post-rehabilitation outcome. Of concern, the re-testing is often conducted with the use of another walking aid, as patients with hip fracture commonly change walking aids during rebabilitation (e.g. from a walker to a rollator, or crutches to unassisted gait).[116]

This further emphasises the need for an examination of the influence of the walking aid on performances in the TUG-testing of patients with hip fracture.

Validity and reliability of measurement instruments

The concepts of validity and reliability are central when measurement instruments are used by physiotherapists in research or in clinical practice, where "reliability relates to the *reproducibility* of measurements whereas validity deals with the *accuracy* (correctness) of inferences drawn from such measurements".[127]

Regarding validity, one needs to know the extent to which an instrument measures what it is intended to measure, and to what extent a meaningful interpretation can be drawn from a measurement.[127] The validity of a measurement relates to a specific measurement context, e.g. if one wishes to extrapolate results from a specific group or subjects to other patient groups, the instrument must be generalisable to those groups in a clearly demonstrable way,[128] which often requires specific examination.

Similarly, reliability, which refers to the extent to which repeated use of a measurement in a population with stable health yields the same result when established in one patient group, may not necessarily be transferable to other patient groups. Scores of a measurement may be reliable without being valid, but the validity of inferences drawn presupposes reliability.

Validity. Two broad types of validity are described, where "*external validity* refers to the extent to which research findings conducted on a sample can be generalised to the population from which the sample was drawn",[127] while *internal validity* refers to the extent to which there is a causal relationship between independent and dependent variables being studied. Validity can be further subdivided into several types; face validity, content validity, criterion validity (which includes concurrent and predictive validity), and construct validity (which includes convergent and discriminant validity).[46, 129]

The evaluation of assesments in this thesis focuses on the predictive validity, which assesses an instrument´s ability to predict the accuracy of another measurement scale or event at a later point in time, that it theoretically should be able to predict.[46] More specifically, the internal validity of TUG-scores in relation to the walking aid used and the number of trials performed is examined.

Reliability. Outcome measures should be stable in stable subjects (reproducibility), but should also be able to detect clinically relevant changes over time (responsiveness).[130] Thus, clinicians using measurements in daily practice or in research need to know the reliability of the measure and the magnitude of difference required for the scale to detect a real change. Reliability of measurements can be estimated in several ways,[46, 129] in this thesis as intertester reliability which is further quantified in terms of either relative or absolute reliability.[131]

Intertester reliability measures the degree of agreement between ratings conducted by different testers whereas *intratester reliability* measures the degree of agreement between ratings conducted by the same tester when administering the same instrument in a population with a stable health condition.

Relative reliability can be expressed by the Kappa statistics, which indicate the degree of agreement beyond that expected by chance, with a score from minus one to one, [132] or by the ICC, which measures the relationship between two or more measures of the same test or score with a coefficient from zero to one.[133] The Kappa is normally used for nominal or ordinal data, with measurement of both individual items (e.g. different activities) in a score and the total score, while the ICC is used to measure reliability for continuous data.

Absolute reliability can be expressed by the SEM, which quantifies the precision of individual scores on a test, and gives a clinician a result in the same unit as the measurement,[131] and by the corresponding SRD which is the smallest measurement change that can be interpreted as a real difference.[130] The SEM can be used to indicate the smallest change needed to be a real change at a group level, while the SRD indicates the change needed to be a real change for a single person.[134] In addition, the corresponding SEM% and the SRD%, are independent of the units of measurement and thereby allow a relative improvement or deterioration to be calculated.[135] The latter is especially useful if heteroscedasticity is present; that is a relationship between the measurement variability and the magnitude of the score, as it to some extent accommodates this.[135]

Physiotherapists ought to select a highly reliable measure that demonstrates validity, according to the intended use of the measurement tool.

Aims

The overall aims of the studies presented in this thesis were to evaluate the reliability and validity of functional assessments used by physiotherapists in patients with different types of hip fracture, and to evaluate pre-surgery factors influencing in-hospital performances and outcome after hip fracture surgery. Specific aims were:

1. To determine the relative and absolute inter-tester reliability of the NMS.
2. To examine the relative and absolute inter-tester reliability of the CAS when obtained by an experienced and inexperienced score user.
3. To examine the predictive value of the NMS to in-hospital performances of basic mobility and discharge destination when adjusted for previously established factors.
4. To examine the influence of individual and clinical factors on the TUG performance, and to establish preliminary normative reference values for the TUG.
5. To determine the relationship between TUG scores and the type of walking aid used during the test, and to determine the feasibility of using the rollator as a standardised walking aid when testing.
6. To examine the number of trials needed to achieve performance stability of the TUG-test using a standardised walking aid.
7. To examine the association between fracture types, thigh oedema in the fractured limb, postural control, knee-extension strength, pain, and function.

Material and Methods

Patients

A total of 656 patients were included in the seven studies (Paper I-VII) on which this thesis is based.

All patients were treated before and after surgery at the specialised Orthopaedic Hip Fracture Unit, Department of Orthopaedic Surgery, Hvidovre Hospital, Copenhagen, Denmark.
Patients not allowed Full Weight Bearing (FWB) post-surgery were excluded from study II-VII.

Study I. A total of 48 patients admitted consecutively within two months from their own home (N=40) or nursing home (N=8) were included in the study of the NMS intertester reliability.

Study II. Fifty patients admitted consecutively (44 from their own home and 6 from a nursing home) were included to evaluate the intertester reliability of the CAS-system. Twelve of them also participated in study VI.

Study III. Four hundred and thirty seven patients consecutively admitted from their own home were studied. 122 patients were excluded because they were non-ambulatory prefracture, had fractures other than of the hip, had early transfer to medical wards or "home" hospital, or underwent re-surgery during primary hospitalisation.

The excluded patients did not differ significantly ($p \geq 0.1$) from the included ones with respect to the examined variables, these being age, gender, prefracture functional level, mental and health status and fracture type. A total of 35 patients who were not included in the study died in hospital. They were significantly older, had a lower prefracture functional level and mental status and a poorer health status ($p \leq 0.008$) when compared to the 280 patients who were included in the study, while no significant gender and fracture type differences were found regarding mortality.

Study IV. Two hundred and sixty six patients admitted consecutively from their own home who performed the TUG upon discharge from the acute hospital were studied. Of these patients, 33 were ≤ 60 years of age, while 37 were discharged to further in-patient rehabilitation in the community, leaving 196 patients who were discharged directly to their own home to be included in analyses. One hundred and twenty three of them also participated in study III.

Study V. One hundred and twenty four patients admitted from their own home who consecutively were to be discharged from the orthopaedic ward with a walker (N=88) or crutches (N=36), and who performed the TUG with a rollator in addition to their discharge walking aid, were included.

Study VI. A total of 122 patients consecutively admitted from their own home and able to perform the TUG upon discharge from hospital, with a standardized walking aid (rollator) were included. Thirty-five of them also participated in study V.

Study VII. Twenty patients admitted from their own home, 10 with a cervical (Garden 1-4) and 10 with an unstable intertrochanteric fracture (Evans 3-5) were included in the study. The inclusion criteria were admission for a primary hip fracture, age ≥ 65 years, intact cognitive status, the ability to cooperate in the standard physiotherapy programme and discharge directly to their own home. The exclusion criteria were prefracture hospitalization, lower-limb surgery within six months prefracture, neurological impairments, uncontrolled cardiac diseases, use of elastic compression stockings, and alcohol or substance abuse.

There were no significant differences between the fracture type groups ($p \geq 0.4$) with regard to age, gender, prefracture functional level, mental and health status, body mass index, or amount of physiotherapy training during admittance. Sixteen of these subjects also participated in study V.

Further details of patients participating in the seven studies are presented in table 1 and in the respective papers.

Table 1. Study design and overview of patients included in the seven studies.

Study	Study design	Number of patients women / men	Age in years	Type of fracture cervical / intertrochanteric / subtrochanteric
I	Inter-tester reliability	39 / 9 (19)	84 (76-89)	23 (48) / 23 (48) / 2 (4)
II	Inter-tester reliability	35 / 15 (30)	83 (68-86)	26 (52) / 21 (42) / 3 (6)
III	Prospective cohorte	203 / 77 (28)	81 (72-86)	148 (53) / 125 (45) / 7 (2)
IV	Prospective cohorte	156 / 39 (20)	80 (74-85)	116 (59) / 76 (39) / 4 (2)
V	Cross-sectional	90 / 36 (29)	74.8 (12.7)	75 (60) / 47 (37) / 4 (3)
VI	Cross-sectional	89 / 33 (27)	80 (67-85)	78 (64) / 40 (33) / 4 (3)
VII	Cross-sectional	15 / 5 (25)	77 (7)	10 (50) / 10 (50) / 0 (0)

Data are presented as number of patients with (percentage), as median (interquartile range), or as mean (SD)

Assessments and procedures

The functional assessments and other examinations in the seven studies were conducted at the Hip Fracture Unit, the Department of Physiotherapy (Paper I-VII), and Gait Analysis Laboratory, Department of Orthopaedic Surgery (Paper VII) at Hvidovre Hospital, Copenhagen, Denmark.

Rehabilitation

All patients included in the seven studies followed a well-defined care plan with multimodal fast track rehabilitation[60] including early surgery within 24 hours of admission, epidural anaesthesia and analgesia continued for 96 hours post-operatively, standardized transfusion protocol if haemoglobin was less than 6,0 mmol l^{-1}, supplemental oxygen when supine in the perioperative period, prophylactic intra-operative antibiotics, perioperative low-molecular weight heparin and enforced perioperative oral nutrition and hydration, including energy and protein supplementation.

Patients were mobilised on the day of surgery if at all possible, and a physiotherapy programme, comprising one or two daily sessions on weekdays (once during weekends) was initiated on the first day after surgery. This programme was primarily aimed at improving transfer and walking ability and the physiotherapist measured progress in basic mobility daily.

Patients admitted from their own home were rehabilitated directly in the orthopaedic ward and were discharged to their previous residence when they were medically stable and safely able to perform “basic mobility skills”, defined as independency in getting in and out of a bed, sitting down and standing up from a chair or toilet, and walking with the aid to be used at home.

Only patients who after intensive rehabilitation at the orthopaedic ward still required additional in-patient rehabilitation were transferred to a secondary rehabilitation facility or nursing home. Patients admitted from a nursing home or other hospital wards were discharged to the nursing home or the ward of origin when medically stable.

Prefracture functional level (Study I-VII)

The NMS developed by Parker and Palmer,[24] and translated into Danish by Kristensen MT (2005) according to international guidelines,[136] was used in all studies to describe the prefracture functional level of all patients. Patients were asked about their walking ability in the week prior to the hip fracture fall, and if deemed necessary relatives or caregivers in the community were consulted for verification.

Table 2. The New Mobility Score (NMS)

Mobility	No difficulty and no aid	With a walking aid	With help from another person	Not at all
Able to get about the house (Indoor walking)	3	2	1	0
Able to get out of the house (Outdoor walking)	3	2	1	0
Able to go shopping (Walking during shopping)	3	2	1	0

An updated version of the NMS is presented in table 2, which is in accordance with the one used in the seven studies and in accordance with the correct interpretation of the original version (personal communication with Mr. Parker, December 2009, "The table you give is exactly how I would use the score").

The recording of the NMS is part of the normal routine on the admission ward by the physician. The NMS used in all seven studies is recorded as part of the clinical routine by physiotherapists at the stationary orthopaedic ward.

In study I, the inter-tester reliability of the NMS was established by two independent physiotherapists who scored the NMS at median (25-75% quartiles) 1.5 (1-2) day and 3 days (2-6) post-surgery.

In study III, the NMS was evaluated as a predictor of in-hospital basic mobility (CAS) outcome (regaining independency in basic mobility or not, and postoperative day of achieving this, if at all) and discharge destination, when adjusted for previously established pre-surgery factors being; age, gender, mental and health status, and fracture type. The NMS was dichotomised at all possible points of the scale to analyse which dichotomization best predicted the three outcome variables.

In study II, IV-VII, the NMS was used to describe participants, compare groups, or evaluate the influence of the prefracture functional level on other parameters.

Basic mobility (Study II, III, and VII)

The CAS [33] as presented in table 3, which measures ambulatory capacity and allows day-to-day measurements of basic mobility of subjects in the early period following surgery, was used in the three studies.

In Study II, one experienced physiotherapist and one inexperienced (a final year physiotherapy student) CAS-score user assessed the three CAS-activities in the same session, at median day 3 (2-5) post-surgery. This procedure was chosen, as patients at this point in time after surgery often change their basic mobility level during the day and even within the same training session. The experienced

CAS-score user gave patients instructions in how to conduct the three activities.

Table 3. The Cumulated Ambulation Score (CAS)

Activity	Able to independently (No assistance or guiding allowed)	Able to with human assistance or guiding from one or more persons	Not able to, despite human assistance and guiding
From supine in bed to sitting on the side of the bed, to standing or transfer to sitting in chair placed beside the bed, and return to the supine position in bed.	2	1	0
Sit to stand to sit from a chair with armrests.	2	1	0
Indoor walking	2	1	0
Ascending and descending stairs, use of handrails allowed	2	1	0

Use of appropriate walking aids allowed in transfer and walking, if necessary.

The one-day CAS (0-6) of basic mobility is the cumulated score of the three activities; bed, chair and walking. Stair walking is not included in this score, not being part of the basic mobility definition.

In Study III, the one-day CAS (0-6) was assessed during the daily physiotherapy sessions, whether there was a return to independency in basic mobility (CAS=6) and the time from surgery to independent mobility in days (scoring 6 on the CAS using the aid to be discharged with) were used in the analyses.

In Study VII, the time from surgery to independent mobility in days in the three activities; bed, chair, and walking (CAS=2 for each activity), and scoring 6 for the one-day CAS, in addition to the cumulated scores from the first three days post-surgery (0 to 18) were used in analyses.

Functional mobility (Study IV-VII)

The TUG-test was measured as the time (in seconds) that it takes a patient (as fast and safely as possible) to rise from a chair with arms (chair seat height = 45 cm), walk three meters to a line drawn on the floor and return to the chair. The time was measured from a seated position (back against the backrest) with a stopwatch started on the command "ready – go" and stopped again when the buttocks touched the seat again. No personal physical assistance was allowed, but verbal cueing during the test was allowed (e.g. a patient who forgot to sit down when returning to the chair).

The patients were given a practice trial followed by one timed trial in accordance with the original TUG-manual and national guidelines (Study IV, V and VII) which had previously been developed and examined for reliability in our unit,[119] while patients were to conduct six additional timed trials in study VI.

In study IV, TUG-performances upon discharge were used to establish normative reference data of patients discharged directly to their own home, in addition to multiple linear regression analyses of individual and clinical factors influencing these TUG-performances.

In study V, all patients who performed the TUG upon discharge with a walker or crutches (their discharge walking aid), also performed the TUG with a standardised walking aid, a 4-wheeled rollator. Half of the patients began testing with their discharge walking aid; the other half was randomised to begin with the rollator. All patients were given a short time to get used to walking with the rollator. The influence of the walking aid used during testing to TUG performances in seconds were examined.

In* study *VI, all patients able to perform the TUG upon discharge were instructed to perform six timed TUG-trials separated with up to one minute seated rest intervals. No practice trial was given, and all trials were performed with a standardized walking aid, a rollator, after familiarisation with the walking aid. Numbers of trials needed to ensure stable TUG data were evaluated.

Based on these TUG-results, the walking aid influence being eliminated, and a new multiple linear regression analysis of factors influencing TUG-performances (similar to the one in study IV) was conducted.

In study VII, all patients performed the TUG twice following the same procedure as in paper V.

A separate pilot study in 10 patients (unpublished observations) was recently conducted in order to examine the inter-tester reliability of the TUG, when using a standardised walking aid and the best of three TUG-trials, based on findings in study V and VI.
This showed that, the ICC, the SEM, and the SRD were 0.96, 1.5 seconds and 4.2 seconds, respectively. No systematic between-rater difference was seen ($p = 0.2$), while a tendency to heteroscedasticity occurred ($r = 0.624$, $p = 0.054$). To accommodate for this, the SEM% and the SRD% were calculated to 7% and 20%, respectively. Accordingly, a group of patients with a mean TUG-score of 30 seconds need to improve by 2.1 seconds to indicate a

real improvement, while a single patient with the same score needed to improve by 6 seconds to indicate a real change.

Fast speed walking (Study VII)

A 10 meter fast speed walking test[137] was measured from a standing position; a stopwatch was started on the command "3-2-1-go" and stopped when the patients first foot crossed a 10-meter line. The 10 meter test was performed once with a rollator and the results are presented as meters walked per second.[138]

Mental status (Study I-VII)

Different measurements of the cognitive function in patients with hip fracture are commonly used, of which the 10-point Short Portable Mental Status Questionaire,[139] is used in a number of Swedish studies,[14, 18, 26, 140, 141] the 10-point Abbreviated Mental Test Score[142] is used in some British studies,[24, 25, 83, 85] while others[9, 71, 74, 143, 144] used the 30-point Mini-Mental State Examination (MMSE).[145]

We used a short 9-point mental test developed in Denmark (referred to as the "Hindsøe´s test", Table 4)[146] as recommended in the first referendum programme of patients with hip fracture in Denmark (1999), and used in a large number of studies of our hip fracture group since 2002. This test was developed as 20% of patients were unable to participate in a Mini-Mental State Examination interview, and is based on information routinely collected during a medical interview. Originally, it consisted of 10 questions but the "name of the nearest relative" question was omitted due to 98% correct answers and difficulties in verifying the answer. This new and short mental test was validated against the MMSE with a score ≤ 20 = impaired cognitive function and ≤ 17 = severe impairment in 180 consecutive patients. A cut-off point of ≤ 5 (score 0-9) gave the highest sensitivity (0.73) and specificity

(0.95) for impaired cognitive function, while the corresponding figures for severe impairment (score ≤ 4) were respectively 0.89 and 0.98, and scores (0-9) were strongly correlated (r = 0.81) with the Mini-Mental State Examination (personal communication with Mr. Hindsø, December 2009).

Table 4. Hindsøe´s mental test score (a positive answer gives one point)

Can account for own age	□ Yes	□ No
Can account for own social security number	□ Yes	□ No
Can account for home address (if recently moved, an answer about just moving is accepted)	□ Yes	□ No
Can account for own phone number	□ Yes	□ No
Can account for own weight (± 5 kg) and height	□ Yes	□ No
Can account for date of hospitalization (± 1 day)	□ Yes	□ No
Can account for reason for hospitalization (ask about possible causes)	□ Yes	□ No
Can account for own medication (type, not necessarily names)	□ Yes	□ No
Can identify the interviewer after approximately 30 minutes	□ Yes	□ No
Total score (sum): 0 1 2 3 4 5 6 7 8 9		

A physician carried out the test upon admission in the emergency unit. A score in the Abbreviated Mental Test Score ≤ 6 is considered to represent cognitive impairment.[25] Accordingly, mental status was dichotomised into two categories, 0-6 (low) versus 7-9 (high) when used in analyses.[79]

Health status (Study II-VII)

Health status was evaluated with the ASA-rating (ASA, 1-5).[147] Ratings are defined as ASA 1 = a healthy patient, ASA 2 = a patient with mild systemic disease, ASA 3 = a patient with severe systemic disease, ASA 4 = a patient with severe systemic disease that is a constant threat to life, and ASA 5 = a moribund patient.

No patients included in any of the seven studies presented ASA-scores of 5, accordingly the patients' health status evaluated by an anaesthetist was classified as poor (ASA 3-4) versus good (ASA 1-2).[10, 12, 14, 25]

Fracture type (Study I-VII)

Fracture type was classified in the three major groups; cervical (femoral neck), intertrochanteric, and subtrochanteric in all studies. Only patients with cervical and intertrochanteric fractures were included in study VII, while very few patients presented subtrochanteric fractures in study I-VI (Table 1). Further, and according to patient characteristics, no significant difference was seen in subtrochanteric fractures when compared to patients who had intertrochanteric fractures in study III-VI. Accordingly, these two fracture groups were combined for the analyses.

Thigh circumference (Study VII)

The circumference (centimetres to one decimal) of the thigh (15 cm above basis patella) was measured upon discharge in both legs before bed rise in the morning between 7 and 8 am, with patients in the supine position, knees extended and the muscles relaxed. The same measuring tape was used in all patients. High intra-session reliability and low standard error of measurement for a similar method of measuring thigh circumference have been reported in healthy subjects.[148]

Thigh oedema in the fractured limb was calculated as % non-fractured ([thigh circumference in the fractured limb/non-fractured limb] x 100). This index assumes the same circumference in the two limbs prefracture.[59] Thus a score above 100% is indicative of thigh oedema.

Postural control (Study VII)

Postural control was measured upon discharge using a biomechanical force plate (OR6-7, AMTI, Watertown, MA, USA). The patients stood with their feet together, eyes open, and with their hands folded in front of the body. After a practice trial, they were instructed to fix their sight on a mark three meters away and "stand as still as possible" during five valid 20-second trials, separated by one minute seated pauses.

Postural control was expressed as the total length of the centre of foot-pressure displacement (sway length) during each trial, and subsequently calculated as a mean of five trials, which was subsequently normalized to subject height.[149]

Muscle strength (Study VII)

Maximal voluntary isometric single-limb knee-extension at a knee joint angle of 75° was measured upon discharge in both limbs using a custom-made strain-gauge dynamometer. The hip joint angle was 90°, and the hands were placed on handrails just under the seat. The centre of the resistance pad was placed 5 cm above the lateral malleoli. After warm-up and familiarization, the patients performed five (5s) maximal knee extensions for each limb with strong verbal encouragement. The first trial was performed with the non-fractured limb to minimise the fear of pain, followed by one with the fractured limb, separated by 30-second pauses.[150]

High test-retest reliability of a similar way of measuring maximal isometric knee-extension strength has been reported.[151] The best of the maximal strength performances for each limb was used in the analyses.[150, 152, 153] The maximal body-weight normalized [154] voluntary knee-extension torque (MVT) in the fractured (MVT *f*) and non-fractured (MVT *nf*) limb was calculated. In addition, it was calculated for the fractured limb as % non-fractured ([MVT *f* / MVT *nf*] x 100), with a score below 100% indicative of reduced strength.

Hip pain (Study VII)

Pain in the fractured hip was recorded during all measurements of TUG, 10m fast speed walking, postural control, and maximal knee extension strength using a five-point verbal ranking scale (VRS, 0= none, 1= light, 2= moderate, 3= severe and 4= intolerable pain).

The VRS has proven more suitable in assessing post-surgery pain in orthopaedic patients compared to the Visual Analogue Scale,[155] and it has been used in other studies after hip fracture surgery.[58, 78, 79, 156] Pain was dichotomised as none to light (0-1), versus moderate to intolerable (2-4) for the analyses.

Blinding (Study I, II, and VII).

The two testers were blinded to each other's ratings and they were not allowed to discuss their ratings before all patients had been assessed (Study I and II). The physiotherapists, assessing the daily scores of basic mobility with the CAS, were blinded to study allocation, while one single physiotherapist, who was blinded to scores of postural control, CAS, TUG, and 10m fast-speed walking performed all measurements on the day before discharge in study VII.

A schematic presentation of the measures used, and their classification according to the ICF, is shown in table 5. As presented, functional assessments and other variables evaluated in this thesis are focused on the domains body functions, body structure, and activity, when influenced by hip fracture trauma and other factors.

Table 5. Assessments used in relation to the International Classification of Functioning

Assessments	Study	Body structure/ Body function	Activity	Participation
New Mobility Score	I-VII		•	(•)
Cumulated Ambulation Score	II, III, & VII		•	
Timed Up & Go test	IV-VII		•	
Fast speed walking	VII		•	
Mental status	I-VII	•		
Health status	II-VII	•		
Postural control	VII	•		
Thigh circumference	VII	•		
Muscle strength	VII	•		
Hip pain	VII	•		
Fracture type	I-VII	•		

Statistics

Statistical methods used in the seven studies are presented in table 6. All continuous data were examined statistically for normality of distribution and presented as mean (SD) or as median (25-75%, quartiles), where appropriate. To analyse differences within individuals or groups, paired *t*-test or Wilcoxons (Paper I, II and V), McNemar-Bowker test (Paper I and II), and repeated measures ANOVA with Bonferroni corrections (Paper VI) were used, while Student *t*-test (Paper IV, V, and VII), Mann-Whitney U-test (Paper I, III, IV, VI), Chi-square test (Paper I, III, V, and VI), and when appropriate Fischer´s exact test (Paper II, III, and V-VII), were used to analyse differences between groups. The One-way ANOVA or Kruskal Wallis (Paper IV) was used when more than two groups were included in analyses.

Person's product moment correlation coefficient (Paper II, V, and VII), Spearman's rank order correlation coefficient (Paper I, II, and V), and simple linear regression (Paper III, and VII) were used to examine the association between variables. Multiple linear regression was used to examine factors influencing continuous outcome variables (Paper III, IV, VII, and Table 7), while multiple logistic regression was used to examine the odds-ratio of predictor variables to categorical variables (Paper III). The number of participants to obtain a reliable regression model is debatable. Ten to 15 cases per predictor is common,[157] but according to Green [158] the minimum sample size to test individual predictors is 104 + *k*, *k* being the number of predictors.

The intraclass correlation coefficient and Kappa statistics (Paper I and II) were used to examine the relative reliability, while Standard Error of measurement (SEM) using the equation SD x $\sqrt{(1\text{-ICC})}$, where SD is the Standard Deviation of the scores from all patients from both raters, was used to establish the absolute reliability.[131]

The corresponding Smallest Real Difference (SRD) was calculated as 1.96 x √2 x SEM to indicate 95% confidence between the true scores (1.96 because of the 95% confidence, √2 because of the difference of two variances).[130] In addition the SEM% = (SEM/mean) x 100 and the SRD% = (SRD/mean) x 100, where mean is the mean for all scores from test session 1 and 2,[135] could be used if heteroscedasticity was present. According to Shrout and Fleiss,[159] one has to choose between six versions when calculating the ICC, that can give quite different results when applied to the same set of data. The ICC (2.1), a two-way random effects model, with absolute agreement was used in this thesis, as it allows findings to be generalised to other raters within the same population.[159]

There is no clear definition on the interpretation of the ICC, but according to Munroe[160]an ICC of 0 to 0.24 reflects poor correlation; 0.25 to 0.49, low; 0.50 to 0.69, fair; 0.7 to 0.89, good; and 0.9 to 1.0, excellent, while Fleiss[161] assessed that values above 0.75 indicated excellent reliability and values between 0.4 and 0.75 represented a fair to good reliability. Similarly, Landis and Koch[162] refer to a Kappa coefficient of 0.40 to 0.59 as moderate, of 0.60 to 0.79 as substantial, and more than 0.80 as almost perfect. Regarding reliability, it has been suggested that a reasonable precision for estimates of reliability requires approximately 50 study participants.[163] P-values were considered statistically significant if $p < 0.05$.

Analyses were conducted using SPSS (SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606) for Windows, version 11.5 (Paper I), version 12.0 (Paper IV, V, and VII), 16.0 (Paper II, III, and VI) and Vassar Stats (http://faculty.vassar.edu/lowry/kappa.html) in study I and II.

A more detailed description of the statistics used is presented in the respective papers.

Table 6. Statistical methods used in the seven papers.

Statistical methods	Papers						
	I	II	III	IV	V	VI	VII
Mean (SD)		•		•	•	•	•
Median (25%-75% quartiles)	•	•	•	•		•	
Confidence intervals (95% CI)	•	•	•	•	•	•	•
Range					•		
Number with percentage	•	•	•	•	•	•	•
Student's *t* test				•	•		•
Mann-Whitney U test	•		•	•		•	
Paired *t* test					•		
Chi-Square test	•		•		•	•	
Fischer´s Exact test		•	•		•	•	•
McNemar-Bowker test	•	•					
One-way ANOVA				•			
Kruskal Wallis				•			
Repeated measures ANOVA						•	
Bonferroni correction						•	
Pearson's product moment correlation coefficient		•			•		•
Spearman's rank order correlation coefficient	•	•			•		
Simple linear regression			•				•
Multiple linear regression			•	•			•
Multiple logistic regression			•				
Intraclass correlation coefficient	•	•					
Kappa statistics		•					
Standard error of measurement	•	•					
Smallest real difference	•	•					

Ethics

The seven studies are parts of Hvidovre University Hospital's hip fracture project, which has been approved by the local ethics committee. The ethics committee of the Capital Region of Denmark approved all the functional assessments used in the seven studies (H-A-2007-0127).

Results

The most important results from the seven studies are presented below in relation to the assessments detailed in table 5.

Intertester reliability of the NMS and CAS

The relative intertester reliability of the NMS (Paper I) and the CAS (Paper 2) were very high as presented in Figure 4A and B. The absolute reliability expressed by the SEM and SRD had respective values of ≤ 0.29 and ≤ 0.80 NMS-points for the three activities (indoor, outdoor, and walking during shopping) (Table 7), while the corresponding figures for the three CAS activities (bed, chair, and walking) and the total CAS were respectively ≤ 0.20 and ≤ 0.55 CAS-points. The SRD of the total NMS was just above 1 NMS-points as presented in table 7.

NMS-scores between the two physiotherapists differed in 7 out of the 48 patients, and these patients presented significantly lower mental scores ($p = 0.02$), when compared to the 41 patients with equally recorded scores (Paper I), while no significant differences ($p \geq 0.2$) in patient characteristics were found between those five patients with CAS-score differences and those 45 without (Paper II).

The two ratings that differed more than 1 NMS point (by 2 and 3 points) in study I both occurred in the activity ‘able to go shopping’. Still, no systematic between rater differences ($P \geq 0.2$) or heteroscedasticity were seen in the two studies (Paper I and II).

Table 7. Relative and absolute intertester reliability of the New Mobility Score, N=48

Activity (score)	Weighted kappa value (95% CI)	Observed agreement (numbers with (%))	Prevalence in % of NMS scores 0-3				SEM	SRD
			0	1	2	3		
Able to get about the house, 0-3	0.97 (0.91-1.0)	47 (98)	2	7	33	58	0.10	0.28
Able to get out of the house, 0-3	0.97 (0.93-1.0)	46 (96)	27	15	25	33	0.15	0.42
Able to go shopping, 0-3	0.90 (0.79-1.0)	44 (92)	48	6	15	31	0.29	0.80
Total NMS, 0-9 ($ICC_{2.1}$)	0.98 (0.96-0.99)	41 (85)	N/A				0.42	1.16

CI; Confidence Interval, SEM; Standard Error of Measurement, SRD; Smallest Real Difference, ICC; Intraclass Correlation Coefficient, NMS; New Mobility Score.

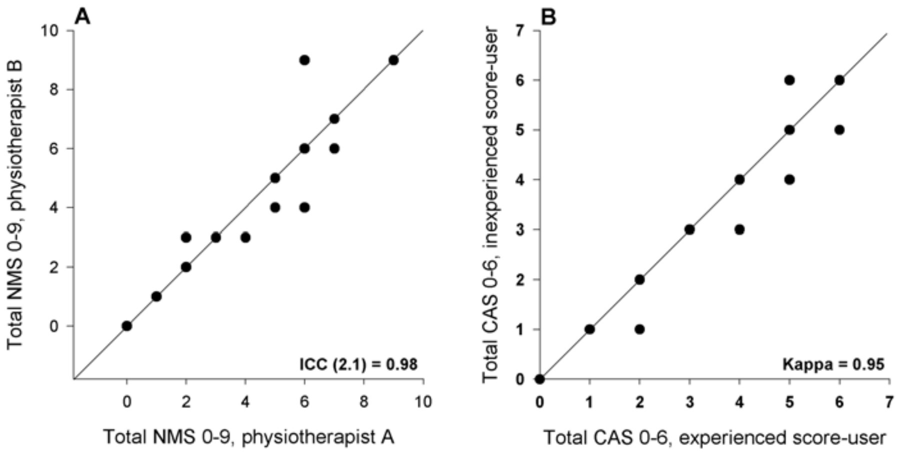

Figure 4. Intertester reliability of the NMS (A) reprinted with permission from Journal of Rehabilitation Medicine 01/2010, and the CAS (B) reprinted with permission from the publisher of Clinical Rehabilitation 12/2009.

Factors influencing in-hospital outcome

Age (Paper III, IV, and VI)

Older age was an independent predictor of: patients not regaining independency in basic mobility during admittance (adjusted odds ratio (AOR)), 1.046, P = 0.04) and not being discharged to their own home (Table 8, Paper III); time from surgery to independent mobility in days (Table 9, Paper III) and TUG performances upon discharge (Paper IV, and Table 10). Specifically, for every additional year of age the odds of not being discharged to own home increased by 5.6 % (Table 8, Paper III), while TUG scores, on average, increased by 0.4 seconds (Table 10).

Table 8. Multiple logistic regression with AOR of patients not regaining basic mobility independency and not being discharged directly to their own home.

Predictor variable	All patients N = 280	Not independent in basic mobility (CAS<6) during admittance		Not being discharged to own home	
		AOR	P	AOR	P
Age (continuous)	81 (72-86)	1.046	0.04	1.056	0.01
Female sex	203 (73)	0.2	0.2	0.5	0.2
Low prefracture function (NMS 0-6)	132 (47)	17.7	< 0.001	12.6	< 0.001
Low mental status	44 (16)	1.9	0.1	1.6	0.3
Poor health status (ASA 3-4)	135 (48)	1.5	0.3	1.1	0.9
Intertrochanteric fracture	132 (47)	4.2	< 0.001	2.2	0.02

Data are presented as medians (25%-75% quartiles) or as numbers with (percentage), CAS; Cumulated Ambulation Score, NMS; New Mobility Score, ASA; American Society of Anaesthesiologists rating, AOR= Adjusted odds ratio.

Gender (Paper III, and V-VII)
Men required fewer days to independency in basic mobility (Paper III), had better TUG-performances upon discharge (Paper V, and Table 10), and presented higher scores of knee-extension MVT (Paper VII) when compared to women.

Thus, women in the present studies required on average: 1.5 days (crude OR, P = 0.005) more to independent mobility (Paper III); used on the average 6.1 seconds more when performing the TUG (Table 10) compared to men and presented mean (SD) knee-extension MVT values of 0.41 (0.20) Nm/kg compared to 0.80 (0.50) Nm/kg (men) in the fractured leg (($p < 0.01$, Paper VII).

Still, differences in basic and functional mobility between genders in study III and Table 10 were not significant in multiple regression analyses.

Prefracture functional level (Paper III and VI)
Detailed analyses of the NMS showed that a cut-off point of ≤ 6 was the best predictor of the three outcome variables evaluated in study III. Accordingly, the prefracture NMS level was classified as low (NMS ≤ 6) versus high (NMS > 6) in the analyses.

The NMS, using this cut-off point (Paper III) and adjusted for previously established factors, was a strong and independent predictor in multiple regression of a patient not regaining independency in basic mobility during admittance (AOR = 18) and not being discharged directly to their own home (AOR = 13) (Table 8, Paper III), when compared to a patient with a high NMS. The statistical model of basic mobility independency presented in Table 8 correctly determined 84% of cases.

Further analyses of patients having a low NMS level and not regaining independency in basic mobility resulted in a sensitivity of

93%, a specificity of 65%, a positive predictive value of 40%, a negative predictive value of 97%, and a negative likelihood ratio of 0.1. Correspondingly, patients who actually did regain their basic mobility independency during hospitalisation in the unit and who had a low NMS, required on average an additional 2.7 days to achieve this when compared to a patient with a high NMS (Table 9, Paper III).

Table 9. Univariate and multiple linear regression analysis of factors influencing the time from surgery to independent mobility in days (CAS = 6).

Predictor variable	All patients N = 223	Days to CAS=6 N = 223	P	Days to CAS=6 N = 214 Adjusted B-values	P
Age (years)*	80 (70-85)			0.1	< 0.001
Female*	161 (72)	6 (4-9)	0.01	0.03	1.0
Male	62 (28)	5 (3-7)			
Low prefracture function (NMS 0-6)*	79 (35)	8 (6-12)	< 0.001	2.7	< 0.001
High prefracture function (NMS 7-9)	144 (65)	4 (3-6)			
Low mental status*	25 (11)	7 (5-11)	0.1	0.3	0.6
High mental status	198 (89)	5 (3-9)			
Good health status (ASA score 1-2)	126 (57)	5 (3-7)	0.004	0.3	0.5
Poor health status (ASA score 3-4) *	97 (43)	6 (4-10)			
Cervical fracture	132 (59)	5 (3-7)	< 0.001	2.3	< 0.001
Intertrochanteric fracture*	91 (41)	6 (4-11)			

*Predictor variables examined in linear regression. Data are presented as medians (25%-75% quartiles) or as numbers with (percentage). Abbreviations (see Table 8).

In study VI, another regression analysis was performed to examine factors influencing TUG-performances upon discharge using the new NMS cut-off point (0-6 vs. 7-9) established in study III. The 120 patients, who used the same standardized walking aid as recommended in study V, and using the better of the first three TUG-scores from study VI, were used in these analyses.

The NMS still influenced TUG-performances (adjusted B-value = 9 seconds, Table 10), which confirms that the TUG upon discharge has the ability to reflect the prefracture functional NMS-level.

Table 10. Univariate and multiple linear regression analysis of factors influencing TUG-performances in seconds (the best of three timed trials used). N = 120

Predictor variable	All patients N = 120	TUG in seconds	Adjusted B-values with 95% CI	P
Age (years)*	75.4 (12.6)	27.6 (13.2)	0.4 (0.2-0.5)	< 0.001
Female*	88 (73)	29.2 (14.3)	4.5 (-0.2-9.2)	0.06
Male	32 (27)	23.1 (8.6)		
Low prefracture function (NMS 0-6) *	17 (14)	37.0 (16.8)	9.0 (3.2-14.8)	0.003
High prefracture function (NMS 7-9)	103 (86)	26.0 (12.0)		
Low mental status*	5 (4)	39.6 (18.3)	13.1 (3.0-23.2)	0.01
High mental status	115 (96)	27.0 (12.8)		
Good health status (ASA score 1-2)	104 (87)	27.0 (12.9)	2.9 (-3.0-8.8)	0.3
Poor health status (ASA score 3-4)*	16 (13)	30.9 (15.3)		
Cervical fracture	77 (64)	25.6 (12.2)	6.0 (1.7-10.2)	0.006
Intertrochanteric fracture*	43 (36)	31.1 (14.4)		

*Predictor variables examined in linear regression. Data are presented as means with (SD) or as numbers with (percentage). Abbreviations (see Table 8).

Mental status (Paper I, III and VI)

Patients who had different NMS scores in study I (n = 7) had a significantly (p = 0.02) lower mental status than those patients with the same scores. Higher in-hospital mortality was seen in patients with a low mental status, while odds against regaining independency in basic mobility and/or not being discharged to own home, among survivors, were significantly higher (p < 0.001, crude OR of 4 and 3.4 respectively) for a patient with a low mental status (Paper III).

Still, mental status was not an independent predictor when entered into multiple regression analyses (Table 8, Paper III). On the contrary, patients with a low mental status presented on average 13.1 seconds (Adjusted B-value) poorer TUG-performances compared to patients with a high mental status (Table 10).

Health status (Paper III)

There was a higher in-hospital mortality associated with an ASA-rating of 3 or 4 compared to an ASA-rating of 1 or 2 in multiple logistic regression, while scores of basic and functional mobility and discharge destination, among survivors, showed no association with ASA-rating (Table 8-10 and Paper III).

Fracture type (Paper III, IV, VI and VII)

AOR of patients not regaining independency in basic mobility and/or not being discharged to their previous residence (own home) were respectively 4.2 and 2.2 times higher for patients with intertrochanteric fractures than patients with cervical fractures (Table 8, Paper III).

Further, patients with intertrochanteric fractures who did regain independency required on average 2.3 days more to achieve independent mobility (Table 9, Paper III), and this assessment was supported by the fact that it took more days to achieve bed, chair, and walking independency compared to patients with cervical fractures (Figure 5, Paper VII). Correspondingly, patients with intertrochanteric fractures presented significantly worse TUG-performances (Paper VII, and Table 10).

Finally, 10 patients with intertrochanteric fractures (classified as unstable, Evans 3-5) in study VII had a greater thigh oedema (Figure 6) and a larger loss of knee-extension MVT in the fractured limb when compared to 10 patients with cervical fractures (Figure 7).

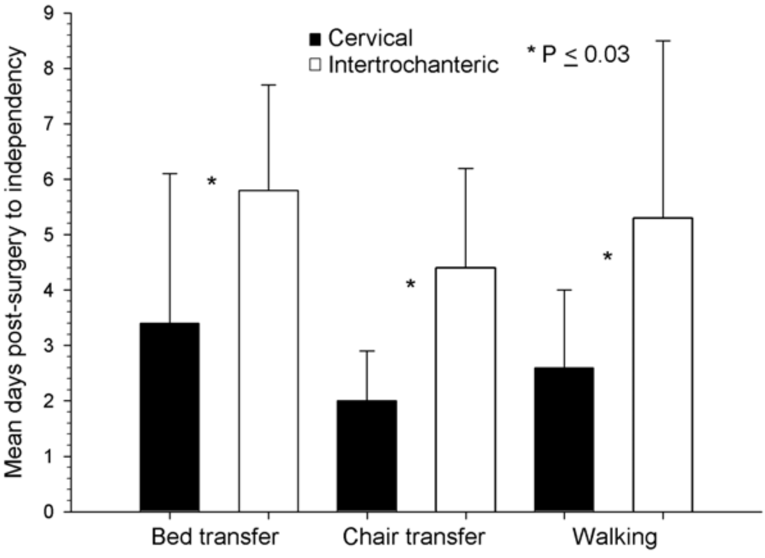

Figure 5. Relationship between fracture type and basic mobility activities

Thigh oedema (Paper VII)

The amount of thigh oedema in the fractured limb was significantly correlated to three-day CAS-scores (0-18) of basic mobility (r = -0.61, p = 0.004), measures of postural control (r = 0.67, p = 0.001), and the fractured limb knee extension MVT deficit (% non-fractured) as shown in figure 8.

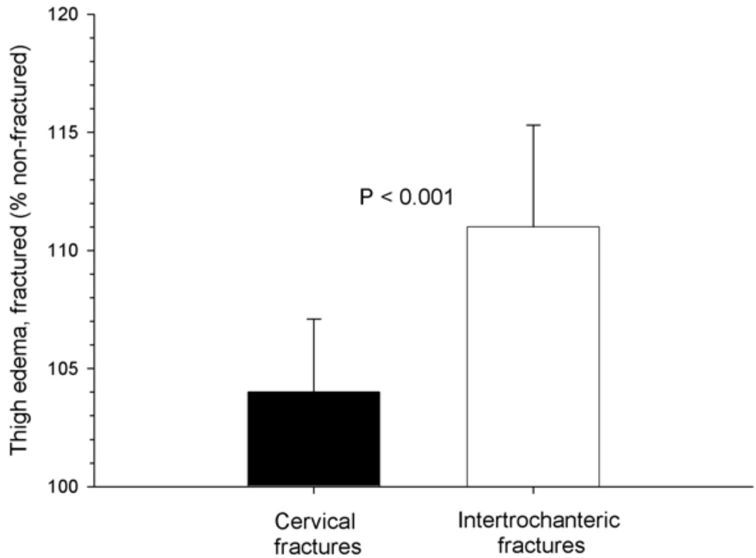

Figure 6. Relationship between fracture type and thigh oedema

Hip pain (Paper VII).

None of the performances of the TUG, 10m fast speed walking, postural control and knee-extension MVT were influenced by pain-scores in relation to the fractured hip region.

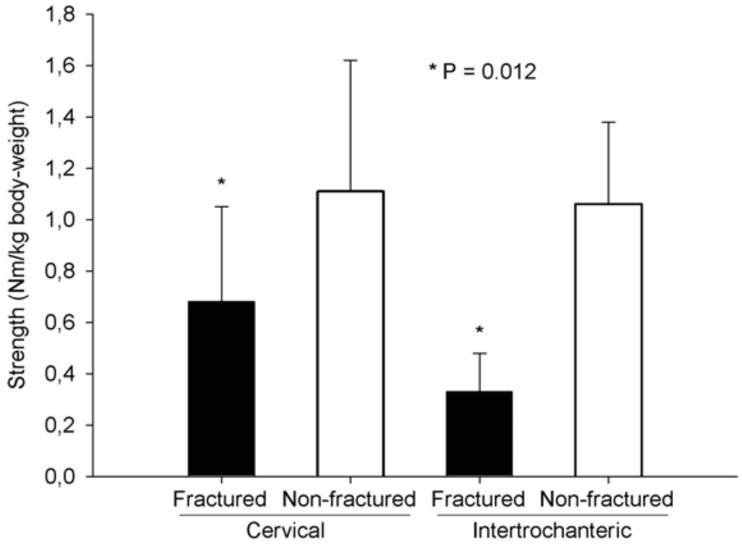

Figure 7. Relationship between fracture type and knee-extension MVT

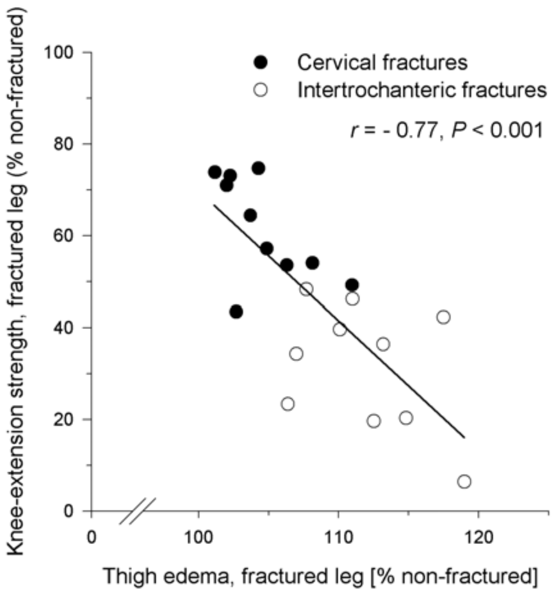

Figure 8. Relationship between thigh oedema and knee-extension MVT (reprinted with permission from Clinical Biomechanics)

Walking aids (Paper IV-VII)

Patients who performed the TUG with a walker upon discharge required on average 15 (95% CI 9.4-20.8) seconds more than patients who performed the TUG with elbow crutches (Paper IV), while patients who performed the TUG with a standardised aid, a rollator, in addition to their discharge walking aid, a walker or crutches, performed the TUG on average, respectively, 13.6 (95% CI, 11.2-16.1) and 3.5 (95% CI, 1.5-5.4) seconds faster when using the rollator (Figure 9, Paper V).

The between walking aid TUG-scores were strongly correlated ($r > 0.883$, $P < 0.001$) in both groups, while the between walking-aid differences correlated significantly with the mean of both TUG scores. Heteroscedasticity occurred, with larger score-differences seen in patients who performed most poorly (Paper V). Still, analyses of logarithmic transformed TUG-data significantly confirmed the walking aid related difference.

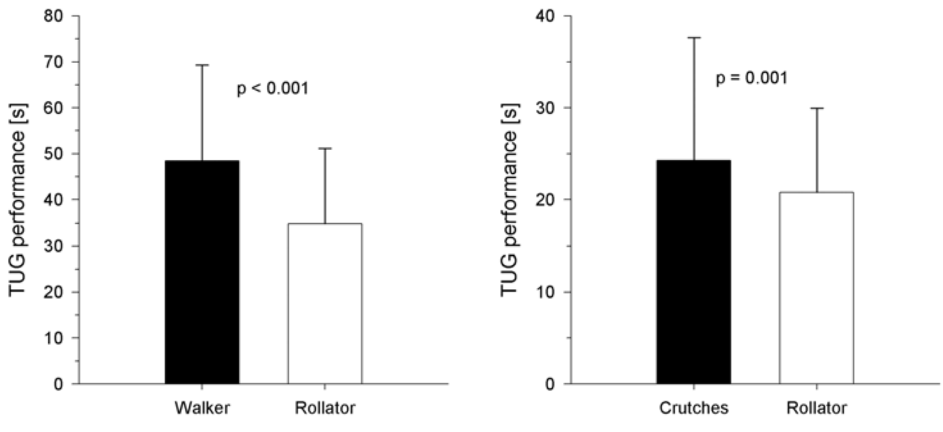

Figure 9. Comparison of TUG-performances with a walker or crutches and a rollator (reprinted with permission from the publisher for Arch Phys Med Rehabil 01/2010)

Further, using the rollator as a standardised walking aid in study VII showed that patients with cervical fractures required less time to perform the TUG when compared to those with intertrochanteric fractures, 26.1 versus 38.2 seconds, respectively ($p = 0.025$), while TUG and 10m fast speed performances (m/s), both performed with the standardised walking aid, were strongly negatively correlated ($r = -0.74$, $p = 0.001$).

Number of TUG-trials needed (Paper IV)

A total of three timed trials were necessary to ensure stable TUG-performances, both in the 106 patients out of 122 (87%) who performed all 6 trials (Figure 10), and in the 120 patients who performed a minimum of 3 timed trials with the standardized walking aid, a rollator.

Thus, the third TUG-trial was, on average, significantly better (faster) than the first ($p < 0.001$) and the second trial in the 120 patients ($p = 0.007$), with mean TUG-scores ranging from 34.4 (95% CI, 31.2-37.7 [TUG1]) seconds to 28.4 (95% CI, 25.8-30.9 [TUG3]) seconds (Figure 11).

The best of the first three trials was significantly correlated to age ($r = 0.424$), the prefracture NMS level ($r = -0.421$), mental status ($r = -0.339$), and health status ($r = 0.280$).

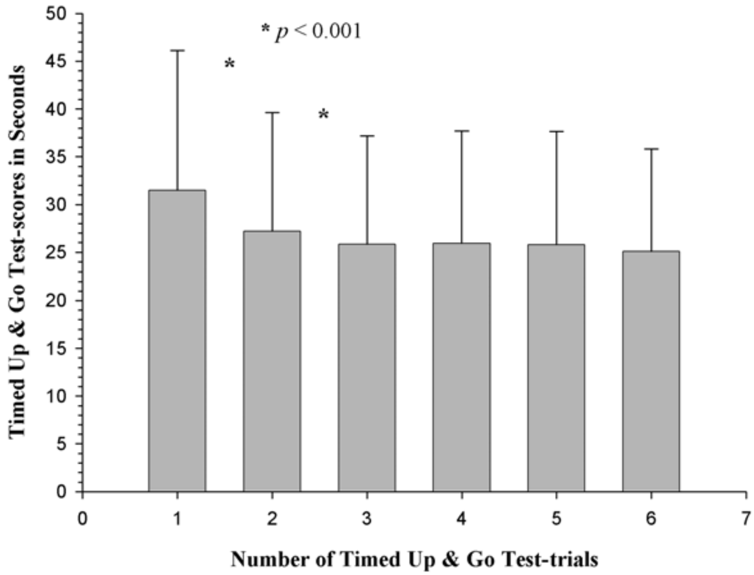

Figure 10. Results of 6 successive TUG-trials (reprinted with permission from the publisher for Arch Phys Med Rehabil 4/2010).

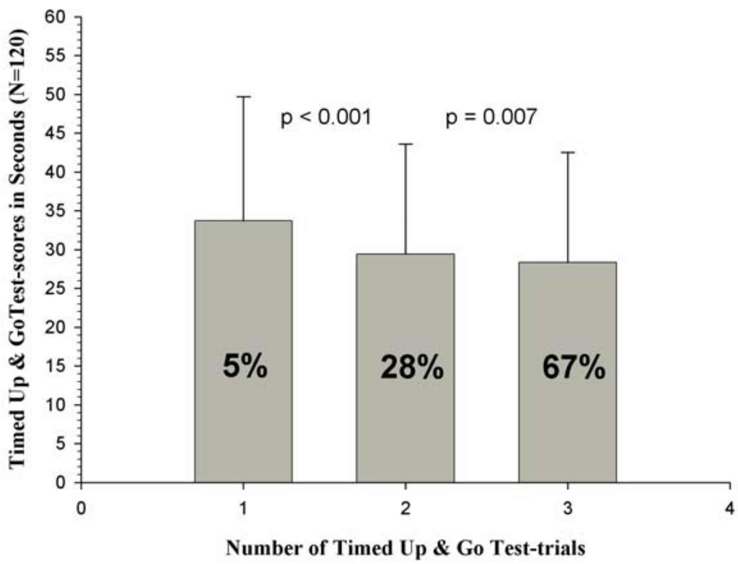

Figure 11. Percentage of patients producing their best (fastest) TUG-trial.

Discussion

This thesis is based on seven studies contributing to a broadening of the knowledge concerning functional assessments used by physiotherapists during and after in-hospital rehabilitation of patients with hip fracture. Further, it evaluates the influence of individual and clinical factors to in-hospital performances and discharge destination of patients after hip fracture surgery.

That is, high relative and absolute intertester reliability of the NMS and the CAS (Paper I and II) have been established; the prefracture NMS-level, in addition to age and fracture type were found to be independent predictors of in-hospital basic mobility outcome and discharge destination (Paper III); scores of the TUG upon discharge were found to be influenced by age, the prefracture NMS level, fracture type and especially the walking aid used during testing (Paper IV); the use of a rollator as a standardised walking aid when TUG-testing was found to be feasible in all patients, and when used in addition to their discharge walking aid, a walker or crutches, patients produced significantly better scores when performing with the rollator (Paper V); a minimum of three timed TUG-trials performed with a rollator were necessary to produce the best performance (fastest score). Further analyses of these “best” performances, showed that TUG-scores under these conditions were significantly influenced by age, the prefracture NMS level, and fracture types (Paper VI); and finally, a significant relationship between a larger thigh oedema, lower scores of knee-extension MVT in the fractured limb and worse performances of basic and functional mobility were found in a matched group of patients with intertrochanteric fractures compared to patients with cervical fractures (Paper VII).

The prefracture New Mobility Score

An ICC ≥ 0.90 has been described as "very high",[160] while a Kappa value above 0.80 has been described as "almost perfect".[162] Thus, the relative reliability of the three NMS activities when evaluated by the Kappa is almost perfect (≥ 0.90), as well as the total NMS-score (0-9) when evaluated by the ICC (0.98). Thus, a change or difference in NMS-scores (0-9) of 0.42 points at a group level or at 1 point for an individual indicates a real change or difference in patients with hip fracture (Paper I).

Physiotherapists or other clinicians who use the NMS should be careful and gather additional information from relatives or caregivers in patients with a lower mental status. This is the first study to evaluate the reliability of the NMS, the results cannot therefore be compared to other findings.

The prefracture functional level when evaluated in other studies was found to be a strong and consistent predictor of short and long term outcome in patients with hip fracture.[9, 10, 12, 13, 21-24, 74, 75] Previous studies of the NMS established predictive validity of six-months functional level,[75] and one-year mortality, [24] while it was found inferior to the CAS in predicting late rehabilitation outcome.[33] Still, studies included in this thesis are to our knowledge the first to perform a more detailed evaluation of the prefracture NMS-level influence and predictive value of in-hospital performances.

In agreement with previous studies, the prefracture functional level when evaluated with the NMS was a consistent and independent factor influencing in-hospital performances and discharge destination (Papers III-VII). That is, basic mobility CAS-performances and/or discharge destination were influenced or predicted by the NMS level (Papers III and VII), as well as functional mobility TUG-performances (Papers IV-VI).

Taken together, these findings indicate that scores of the NMS, in addition to the previously established long-term predictive values, have a high relative and absolute reliability, and are a strong, consistent and independent predictor of in-hospital basic and functional mobility performances and discharge destination in patients with hip fracture.

As can be seen, different NMS cut-off points were used in some of the studies. That is, the previously used "long-term" cut-off point of 5,[24, 75] was used in study I, II, and IV as this was the one available at that time, while a cut-off point of 7 based on preliminary analyses in study III was used in study V and VII. The latter study divided patients into a group that was fully independent (NMS=9) and a group that was not, as it is seldom that a score of 8 is achieved. Patients included in study VII had a higher prefracture level than patients included consecutively in the other six studies and in general (Appendix). Thus, dividing patients into those using walking aids and those who did not, enabled to some extent analyses of the prefracture functional level influence in study VII.

In contrast to more extensive scores, such as the Functional Independency Measure,[74] and the Functional Recovery Score,[22] the NMS has the advantage of being based on three simple questions about prefracture walking ability that can easily be recorded, without manuals, by all ward personnel at the patients bedside, after a short introduction.

In conclusion, the cut-off point of 6, which is based on the first detailed analysis of the NMS predicting in-hospital outcome, is recommended as the NMS cut-off point to be used in clinical practice when evaluating the influence on in-hospital performances and discharge destination. Also, the NMS is recommended be used for stratifying patients participating in research studies.

The basic mobility Cumulated Ambulation Score

Landis and Koch[162] refer to a Kappa coefficient of more than 0.80 as almost perfect. Thus, the relative intertester reliability of the CAS between an experienced and an inexperienced score-user of ≥ 0.92 for individual activities and the one-day CAS may be perfect in accordance with that previously reported in a smaller sample by Foss et al.[33] Furthermore, data of the absolute CAS reliability indicate that a change or difference of 0.20 or 1 CAS point indicates a real change at a group level and for a single patient respectively (Paper II).

This is considered to be important knowledge to physiotherapists or others using the score-system in clinical practice as they can encourage their patients by informing them that even small improvements are a real improvement. At the same time, clinicians who observe a sudden deterioration in basic mobility for an individual should be extra vigilant as this could be related to undiagnosed complications, such as anaemia.[60]

Also, the small changes needed to indicate real differences support the validity of findings in study III and VII. That is, basic mobility CAS-outcome differed in relation to patient age, prefracture NMS level and fracture type (Papers III and VII), while CAS-assessments were correlated to measures of postural control and especially the knee-extension MVT of the fractured limb (Paper VII). This indicates that the CAS-system has the ability to reflect critically relevant differences in patients with hip fracture.

Still, some might recommend the use of a more “complex” score system than the CAS, such as the 7-point ordinal scaled Iowa Level of Assistance Scale,[164] when evaluating patients with hip fracture. It grades levels of assistance for each activity on a scale from 0-6; “0=independent, 1=standby supervision but no contact from another person, 2=minimal, one point of contact from one person for safe performance, 3= moderate, two points of contact necessary from one or two persons to perform function, 4=maximal, significant support is necessary at a total of three or more points, 5=failed, despite maximal assistance, 6=not tested, for medical or safety reasons”.[164] This test has been used in patients with hip facture.[32, 42] However, inter-tester reliability between four physiotherapists with three to 11 years of experience, and after one hour of daily score-system training for five weeks, did not reach the “almost perfect” level (weighted Kappa, 0.48-0.66) when evaluating activities similar to the three CAS-activities in patients with total joint replacement.[165]

Regarding the use of the CAS-system in research, it has proven useful in predicting late rehabilitation outcome[33] and it reflects different ambulation levels in relation to hip pain[58] and anaemia.[60] Early ambulation after hip fracture surgery has been related to a positive outcome in a number of studies.[41-43]

Physiotherapists involved in early rehabilitation of patients with hip fracture need to focus on independency in transfer and ambulation, since this, together with medical stability, is considered a minimum criterion for the patient to be discharged to own home.[30, 32] Thus, the importance of early training and the measuring of transfer and ambulation seems unquestionable for physiotherapists. Still, for such measures to be recommended, high inter-tester reliability is needed as misclassifying a patient as independent if not, may lead to an undesirable situation if not supervised in the ward or if discharged to own home.

Accordingly, the high inter-tester reliability of the simple and standardised CAS-score supports its value in research and clinical practice in comparison with other more extensive, but less reliable measures of transfer and ambulation.

The functional mobility Timed Up & Go Test

The original TUG-manual prescribes one practice trial before one timed trial, these to be performed “at a comfortable and safe pace”.[87] However, it does not deal with the potential influence of different walking aids used during testing, and to our knowledge the number of trials needed to actually produce the best result has not been examined.

This calls for concern, as studies in elderly people[105, 108] indicate that the use of different walking aids may influence TUG-scores, and the use of different walking aids has been related to different cardio-respiratory demands.[126] Furthermore, different procedures from the original manual, regarding the timed trial reported, have been used in studies of elderly people[90, 91, 101, 103, 105, 108] and patients with hip fracture.[114, 116, 121, 122]

Also, different procedures regarding the instruction given in relation to walking speed, from “comfortable speed”,[166] “self selected”,[108] “normal and safe pace”,[114], “comfortable and safe pace”,[107] “comfortable, fast and secure pace”,[91] to “as fast/quickly as safely possible”,[88, 99, 105] have been reported.

We have chosen to use the instruction “as fast as safely possible” as fast speed walking correlates much better to age and maximal knee-extension strength than comfortable gait speed.[167]

We found that the walking aid used during testing seems especially important, as patients who used a walker took on average 15 seconds longer to perform the TUG compared to those who used crutches (Paper IV). This was confirmed when a comparable group of patients using a rollator in addition to their discharge walking aid (being a walker or crutches), took a mean of 13.6 and 3.5 seconds less when using the rollator, which could be used by all patients (Paper V).

Further, a minimum of three timed trials was necessary to achieve significantly stable TUG-performances in 120 patients when using the rollator as a standardised walking aid (VI). Sixty-seven percent of patients performed best (fastest) at the third TUG-trial, with up to 15 seconds improvement from the second to the third trial, and the trial that produced the best TUG-performance was not related to age, the prefracture NMS-level, the fracture type or the patient being trained to walk with a rollator (Paper VI).

The slower performances, especially when using a walker, may partly be explained by the delayed five point walking technique, the need to lift the aid in order to move forward, and the associated greater energy requirement.[125, 126] These findings, although the first to determine the effect of the walking aid and number of trials measured, call for a new TUG-manual in patients with hip fracture. This new TUG manual is justified by the fact that TUG-scores were able to distinguish between relevant ages, prefracture NMS, and fracture type groups (Table 10) in accordance with findings in study III.

These results may be important for both clinicians and researchers who use the TUG. Thus, physiotherapists who wish to measure TUG-score changes within rehabilitation might get the wrong picture if they score using the original manual and with a different walking aid at baseline and at retest. Similarly, research results might be difficult to interpret if not using the optimal assessment.

Accordingly, previous reports of significant TUG-score group improvements in intervention studies,[113, 117, 168] but without detailed information of the walking aid used at baseline and at retest, need to be interpreted with caution. Also, previous reports of the TUG predicting non-fallers,[80] and correlation to the Berg Balance Scale[118] and the Functional Independence Measure,[114] probably need reinterpretation in relation to the walking aid used. The number of TUG-trials needed further compromises previous use of the TUG in patients with hip fracture, especially when only one timed trial was reported.[114, 121] Additionally, measurements using the original prescribed procedure with one practice trial followed by one timed trial,[80, 166] need to be interpreted with caution.

Finally, reports from an additional pilot study, not included in this thesis of the intertester reliability of the TUG conducted upon discharge from hospital, suggest a high relative and absolute reliability of the TUG in patients with hip fracture (unpublished, Kristensen MT et al. 2010). This reliability should be further assessed in future research.

Influence of fracture type and thigh oedema on outcome

Previous studies have shown higher mortality two months post-fracture,[23] higher mortality and nursing home residence,[13] larger thigh oedema in the fractured limb,[59] higher mortality upon discharge and at one year with fewer able to walk independently upon discharge[29] in patients with intertrochanteric fractures compared to patients with cervical fractures. Also, the odds of staying longer than 10 days in the orthopaedic ward were significantly higher for patients who had a hip fracture other than an undisplaced intracapsular fracture.[18]

The examination of mortality in connection with hip fracture surgery was not among the aims of this thesis, but we did not find any significant difference in mortality between fracture types of those patients not included in study III due to in-hospital mortality (n= 35) and those 280 included. On the contrary, our finding of limitations in CAS, TUG, and muscle strength performances, a larger thigh oedema in the fractured limb and more patients not being discharged to their own home after an intertrochanteric fracture (Papers III-VII) is supported by these previous findings. That is, the odds of a patient with an intertrochanteric fracture not regaining independency in basic mobility were 4 times higher than a patient with a cervical fracture (Paper III). These findings are supported by the fact that patients with an intertrochanteric fracture required an average of 6 seconds more to perform the TUG upon discharge (Table 10).

These differences may partly be explained by a larger hidden blood loss[57] and more hip-pain[58] in patients with trochanteric fractures compared to patients with cervical fractures. As evidenced in previous studies,[153, 169, 170] patients lost more than 50% of their knee-extension MVT in the fracture limb compared to the non-fractured limb (Paper VII).

Our finding of oedema is in accordance with Kazmi et al.,[59] but to our knowledge, our study (Paper VII) is the first to show significantly larger strength impairments in patients with intertrochanteric versus cervical fractures (67% versus 39% strength loss), and a correlation with the amount of thigh oedema (r^2 = 0.59). Also, reduced performances of postural control (r = 0.67) and three-day CAS (r = -0.61) were related to thigh oedema. Furthermore, functional limitations in all CAS and TUG-performances were seen in patients with intertrochanteric compared with cervical fractures, while all performances (including 10m fast speed walking) were correlated to scores of knee-extension strength in the fractured limb (Paper VII), the latter being similar to previous findings by Lamb et al.[169]

This suggests that physiotherapists in clinical practice by knowing the fracture type, and/or by measuring the circumference of the fractured and non-fractured thigh, get an indication of potential functional limitations and strength impairments if strength measuring equipment is not available.
Finally, efforts to reduce the oedema are required. The extent of the oedema is of course related to the nature of the fracture with a larger blood loss[57] and corresponding oedema[59] in trochanteric than cervical fractures, but also the thromboprophylaxis given to all patients in order to avoid venous thromboembolic events, probably increases the bleeding, causing a larger "oedema". Foot and calf pump devices have to some extent proven effective in preventing venous thromboembolic events,[171] and it might be that thromboprophylaxis could be reduced in patients following an intensive mobilisation programme in a multimodal approach, without compromising safety.

Also, intensive strength training and/or neuromuscular stimulation commenced immediately after surgery might reduce strength impairments, thereby reducing functional limitations seen after total hip arthroplasty.[172] Still, these issues await further studies in patients with hip fracture.

Importantly, and with no relation to the fracture type, no significant differences regarding age and the prefracture level or the amount of physiotherapy training during admittance could be demonstrated in study VII. Also, none of the impairments or limitations observed were influenced by pain in the fractured hip, indicative of an optimal pain treatment upon discharge in this multimodal programme.[77] This may be important, as previous functional limitations of patients with hip fracture have to some extent been related to pain.[58, 169, 173]

In conclusion, the findings presented in this thesis (Papers III, IV, VII and Table 10) indicate that a hip fracture is not "just a hip fracture" as indicated in a previous review.[45] Thus, physiotherapists and other clinicians involved in clinical practice and/or research of patients with hip fracture need to take the influence of the fracture type and the corresponding oedema into account, especially as falls in elderly people have been associated with asymmetrical lower extremity strength and/or power.[174, 175]

Other factors potentially influencing outcome

Age. The influence of age on the outcome for patients with hip fracture has previously been established. [9-15, 18, 25] That is, greater age was associated with a larger proportion of patients not being discharged directly to their own home,[9, 13] and a higher in-hospital, four months and one year mortality.[18, 19] Furthermore, being 85 years or older was associated with a higher incidence of mortality[14, 16] and failure to recover the prefracture ambulatory level[12] compared to those under 85 years of age, whilst the odds of being alive and walking independently six months post fracture were higher for patients under 75 years of age compared to those over.[15]

We also found that greater age was associated with a higher degree of in-hospital mortality (Paper III), and age was an independent predictor, influencing both functional performances and discharge destination (Papers III, IV, and Table 10). Thus, the odds of not being discharged directly to one's own home increased by 6% for each additional year of a patient's age, while a patient 80 years of age, on average, requires 1 additional day to achieve independency in basic mobility, if it is achieved at all, compared to one of 70 years (Paper III).

Our findings on the association between age and discharge destination are in accordance with previous studies.[9, 13] However, although discharge to own home probably indicates independency in basic mobility in these studies, our study III is probably the first to present a detailed analysis of the influence of age on the in-hospital basic mobility outcome. Also, the fact that TUG-performances upon discharge were related to age (Table 10) seems appropriate, and in accordance with previous associations seen between age, TUG-scores, [88] and fast speed walking[167] in elderly people.

Thus, physiotherapists and other clinicians need to consider the age factor per se to limit in-hospital activities and number of patients being discharged directly to their own home after hip fracture surgery.

Gender. Being a man with a hip fracture, although often younger than a woman in the same situation, is associated with a higher in-hospital to one-year mortality in patients with hip fracture.[13-20] As stated, this thesis did not focus on mortality following hip fracture surgery, but in contrast to the above mentioned, we did not find higher in-hospital mortality in men compared to women, and the regain of independency in basic mobility or discharge status were not related to gender (Paper III).

On the contrary, we did find that women on average required 1.5 days more than men to achieve this independency in univariate analyses, but this difference did not persist when entered into multiple linear regression analysis (Paper III). Also, men presented faster TUG-scores in study V, and better knee-extension MVT in study VII, but the TUG-score difference between genders was not significant ($p = 0.06$) when entered into multiple linear regression (Table 10).

No difference between genders regarding six months post-surgery ADL and walking ability was found in one study,[15] while Holt et al. [17] found men less likely to return to their home or mobilise independently four months post-fracture. Thus, the gender influence on functional outcome following hip fracture seems confused, and further analyses of long-term mortality in “our” population (Appendix) did show higher mortality in men, despite a significantly lower age and higher prefracture NMS level compared to women. This suggests that men may be more fragile and have less suitable coping strategies for a situation of functional dependency compared to women, as previously hypothesied.[141]

Summarising, the recovery of men after the initial hip fracture phase may need a higher priority in the rehabilitation programme in the future.

Mental status. Of importance, and independent of the score system used, cognitive impairments seem to influence the outcome of patients with hip fracture. That is, higher mortality,[14, 15, 18, 24, 26] limited functional performances or fewer being discharged to their own home[9, 15, 25, 26, 141, 143] were seen in patients with cognitive impairment.

Examination of the influence of cognitive status on outcome was, however, not a primary issue in this thesis. Still, using a short mental test,[146] similar to the Short Portable Mental Status Questionaire,[139] and the Abbreviated Mental Test Score,[142] we did find that mental scores of patients were significantly correlated to the prefracture NMS level (r = -0.61), and that score differences of the NMS were significantly related to patients with cognitive impairment (Paper I). Additionally, in-hospital mortality and fewer patients regaining independency in basic mobility or being discharged to their own home were significantly related to cognitive impairments (Paper III).

Still, when entered into multiple logistic regressions, only the influence on in-hospital mortality remained significant in study III, while patients with cognitive impairments required an average of 13 seconds extra to perform the TUG in multiple linear regression analyses (Table 10). Only five patients with a cognitive impairment were included in this last analysis (Table 10), which seems inherent in the use of objective timed walking tests upon discharge from an acute orthopaedic ward, with very few patients with cognitive impairments included in the Papers IV-VI. This supports the use of a score like the CAS, which enables evaluation of the basic mobility level in all patients with hip fracture regardless of cognitive status.

Importantly, cognitively impaired patients seem to have the same potential of successful rehabilitation as non-impaired when mobile prefracture.[176] Also, being discharged to a rehabilitation unit instead of discharge to local hospitals or returning directly to the previous place of residence, were associated with a return to the community,[144] preserved walking ability and ADL index after hip fracture surgery[140] in patients with cognitive impairments.

Thus, it seems as if cognitively impaired patients with a hip fracture may have the same potential for rehabilitation, if given the appropriate time and conditions.

Health status. The patient's prefracture health status evaluated by the ASA-rating or numbers of co-morbidities significantly influences the outcome following hip fracture surgery. Thus, an ASA-rating of 3 or 4 compared to 1 or 2 was associated with higher mortality,[14] and failure to recover function or reside at home,[10, 25] respectively four months and one year post-fracture, while mortality was associated with more co-morbidities.[15, 16, 19, 20]

Correspondingly, we found an ASA-rating of 3 or 4 to be significantly associated in simple regression analysis with higher in-hospital mortality, fewer patients regaining independency in basic mobility and/or being discharged to their own home and with more days to independency in basic mobility compared to those with ASA 1 or 2 (Table 8, 9 and Paper III).

Validity of the findings

All included patients, who followed a multimodal rehabilitation concept, were recruited from the same specialised orthopaedic hip fracture unit. Still, patients were in general representative of the hip fracture population, and similar to a large consecutive sample, as presented in the appendix.

Of importance, patients admitted consecutively from either their own home or nursing homes were included in the two first reliability studies (Papers I and II), and an appropriate number of patients participated.[163] On the contrary, only patients admitted from their own home were included in the other five studies (Papers III-VII).

Residing in nursing homes when fracturing, and not being included in these studies (Papers III-VII) is to some extent inherent to different discharge procedures for this group of patients (about 20% of the total sample in our unit). That is, as seems common in Sweden[140] and Canada,[69] that patients admitted from a nursing home in Denmark are commonly being discharged to their previous residence when considered medically stable a few days after surgery, but most often without having regained independent walking ability, which is present in 81% of the prefracture assessments (Appendix).

The assumption is that these patients, who more frequently have cognitive impairments, are “better off” in a familiar environment, but the limited knowledge of the future rehabilitation provided is of concern.[69] Including patients admitted from nursing homes or other institutions that follow such discharge procedures, in predictive studies of regaining independency or using length of stay as an outcome measure in comparison with other settings, certainly compromise the validity and comparability of the study results.

Similarly, the length of stay between settings who transfer the majority of patients admitted from own home to further in-patient rehabilitation facilities,[69] should not be compared with settings who primarily rehabilitate their patients in the acute orthopaedic ward.

Supporting our findings, the large number of patients admitted from their own home, and included in study III-VI, were included consecutively. Still, although the number of participants was large,[158] the findings from the regression models presented in study III ought to be validated in another sample.

Also, all patients included in study III-VII were allowed FWB (practiced as weight bearing that is tolerated) after surgery, which is the standard procedure in our unit and also recommended in the National Referendum Programme in Denmark (2008). Thus, findings may be different for patients not allowed FWB.

Finally, the findings in study VII were based on “only” 10 patients with cervical fractures (non-displaced = 3 and displaced = 7) and 10 patients who all had an unstable intertrochanteric fracture (Evans 3-5) and surgery with a short intra medullar hip nail and dynamic hip screw. Hence, findings ought to be confirmed in a larger sample, and include patients with stable intertrochanteric and subtrochanteric fractures.

The included and evaluated measures within this thesis (Papers I-VII) primarily cover the body structure and function and activities of the ICF.[73] Thus, future studies of patients with hip fracture should include components at the participation level, such as those measured with the Short-Form 36 (SF-36) health related quality of life questionnaire.[177]

Major conclusions

- The relative intertester reliability of the NMS (Paper I), and the CAS (Paper II) is high, with small changes needed to reflect a real difference in both assessments, indicative of a high absolute reliability.

- The prefracture NMS level using a cut-off point of ≤ 6, in addition to age and fracture type, is a strong and independent predictor of in-hospital CAS- and TUG-performances and discharge destination (Papers III, IV and Table 10). Thus, a low prefracture NMS level, older age, and having an inter- or subtrochanteric fracture seems to compromise performances.

- TUG-performances upon discharge from hospital are strongly influenced by the walking aid used during testing (Paper IV and V), and a minimum of three timed TUG-trials is needed to achieve stable TUG-performances, when using a rollator as a standardised walking aid (Paper VI).

- Having an unstable intertrochanteric fracture is associated with more thigh oedema, larger impairment in knee-extension strength in the fractured limb, and functional limitations in measures of basic- and functional mobility when compared to a patient with a cervical fracture. In addition, thigh oedema and all functional performances were significantly correlated to knee-extension MVT of the fractured limb (Paper VII).

Implications and future perspectives

The NMS, CAS and TUG, used in a number of settings, for the evaluation of the prefracture functional level, the basic mobility level, and the functional mobility level in seconds are recommended for use in more surgical and non-surgical settings, including other short-duration non-independent ambulators.

These three easily applicable and non-time consuming assessments might be part of a standard portfolio of validated and patient-orientated outcome measures that enable meta-analysis in future trials, as suggested in the Cochrane review.

The original TUG-manual needs to be modified for patients with hip fracture, since the best of three timed trials performed with a standardised walking aid is needed in this patient group. This may also apply to other timed measures and the use of the TUG in other frail groups, and call for further investigations, in addition with studies of the reliability of this new TUG-manual.

Knowing the NMS-score, age and fracture type provides physiotherapists and other clinicians with three easily applicable and important instruments to predict the early outcome for patients with hip fracture following a multimodal rehabilitation concept.

Despite an intensive mobilisation programme including physiotherapy seven days a week, patients lost more than 50% of their maximal knee-extension strength in less than 10 days, this being associated with the amount of thigh oedema in the fractured limb.

This calls for efforts in reducing oedema and/or the large strength impairments, especially in patients with inter- and subtrochanteric fractures, as falls in elderly people have been associated with asymmetrical lower extremity strength and/or power.

Also, our findings suggest the importance of patients being stratified according to their prefracture functional level, age, and fracture type, when entered into research studies commenced before or after the hip fracture operation.

Specifically, physiotherapists should carry out more in-hospital high quality randomised control trials, examining the effect of different interventions (e.g. the amount of physiotherapy, neuromuscular stimulation or strength training) in the future.

Examination of the feasibility and effect of strength training, commenced immediately after surgery in the acute orthopaedic ward should have a high priority.

Summary in Danish

Et hoftebrud er en af de væsentligste frakturer for ældre personer og som følges af høj afhængighed og dødelighed, og estimeret til cirka 5 millioner årlig tilfælde i år 2050, på verdensplan. Det synes således indlysende at hoftebrud så vidt muligt bør forebygges, samtidigt med at optimal behandling bør tilbydes dem der pådrager sig et sådant.

Formålet med denne afhandling, var at undersøge reliabiliteten og validiteten af tre scoringssystemer: New Mobility Score (NMS, 0-9 point) der belyser funktionsniveauet umiddelbart før hoftebruddet, Cumulated Ambulation Score (CAS, 0-6 point) der evaluerer niveauet for basis mobilitet, samt Timed Up & Go testen der kvantificerer den funktionelle mobilitet i sekunder. Dertil, betydningen af især det tidligere funktionsniveau og frakturtype, men også alder, køn, kognitivt niveau og helbredsstatus, i forhold til patient præstationer under indlæggelse i den primære ortopædkirurgiske afdeling. Afhandlingen omfatter syv publicerede eller antagne delarbejder med i alt 656 patienter der alle fulgte et multidisciplinært behandlingsforløb.

Den relative intertester reliabilitet for NMS- og CAS-scoren, optaget af to forskellige fysioterapeuter var meget høj, mens data for den absolutte reliabilitet viste at en ændring på et point i en af de to scorer er udtryk for en reel ændring for en enkelt person.

Det tidligere funktionsniveau vurderet ved NMS viste sig sammen med alder og frakturtype selvstændigt at kunne forudsige hvorvidt selvstændighed i basismobilitet blev generhvervet, udskrivningsstatus, samt niveauet for TUG-scoren. Således var sandsynligheden for at en patient med et lavt NMS niveau (NMS $\leq$ 6) og/eller en per/subtrokantær fraktur respektivt, 18 og 4 gange større for ikke at genvinde denne basismobilitet

sammenlignet med en patient der havde et højt NMS niveau og et cervikalt brud. Dertil, steg sandsynligheden for dette med 5% for hvert år en patient blev ældre. Samstemmende med dette, anvendte patienter med et lavt NMS niveau og/eller en inter/subtrokantær fraktur gennemsnitligt henholdsvist 9 og 6 sekunder mere for at gennemføre TUG-testen.

Anvendelse af forskellige gangredskaber ved testning havde stor indflydelse på TUG-scoren. Således brugte den samme gruppe patienter gennemsnitligt 13.6 sekunder mere når de anvendte det gangredskab de blev udskrevet med: en gangbuk/stativ, i forhold til test med en rollator. Yderligere, så viste det sig at patienter der gennemførte seks på hinanden følgende TUG-test med en rollator, forbedrede sig signifikant til og med den tredje tur.

Endelig, havde patienter med et pertrokantært brud signifikant mere ødem i det opererede lår (11% stigning ifht. ”rask” ben) sammenlignet med cervikale brud (4%). Samlet set korrelerede omfanget af ødem med scorer for basis mobilitet (r = -0.61), postural kontrol (svaj, r = 0.67), og knæ-ekstensions styrke i frakturbenet (% ikke-frakturerет, r = -0.77) hvorved fra 32% til 59% af variationerne (r^2) i præstationer kunne forklares.

Resultaterne tyder på at den original TUG-manual bør modificeres, idet den bedste af tre ture med standardiseret gangredskab (rollator) anbefales ved testning. Tidligere NMS-niveau, alder og fraktur-type giver klinikeren et godt bud på hvilke forventninger og krav der kan stilles til den enkelte patient, samt hvem der potentielt vil profitere mest af et mere intensivt behandlingsforløb.

Såvel klinikere som forskere bør inddrage disse tre faktorer i deres videre arbejde.

Acknowledgements

I would like to express my sincere gratitude to my co-authors and all those who were involved in and contributed in various ways to this work, with special thanks to:

Henrik Kehlet, my overall advisor and mentor, for involving me in the multidisciplinary research team of patients with hip fracture at Hvidovre Hospital, and for introducing me to the world of research; for never-ending encouragement, constructive criticism of many manuscripts, inspiration and support. This thesis would never have been initiated without you believing in me, and generously sharing your vast knowledge. I am deeply grateful.

Charlotte Ekdahl, my supervisor, for promoting my way as a doctoral student at Lund University, for excellent guidance and support, and for arranging enrichment seminars for the doctoral students in the Department of Physiotherapy.

Nicolai Bang Foss, my co-author and colleague in the hip fracture research team, from Department of Anaesthesiology at Hvidovre Hospital, for introducing me to the world of research and statistics when my primary skill was clinical experience, for great collaboration and valuable discussions.

Thomas Bandholm, my co-author and colleague from Department of Physiotherapy, Orthopaedic Surgery, and Clinical Research Centre, Hvidovre Hospital, for great collaboration and valuable discussions, and for great companionship climbing the Big Chief and exploring the Tofino area in British Columbia.

Pia Søe Jensen and Henrik Palm my two other valuable colleagues from the hip fracture research team, Department of Orthopaedic

Surgery, Hvidovre Hospital, for great collaboration and valuable discussions.

Michael Krasheninnikoff, Head of the Hip Fracture Unit, Department of Orthopaedic Surgery, Hvidovre Hospital, for great collaboration and for keeping the unit together through the years. Also, many thanks to nurses, secretaries and other doctors at the Hip Fracture Unit.

Ingrid Carstens and Jette Christensen, the former and present Head of Department of Physiotherapy, Peter Gebuhr, Head of Department of Orthopaedic Surgery, and the Management of Hvidovre Hospital, for giving me the opportunity to do this thesis, and for their continuous support.

My colleagues at the Department of Physiotherapy, Hvidovre Hospital, for your invaluable support and doing a great job in testing and data collection, with a special thank to Thomas Linding-Jacobsen, for your warm support, enthusiasm, and doing an excellent job in spreading the news of research.

My fellow doctoral students, for inspiring discussions at seminars.

Pernille, my mother Nina, and my two brothers Esben and Søren for your continuous interest in my work, for your love and support, especially when times were tough.

And above all, my two lovely daughters Laura and Clara, for bringing so much joy into my life.

Financial support was received from the IMK foundation, the Danish Physiotherapy Association (research and jubilee fund), and Hvidovre Hospital, Copenhagen, Denmark.

Morten Tange Kristensen, April 2010, Copenhagen.

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Appendix

Characteristics of 1000 consecutive patients with hip fracture, admitted from 2002-2006 at the specialised orthopaedic hip fracture unit, Hvidovre Hospital, Copenhagen, Denmark.

Variable	All patients N=1000	Admitted from		
		Own home N=738 (74)	Other hospital ward N=70 (7)	Nursing home N=192 (19)
Age	83 (76-88)	81 (74-87)	83 (79-87)	87 (81-92)
Female	739 (74)	529 (72)	55 (79)	155 (81)
Male	261 (26)	209 (28)	15 (21)	37 (19)
High prefracture level, NMS 7-9	474 (47)	447 (61)	12 (17)	15 (8)
Low prefracture level, NMS 0-6	526 (53)	291 (39)	58 (83)	177 (92)
High mental status	706 (71)	574 (78)	31 (44)	27 (14)
Low mental status	294 (29)	164(22)	39 (56)	165 (86)
High health status, ASA 0-2	479 (48)	396 (54)	22 (31)	61 (32)
Low health status, ASA 3-4	521 (52)	342 (46)	48 (69)	131 (68)
Use of walking aids prefracture:				
- None	396 (40)	341 (46)	12 (17)	44 (23)
- Cane/stick/crutches	171 (17)	151 (21)	11 (16)	9 (5)
- Rollator	370 (37)	231 (31)	39 (56)	101 (53)
- Non-ambulators	57 (6)	12 (2)	8 (11)	37 (19)
Fracture type:				
- Cervical	481 (48)	368 (50)	32 (46)	81 (42)
- Intertrochanteric	486 (49)	342 (46)	36 (51)	108 (56)
- Subtrochanteric	33 (3)	28 (4)	2 (3)	3 (2)
Other fractures	64 (6)	43 (6)	9 (13)	12 (6)

Data are presented as medians (25%-75%, quartiles) for age, otherwise as numbers with (percentage). NMS; New Mobility Score, ASA; American Society of Anaesthesiologists rating (0-5). Data from the hip fracture database at Hvidovre Hospital.