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Optimization of physical functioning of patients before and after total hip arthroplasty

ELLEN OOSTING

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Ellen Oosting

Promotor:

Prof. dr. N.L.U. van Meeteren

Copromotoren:

Dr. J.J. Dronkers (University of Applied Science, Utrecht, Ziekenhuis Gelderse Vallei, Ede)

Dr. T.J. Hoogeboom (Radboud Institute for Health Sciences, IQ Healthcare, Nijmegen)

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Prof. dr. ir. C.P.G.M. de Groot (Wageningen University&Research)

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1

Introduction

Introduction

In the future, life expectancy will increase or continue to increase thanks to decades of improvements in urbanization, education, hygiene, and health care. People want to stay active, autonomous, and independent into old age and to lead active lives after their retirement,[1] in their own environment and in society at large, at their own pace, with their own challenges and preferences. Physical functioning is the most important element of healthy aging and implies independence, well-being, and freedom.[2,3] Functioning is defined by the World Health Organization (WHO) in the International Classification of Functioning, Disability and Health (ICF) in terms of body functions, activities, and participation, in their interactions with health conditions and contextual factors.[4]

However, sooner or later most old people develop comorbidity, disability, and frailty, accompanied by an increasing risk of gradual societal isolation. Many old people become inactive and experience a decrease in functioning, especially during major life events, such as surgery or hospitalization, and this adversely affects their health.[5] In this respect "health" is not about the absence of disease or about a state of complete physical, mental, and social well-being, as defined by the WHO, but about the ability to self-manage and adapt to physical, social, and emotional challenges in life.[6] Whereas traditionally professionals considered bodily function to define health, nowadays patients consider other domains, such as spiritual/existential dimension and social and societal participation, as being equally, if not more, important.[7]

In line with increasing prosperity, the aging population, and technological developments, health care is changing. Because the elderly population is growing and its demographics are changing, we must take this diversity into account and focus on what is relevant for older people.[1,3] In addition to curative treatment for disease, care and treatment should increasingly involve encouraging and supporting individuals to retain their ability to function and participate.[3] From this perspective, the studies described in this thesis investigate ways to preserve or optimize the physical functioning of older people after a major life event, namely, total hip arthroplasty (THA).

Osteoarthritis and total hip arthroplasty

Seventy-nine percent of the older adults in the Netherlands aged 75 years or older has one or more chronic health conditions, and 49% have multiple chronic health conditions, including diabetes, heart failure, and arthritis.[8] Osteoarthritis (OA) is one of the most common chronic diseases and a major cause of disability in elderly people, causing pain and limitations in activities and participation.[9,10] If conservative therapies (such as weight loss, therapeutic exercise, activity modification, drugs, braces/orthotics, and intra-articular injections[10]) are no longer effective in people with hip OA, and pain and functional problems increase, elective surgery with hip joint replacement can be

considered.[11,12] In the Netherlands, the number of people with arthrosis of the hip who opted for THA increased from 13,785 in 1995 to 25,642 in 2013.[13,14] Sociodemographic trends, such as the increasing number of elderly people and the prevalence of overweight, combined or not with a sedentary lifestyle, will increase the number of people with OA and specifically hip OA and increase the number of people who will choose to have a THA procedure. If policies continue unchanged, the number of people who will have a THA is projected to increase to 51,680 in 2030 (+149%).[13] Similar trends have been reported in the United States of America.[15]

Pathways for THA

People with hip OA usually enter the THA care pathway after being seen in a local hospital, with care being coordinated to achieve a quick postoperative recovery.[16,17] Improvements in clinical care have significantly improved several indicators of the quality of care, such as postoperative complications, length of stay (LOS), and have reduced costs.[18] Optimization of care and surgical and anesthesia techniques has already substantially reduced the negative side effects of surgery and provide better outcomes in terms of functional recovery. Preoperative assessment of patients before THA is becoming more common and mostly focuses on medical factors, general overall health status, and comorbidity. A recent review of Elings et al. underlined the necessity of such an approach given that there is strong evidence that variables such as the Society of Anaesthesiologists score (ASA), the number of comorbidities, and the presence of heart or lung disease, predict LOS after THA.[19] Furthermore many instruments are successfully developed and implemented to predict discharge destination such as the Risk Assessment and Prediction Tool (RAPT).[20,21]

As preoperative physical functioning is an important predictor of postoperative recovery and outcomes after THA,[22,23] it would seem reasonable to evaluate physical functioning in the preoperative assessment. In addition to this assessment, health professionals should also consider advising patients and formal caregivers about preventive interventions that might improve postoperative functional recovery. Although many interventions to improve physical functioning have been evaluated for the last decades, their effectiveness is still intensely debated.[24–28] For instance, while patients awaiting THA greatly appreciate preoperative education sessions, it is questionable whether such sessions actually improve functional outcomes.[28] Likewise, recent systematic reviews have concluded that preoperative exercise interventions (also called 'prehabilitation') for people scheduled to undergo joint replacement do not affect postoperative pain and function to a degree that is clinically relevant.[24,25]

Just as improvements in preoperative therapeutic interventions may be necessary, so too may improvements in postoperative management. After surgery, people are usually guided in their mobilization by a physical therapist. Rapid mobilization after the surgical intervention can speed up recovery, avoid inactivity, and prevent hospital-associated disability.[16,29,30] Chen et al. concluded that starting these exercises on the day of surgery shortened the LOS.[31] In Dutch hospitals, physical therapy in the acute

phase after THA mainly consists of exercises to improve functions and activities.[32] After discharge, rehabilitation is an integral part of THA management, with the physical therapist being considered essential to the patient achieving functional independence.[33] Functional exercises, patient education, and gait training are typically advised,[34] initiated as soon as possible after surgery. In the Netherlands, the guideline regarding acute care physical therapy after THA or total knee arthroplasty (TKA) recommends muscle strengthening and functional exercises.[35] An evaluation of daily physical therapy practice in the Netherlands showed that most physical therapists adhere to these recommendations, usually in individual one-on-one treatment sessions.[36] However, the effects on these interventions on physical functioning is somewhat obscure, and apart from the well-known medical outcome database LROi[37] there is no collective database for functional outcomes. Thus there is no benchmark information from continuous comparative effectiveness research.[38,39]

Most people who elect to undergo THA appreciate the care they receive and consider it effective. Many studies, also from the Netherlands, report that the majority of people consider THA a successful procedure, because it reduces pain and improves self-reported functioning and health-related quality of life in the long-term.[40–42]

Delayed recovery of activities after THA

Although most people make a quick and satisfactory postoperative recovery after THA, a minority experience barriers to their recovery. While many patients report good outcomes,[40,41] not all achieve a satisfactory recovery of physical functioning in the short and long-term.[43–45] In the long-term, the improvement of performance based physical functioning is often less than PROMs suggest; De Groot et al. concluded that, in contrast to the large effect on pain, stiffness, and self-reported physical functioning, the improvement in actual physical activity of people after THA was less than expected 6 months after surgery.[43]

In the short-term, the first concern after surgery nowadays is the recovery of basic activities, such as walking, so that people can return home and pick up their daily activities as soon as possible. Most people prefer to go home after surgery, because they want to get back to their normal routines and relatives.[46] But for older people this is not always possible within a few days. Compared with younger fitter people, older frail people are likely to experience more problems during recuperation because of postoperative complications and admission to the ICU.[47] They stay in the hospital longer and are more frequently discharged to a skilled care facility.[47,48] Fang et al. found in a USA hospital that there was a dramatic increase in LOS and admission to skilled nursing facilities in people older than 80, especially in patients with comorbidities. In their study, only 37% of people older than 80 were discharged home after THA.[47] McIsaac et al. reported that more frail people than non-frail individuals were discharged to institutional care (56.5% vs. 34.6%) in their study in Canada.[48] In contrast, Pitter et al. reported higher rates of discharge to home (93%) of people older than 85 years old in Denmark, but with high readmission rates (14.2% and 17.9% within 30

and 90 days, respectively), partly due to falls.[49] Advanced age and living alone are risk factors for falls after THA.[50] While data about discharge destination, complications, and readmission rates may be influenced by country, hospital, and organizational systems, it is desirable for all older people that daily activities are resumed as soon as possible. The functional decline, complications and challenges older people face after THA may have several physical, contextual, and personal reasons.

Physical barriers for recovery: Surgical stress response

Older people might have a delayed recovery of activities after surgery because they are unable to respond adequately to surgery. Surgery and anesthesia are known stressors, referred to in the literature under the umbrella term "Surgical Stress Response",[51] that can have long-term effects. Functioning decreases immediately after surgery in most people, as a result of surgical stress and bed rest.[52,53] Whereas most people have an adequate stress response and regain mobility within a few days postoperatively, people with a poorer preoperative physical function and condition might not respond well to hospitalization, surgery, and anesthesia and may experience functional loss and even a further decline over a longer period.[53] Figure 1.1 provides a conceptual framework for functional decline and recovery after hospitalization and surgery, including the preoperative period. The green line represents the people who have a satisfactory functional recovery during the postoperative period. The red line represents those frail elderly people with a poorer preoperative physical condition, whose functional status decreases before admission to hospital and who may end up in the critical zone, making them high-risk patients for delayed recovery of activities. A decrease in physical functioning is also reported in the "waiting period" before THA surgery.[54,55] Older people with end-stage OA are not always motivated to stay physically active, once the decision for THA has been made, resulting in a decrease of physical fitness.[56,57] This sedentary behavior is facilitated by functional inability, pain, anxiety to move (with respect to falls for instance), and limited social support and encouragement in this frail population.[58] As a result, the physical condition of these patients, especially those in poor condition, decreases further before surgery.

Personal and contextual barriers for recovery

The loss of perioperative functioning and condition/exercise tolerance is possibly exacerbated by the context in which people function. In essence, the (acute) care context is quite sedentary, mentally, physically, and socially.[59–61] Bed rest and inactivity are well-known risk factors for a loss of functional capacity, in particular in elderly or frail patients.[62] Hospitalization-associated disability (when people are discharged with a disability in daily activities they did not have before hospitalization) occurs in approximately one-third of patients older than 70 years.[61] Unfortunately, many hospitals still have the culture and environment that encourage inactivity. The professionalization of the care context often means that people lose the management

of their own activities. For example, relatives take over activities from their - temporarily – disabled relatives out of politeness and goodwill. This might not be a problem for relatively fit people who can resume their normal habits once they are back home, thereby steadily improving their health and functional status. However, for those who are frail and old, a period of inactivity within this sedentary context combined with anesthesia and surgery can have serious and long-lasting side effects.[61,63]

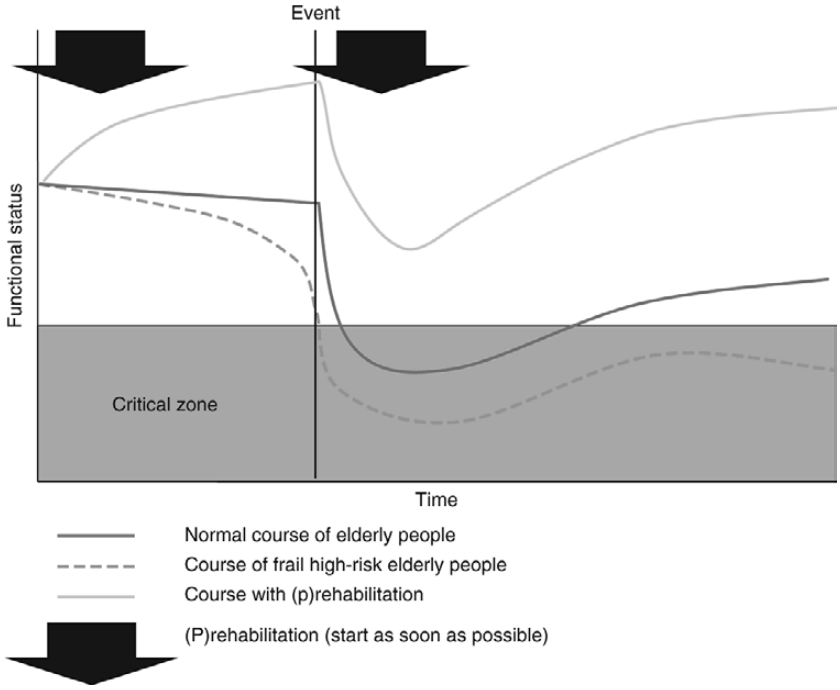

Figure 1.1 Functional decline and recovery after hospitalization and surgery (Hulzebos et al. [53]).

Elderly people might experience more personal barriers and challenges while recovering from surgery. For these individuals, postoperative recovery is a complex process involving physical, physiological, psychological, social, and economic aspects.[52] Elderly people have difficulties coping with pain, a loss of independence, and limitations in activities and participation after being discharged home after THA.[46,64,65] Barriers in their personal environment, such as living alone with limited social support,[1,65] will almost inevitably complicate the recovery of function, which then hinders the recovery of activities.[66] Perry et al. found in their meta-analysis that concepts of faith, confidence, fear (in particular of falling), appreciation, and motivation are associated with a successful transition home after surgery.[64] However, not all people are able to

use these strategies to cope with new stressful situations.[67] Moreover, health professionals do not always provide relevant information in a manner appropriate to the individual needs of elderly people.[46,64]

The gap between current care pathways and the needs of elderly people

It seems that current care pathways are not fully adapted to the differences in functioning between relatively fit people and elderly people with a poor physical fitness. Although exercise programs have an important role in optimizing preoperative and postoperative functioning, their effectiveness is still limited.[24–26,68,69] Given the different barriers elderly individuals face in their recovery after THA, there are several gaps between the needs of elderly patients and current care pathways and research.

To date, emphasis has been mainly on postoperative care. However, optimizing functioning as soon as possible after a patient has opted for THA, especially in the frail people, may prevent a further decrease in physical fitness before surgery and a long postoperative recovery of function.

Therapeutic training programs do not usually focus on the people who most need them. For example, in the systematic review of Wang et al., most studies involved participants younger than 70 years, which suggests that frail elderly people were not recruited, yet they may benefit the most from prehabilitation.[24] It would be logical to include those people who are at risk of delayed functional recovery after THA, but little is known about predictors of delayed inpatient recovery of activities. A recent review of Elings et al. concluded that there were no strong predictors of inpatient recovery of physical functioning[70]; only 2 of the 24 factors investigated were related to limitations in activity (namely, functional status /activities of daily living) and no factors were related to participation.

The content and quality of training programs may be insufficient. Most care pathways and physical therapy interventions seem to be based on one-size-fits-all principle: on average, all patients receive the same intervention. The randomized controlled trials (RCTs) included in systematic reviews of the effectiveness of perioperative exercises typically used standardized exercises,[25,68,69] even though older people often have multiple diseases and geriatric symptoms that affect their physical abilities. A more tailored functional exercise program may fit the individual needs of elder people better.[71] De Vreede et al. concluded in their RCT that functional task exercises were more effective in improving daily functioning than conventional resistance training even long after the training was stopped.[72]

The short-term success of THA care pathways is usually measured by means of economic and medical outcomes, such as LOS, or complication rates, rather than in terms of physical functioning. In the review of Wang et al., only 2 of 22 studies used short-term functioning as an outcome.[73,74] Although LOS is a widely used and important outcome, it might be more appropriate to measure recovery of activities in the clinical period, because LOS is often influenced by local perceptions and organization, and many patients are not discharged on time, even when they meet functional discharge

criteria.[75,76] Inpatient recovery of activities is indicative of the speed and quality of long-term functional recovery.[77,78]

Time to improve

Considering the growing number of older people and the economic and financial affordability of the health care system in most countries including the Netherlands, health professionals and their leaders as well as policymakers and patients should focus on improving health care. People, especially the frail and those at risk, should be given tools to improve, or at least retain, the ability to return home safely after surgery and to function and participate in society as soon as possible after THA. Not the disease or disorders, but functioning, resilience, and self-management should be the key elements of care pathways in the whole trajectory of surgery and outcome monitoring.[3] The health care needs of individual patients, rather than standardized care, should be the starting point. For example, tailored interventions throughout the preoperative trajectory to optimize functioning and recovery after THA, especially for those individuals at risk of adverse outcomes.[16]

Preoperative therapeutic exercise programs should be considered in this respect, as they have the potential to increase a person's ability to adapt to the physical stress of surgery and to preserve their physiological reserve.[53,79] As shown in Figure 1.1, preoperative training is hypothesized to improve functional status, making elderly people less susceptible to complications and functional decline. Preoperative training has other advantages. It changes the passive "waiting list period" into a proactive "empowerment period" and creates an active culture and environment throughout the entire care pathway, extra- and intramural.[53] Furthermore, people would be better prepared for their recovery period at home, when discharge planning is timely and tailored to the personal needs of the patient in the postsurgical phase.[80] This may lead to a decrease in post-acute care utilization and in the total episode-of-care cost for patients who undergo total joint replacement surgery.[81] Snow et al. found in their cohort study that the use of preoperative physical therapy was associated with a 29% decrease in the use of any post-acute care services. This association was sustained after adjustment for comorbidities, demographic characteristics, and procedural variables.

Our approach

Improving the physical functioning of people waiting for THA is complex because it involves several interacting components.[38,39] Complex interventions may work best if tailored to local circumstances and developed in local individual practice.[38,82] Within a daily practice setting, here the setting of *Ziekenhuis Gelderse Vallei*, a local hospital in the mid-east of the Netherlands, we aim to develop interventions that can be combined with context and professional expertise.[83] The combination of preventive interventions and the care demands of individual patients plus modern theoretical concepts of human movement embedded in daily health practice should lead to

tailored, personalized care "*what is best for this person, at this point in time, considering his or her health*".[83] This type of approach and mode of care provision should improve patient performance and reduce costs, thereby increasing the affordability of the care system. In our hospital, an enthusiastic team of physical therapists expanded interdisciplinary (with for example nurses, orthopedic surgeons, anesthetists) and transmural collaboration (physical therapists in the region) in the care pathway and implemented, developed, and evaluated a preoperative functional assessment and a personalized preoperative intervention focusing on performance-based physical functioning.

The aim of the studies described in this thesis was to evaluate the preoperative functional assessment and personalized preoperative intervention developed for people with end-stage OA of the hip who elected to undergo THA, with a view to determining which patient-related factors and personal preferences affect functioning before and after surgery. Another objective was to evaluate the content, feasibility, and preliminary effectiveness of a preoperative intervention to improve functioning before THA in high-risk individuals with a poor functional status and health.

The following aims and questions formed the basis of these studies:

- What is the therapeutic validity and effectiveness, in terms of postoperative recovery, of existing therapeutic exercise programs in patients awaiting primary total joint arthroplasty (TJA)? (A systematic review and Delphi study)
- Which people are at risk of delayed recovery of activities after THA? (A prospective cohort study)
    - What is the additional value of performance-based functional tests besides conventional factors (such as age, sex, and body mass index) and the RAPT scale for predicting delayed inpatient recovery of function (i.e., the inability to walk independently with a walking aid in less than 3 days) after THA?
    - Does preoperative obesity interact with muscle strength, measured by handgrip strength, in the association with postoperative inpatient recovery of activities and LOS after THA?
- What is 'personal meaning' of a person who received physical therapy prior to THA with regard to her daily functioning? (A case study with narrative analysis)
- What is the feasibility and preliminary effectiveness of a home-based, short-term intensive therapeutic exercise program for frail elderly patients scheduled for elective THA? (A pilot Randomized Controlled Trial)

Outline of this thesis

In the study reported in Chapter 2 we evaluated best practice regarding exercises before TJA. We used a Delphi method to develop a rating scale to assess therapeutic validity that took into account the quality of the interventions used in the RCTs. In meta-analyses, we assessed the effectiveness of preoperative exercise on postoperative self-reported and performance-based functioning. We also assessed the association between therapeutic validity and effectiveness of exercise interventions.

In the studies described in Chapters 3 and 4 we investigated which people are at greater risk of delayed inpatient recovery of activities after THA. Using regression analysis, we investigated the association between conventional preoperative factors (age, body mass index, comorbidity, and gender), self-reported functioning (RAPT), and performance-based functioning and recovery of activities after THA. In Chapter 3 we investigated whether performance-based information is of additional value to predict recovery of activities, and in Chapter 4 we investigated whether muscle strength modifies the association between obesity and recovery of functioning after THA.

In the study presented in Chapter 5 we investigated the personal and environmental factors of a person before THA in a single case report. In addition to a medical and functional preoperative assessment, we attempted to gain insight into personal preferences and motivations of a person receiving physical therapy. To this end, we used narrative analysis of the stories of a person before THA, her daughter, and her physical therapist.

In the study described in Chapter 6 we evaluated an intensive exercise program to improve the preoperative functioning of frail elderly individuals. This program takes personal and environmental factors into account. In a pilot RCT, we investigated the feasibility and preliminary effectiveness of the therapeutic exercise training intervention in high-risk patients.

In Chapter 7 we present a general discussion of the main results, followed by recommendations for clinical practice and future research, and in Chapter 8 (Valorization) we show how findings can be implemented in practice and used to the benefit of society.

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2

Therapeutic validity and effectiveness of preoperative exercise on functional recovery after joint replacement: a systematic review and meta-analysis

Hoogeboom TJ
Oosting E
Vriezekolk JE
Veenhof C
Siemonsma PC
de Bie RA
van den Ende CHM
van Meeteren NLU

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Abstract

Background
Our aim was to develop a rating scale to assess the therapeutic validity of therapeutic exercise programmes. By use of this rating scale we investigated the therapeutic validity of therapeutic exercise in patients awaiting primary total joint replacement (TJR). Finally, we studied the association between therapeutic validity of preoperative therapeutic exercise and its effectiveness in terms of postoperative functional recovery.

Methods
(Quasi) randomised clinical trials on preoperative therapeutic exercise in adults awaiting TJR on postoperative recovery of functioning within three months after surgery were identified through database and reference screening. Two reviewers extracted data and assessed the risk of bias and therapeutic validity. Therapeutic validity of the interventions was assessed with a nine-itemed, expert-based rating scale (scores range from 0 to 9; score ≥6 reflecting therapeutic validity), developed in a four-round Delphi study. Effects were pooled using a random-effects model and meta-regression was used to study the influence of therapeutic validity.

Results
Of the 7492 articles retrieved, 12 studies (737 patients) were included. None of the included studies demonstrated therapeutic validity and two demonstrated low risk of bias. Therapeutic exercise was not associated with: 1) observed functional recovery during the hospital stay (Standardised Mean Difference [SMD]: -1.19; 95%-confidence interval [CI], -2.46 to 0.08); 2) observed recovery within three months of surgery (SMD: -0.15; 95%-CI, -0.42 to 0.12); and 3) self-reported recovery within three months of surgery (SMD -0.07; 95%-CI, -0.35 to 0.21) compared with control participants. Meta-regression showed no statistically significant relationship between therapeutic validity and pooled-effects.

Conclusion
Preoperative therapeutic exercise for TJR did not demonstrate beneficial effects on postoperative functional recovery. However, poor therapeutic validity of the therapeutic exercise programmes may have hampered potentially beneficial effects, since none of the studies met the predetermined quality criteria. Future review studies on therapeutic exercise should address therapeutic validity.

Introduction

Total joint replacement is considered an effective and successful end-stage surgical procedure for relieving pain and improving functional status.[1,2] However, a significant number of patients experience persistent pain and functional disability after major joint replacement.[3,4] To enhance postoperative functional recovery, preoperative exercise is a potentially effective intervention by which to optimise the preoperative physical status of patients awaiting joint replacement.[5,6] However, systematic reviews are inconclusive regarding the effectiveness of preoperative exercise in terms of postoperative health status following total hip (THR) or total knee replacement (TKR).[7-10]

These reviews might be flawed as they fail to take into account the therapeutic validity of the exercise interventions in the individual studies, as recommended by Herbert and Bø.[11] It is known that, in the field of preoperative therapeutic exercise, there is a tendency for trials to include relatively healthy patients,[12] rather than patients with known high-risk profiles for delayed postoperative recovery (patients of older age,[13,14] with co-morbidities and/or poor pre-operative status,[13-19] thus excluding patients for whom preoperative exercise is specifically indicated.[20] Furthermore, to yield optimal effects, the content of an exercise programme should be in line with the latest research, be of sufficient volume,[21,22] and be tailored to the potential of the participants.[23] In terms of the latter, we hypothesize that poor therapeutic validity could result in negative study findings. To date, there is no clear set of criteria by which to assess the therapeutic validity of a therapeutic exercise intervention.

Therefore, the aim of our study was threefold. First, we developed a rating scale to assess the therapeutic validity of therapeutic exercise programmes. Second, we assessed the therapeutic validity of preoperative therapeutic exercise programmes in patients awaiting elective, primary THR or TKR, and, finally, we assessed the association between therapeutic validity and the effect of the interventions on postoperative functional recovery.

Methods

The study comprised two phases: (1) a Delphi study to develop a rating scale for the therapeutic validity of therapeutic exercise, and (2) a systematic review and meta-analysis to assess the effectiveness of therapeutically valid exercise regimens in terms of observed functional recovery during the hospital stay, and in terms of self-reported and observed functioning after discharge within three months after surgery. This systematic review is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[24,25]

Delphi rounds

For the Delphi rounds, we followed the method described by Yates et al. (2005).[26] For the Delphi panel, we selected five, internationally renowned, Dutch experts on therapeutic exercise. All participants met the following criteria: (1) previous involvement in a published RCT of a therapeutic exercise treatment, (2) two or more published articles on therapeutic exercise, (3) two or more conference presentations on therapeutic exercise, and (4) licensed health professional in a relevant discipline. The experts were invited by e-mail to participate in the study. Anonymity among experts was maintained throughout all Delphi rounds.

The Delphi study was conducted over four rounds.[26] In the first round, participants responded to open-ended questions regarding therapeutic validity of therapeutic exercise. We defined therapeutic validity as '*the potential effectiveness of a specific intervention given the potential target group of patients*'. In the second round, the first and second authors collated and grouped the responses from round one into a number of statements regarding different aspects of therapeutic validity in therapeutic exercise. The expert group was then asked to determine which of the statements would be essential in a rating scale designed to measure the therapeutic validity of therapeutic exercise programmes (one point = very unnecessary, through to seven points = very necessary). In the third round, the first author created personalised questionnaires for each of the experts, comprising the median and inter-quartile range (IQR) of scores of each statement (representing group level of agreement and the degree of consensus, respectively) and the rating of the individual expert as a reminder. All experts then reviewed and re-rated the statements. A list of statements, which achieved consensus agreement, was prepared by the first author. Consensus for inclusion was defined as a median rating of six or seven on the seven-point rating scale and an IQR of 1.5 or less.[26] In the fourth and final round, all experts were allowed to anonymously express any final concerns regarding the list. These concerns were either accepted or declined by the whole expert group. Finally, the first and second authors drafted the output generated by the Delphi panel into a workable rating scale for the therapeutic validity of exercise programmes.

Systematic review

Search Strategy and Study Selection

We searched the following electronic databases (through to January 2012): MEDLINE (accessed by PubMed), Cochrane Central Register of Controlled Trials, EMBASE, ClinicalTrials.gov, CINAHL and PEDro. In addition, we manually searched the references of published studies. The initial search was not limited by language and comprised the terms *arthroplasty*, *exercise*, and related entry terms associated with a high-sensitivity strategy for the search of RCTs.[29] The complete search strategies used for the different databases are shown in Table S2.1.

We included (quasi)RCTs that compared the effectiveness of preoperative structured therapeutic exercise training with a control intervention, with postoperative recovery of functioning (self-reported or performance-based) as an outcome in patients older than 18 years awaiting elective, primary THR or TKR. Structured exercise training was defined as an intervention in which patients were engaged in planned and supervised exercise programmes (i.e. resistance, aerobic or functional exercise). We only included studies that reported means or differences between means, and respective dispersion values of postoperative functional recovery during the hospital stay and within 3 months after surgery. Exclusion criteria were: (1) duplicate publications or sub-studies of included trials, and (2) studies with two or fewer supervised exercise sessions. The comparator (control) group could be active (any non-exercise intervention) or placebo (no treatment or waiting list) group.

Titles and abstracts of retrieved articles were independently evaluated by two reviewers (T.J.H. and J.E.V.). Reviewers were not blinded to authors, institutions, or manuscript journals. Abstracts that did not provide enough information about the inclusion and exclusion criteria were retrieved for full-text evaluation. Reviewers independently evaluated full-text articles and determined eligibility for inclusion in review. Disagreements were resolved by consensus and, if disagreement persisted, by a third reviewer (C.H.M.E.). To avoid possible double counting of patients included in more than one report by the same authors or working groups, patient recruitment periods were evaluated and, if necessary, authors were contacted for clarification.

Data Extraction

Two reviewers (T.J.H. and E.O.) used standardised forms to independently extract the following information from each eligible publication: year of publication, geographical location, study population, functional outcome measures, duration of follow-up, and type and dose of exercise intervention. For the outcome measure of interest, the number of observations and means and standard deviations (SDs) were extracted for both the intervention and control groups at the following measurement points: 1) baseline (preoperative), 2) in-hospital (postoperative), and 3) after discharge (<3 months postoperative). If measures of variability were unavailable, we imputed the averaged SD of similar measures from other studies. If results were expressed as confidence intervals or interquartile ranges, we used transformation methods as recommended.[28] Where necessary, means and measures of dispersion were approximated from figures in the manuscripts using WebPlotDigitizer.[29] Characteristics of the exercise interventions were extracted, including the type, frequency, duration, and intensity. We used the Compendium of Physical Activities[21] to estimate the exercise intensity in terms of metabolic equivalents (METs). Exercise volume (total energy expenditure on exercise, in $METs \cdot h^{-1} \cdot wk^{-1}$) was calculated by multiplying the intensity in METs by total time spent exercising (number of exercise sessions multiplied by duration of each exercise session).[30]

Any disagreements about the extracted data were solved by consensus or by a third reviewer (C.H.M.E.). In case of missing data, the corresponding author of the included study was contacted.

Assessment of methodological (risk of bias) and therapeutic validity

Two reviewers (T.J.H and E.O.) independently assessed the methodological validity of the studies and the therapeutic validity of the therapeutic exercise programmes. The methodological validity (risk of bias) was scored using the adapted version of the Cochrane Collaboration's tool.[31] This adapted tool reviews five domains, with 11 items in total (see Table S2.2). Each item is rated as 'yes', 'no', or 'unsure'. Studies fulfilling six or more items were regarded as having a low risk of bias.[32] Therapeutic validity was scored using the rating scale developed in the Delphi rounds. Each item was rated as 'yes' or 'no'. Studies with six or more points out of nine were regarded as being of high therapeutic quality. Disagreements were resolved in a consensus meeting between the two raters. The strength of agreement between the two raters was measured by Cohen's κ coefficient (95%-confidence intervals), with κ=0.41-0.60 indicating moderate agreement, κ=0.61-0.80 representing good agreement, and κ≥0.81 representing very good agreement.[33]

Data analysis

In this study, we compared structured, valid therapeutic exercise with a control intervention at three different outcome levels, namely 1) observed functional recovery during the hospital stay; 2) recovery of self-reported functioning within three months of surgery; and 3) recovery of observed functioning within three months of surgery. In our primary analyses, we only included highly valid studies (i.e. risk of bias score >6 & therapeutic validity score >5). Sensitivity analyses were performed without any restrictions on validity. All analyses were carried out separately for patients awaiting either TKR or THR. When more than one study was available, data were statistically pooled where appropriate.

Measures of functioning (performance and self-reported measures) in the treatment and control groups were transformed to standardised mean differences (Hedges *g*) to cope with the variety of outcome measures.[28,34] To ensure uniform interpretability of all scales (i.e., higher scores representing more functional problems), we transformed our data according to the Cochrane recommendations.[28] For studies that compared multiple exercise interventions with a single control group, we split this shared control group into two or more subgroups with smaller sample sizes weighted in relation to different exercise interventions. We applied this approach to ensure reasonably independent comparisons and to overcome a unit-of-analysis error for studies that could contribute to multiple and correlated comparisons.[28] Calculations were performed using a random-effects model. An α value of <0.05 was considered statistically significant.

We assessed statistical heterogeneity of the treatment effect among studies using the inconsistency I^2 test, in which values greater than 50% were considered indicative of high heterogeneity.[28] To assess heterogeneity between studies, we reran the meta-analyses whilst removing one study at a time to check if a particular study caused heterogeneity.

To explore whether effects of the exercise interventions on functional recovery were associated with therapeutic validity (0-9 points) or by exercise volume (METs·h^{-1}·wk^{-1}), we performed meta-regression analyses on each of the three outcome points (i.e. in-hospital functional recovery, short-term observed functional recovery, and short-term self-reported functional recovery), whilst accounting for hip or knee replacement. We evaluated the goodness of fit of each model using the adjusted R^2, which denotes the proportion of between-study variation explained by the covariates.

Publication bias was assessed using a contour-enhanced funnel plot of each trial's effect size against the standard error.[35] Funnel plot asymmetry was evaluated by Begg and Egger tests, and a significant publication bias was considered to be present if the P value was less than 0.10. If publication bias was apparent, trim-and-fill computation was used to estimate the effect of publication bias on the interpretation of results.[35,36]

All analyses were conducted using Stata software, version 10.0 (Stata Inc., College Station, Texas).

Results

Delphi study

The initial open-ended questionnaire was sent to five experts in the field of therapeutic exercise, all of whom met our predetermined criteria. All five experts responded to the invitation and completed each of the four Delphi rounds; no attrition occurred. The experts agreed unanimously that trials on exercise therapy should be assessed on therapeutic validity and that therapeutic validity should be accounted for in best evidence synthesis in systematic reviews.

After the first round, a total of 49 unique statements were generated which could be aggregated into 10 recurrent themes (see Table S2.3). After the second round, consensus was reached on 22 out of the 49 statements (45%). The highest level of disagreement (i.e. largest IQR) was found for the item: “The exercise programme is personalised for each participant”. The lowest score was found for the item: “Natural fluctuations in disease activity must be controlled for.” In the third round, full consensus (i.e. median=7 and IQR=0) was not reached for any of the items, although for 10 items the degree of consensus was zero with a median score of six. In the fourth and final round, eight concerns were expressed regarding the pre-final list, mostly due to item formulation (n=4).

In the final phase, the expert panel considered the 22 statements generated by the Delphi panel and collated them into a nine-item rating scale covering five critical areas.

This scale was named the CONTENT (Consensus on Therapeutic Exercise Training) scale (see Table 2.1).

Table 2.1 The CONTENT scale for the therapeutic validity of therapeutic exercise programmes.

Items	Judgement
A. Patient eligibility	
1. Was the patient selection described? To score "yes", patient selection should be described and participants should be screened for contraindications (for instance, using red and yellow flags) (this must be explicitly mentioned in the manuscript; otherwise "no").	Yes No
2. Was the patient selection adequate? This item can be scored as "yes" if: the goals of the therapeutic exercise match the participants' problems (for instance, if the goal of the therapeutic exercise is to improve a patients' functional status, then only patients with deprived functional status should be included). In this case participants' problems represent bodily functions and structures, activities and participation levels, see the 'International Classification of Functioning, Disability and Health (ICF); and the selection criteria match the majority of potential participants. Ergo, the therapeutic exercise should not be evaluated in a population that - in clinical practice - is nearly non-existent.	Yes No
B. Competences and setting	
3. Were eligibility criteria for therapist and setting determined and adequate? The questions to be answered here are: Are the goals and content of the therapeutic exercise matched to the therapist's competences and skills? Are the goals and content of the therapeutic exercise matched to the location or setting where the therapeutic exercise takes place? If no eligibility criteria are described, this item should be scored as "no".	Yes No
C. Rationale	
4. Was the therapeutic exercise based on a-priori aims and intentions? Did the authors describe a-priori aims, intentions and hypotheses about the therapeutic exercise on theoretically driven and/or argued choices? If this question can be answered with "yes", this item is scored as "yes".	Yes No
5. Was the rationale for the content and intensity of the therapeutic exercise described and plausible? Did the authors describe why they believed the content (e.g. resistance exercise training, aerobic exercise training, flexibility training, etc.) and intensity (e.g. moderate/vigorous intensity, length of exercise, etc.) of the studied intervention was likely to achieve their treatment goals?	Yes No
D. Content	
6. Was the intensity of the therapeutic exercise described? This item can be scored as "yes" if: the content of the therapeutic exercise is described in specific terms (i.e. duration, frequency and intensity of exercise sessions (e.g. 80% VO_{2max}, level of exertion (RPE), repetition maximum, etc.) and the total duration of the therapeutic exercise); the intensity of the therapeutic exercise was selected and adjusted on theoretically driven and/or argued choices; and the content of the therapeutic intervention is suitable for the majority of patients..	Yes No
7. Was the therapeutic exercise monitored and adjusted when considered necessary? This item can be scored as "yes" if: the regular and structured monitoring of therapy progression allows the therapist to: strive for optimal exercise intensity; adjust the intervention in case of therapy failure on an individual level; and identify and monitor adverse events. the outcome measures match the therapy goals.	Yes No

Table 2.1 (continued)

Items		Judgement
8.	Was the therapeutic exercise personalised and contextualised to the individual participants? The goals and content of the therapeutic exercise should not only match the patients' bodily functions and structures, activities and participation levels, but also their personal and environmental factors (see ICF). This item can be scored as "yes" if the therapeutic exercise accounts for relevant personal (e.g. motivation, coping, ethnicity, etc.) and environmental (e.g. logistics, support family/friends, products and technology, etc.) factors for each of the included participants.	Yes No
D. Adherence		
9.	Was adherence to the therapeutic exercise determined and acceptable? For adherence to be properly described and acceptable, adherence should be described in such a way that it allows the reader to understand whether the actual executed therapeutic exercise differed from the planned therapeutic exercise (i.e. data should be provided on the achieved intensity, for example number of sessions attended, achieved exercise intensity, number of exercises etc.). Moreover, adherence should be quantitatively known, allowing it to be controlled for in the analysis.	Yes No

Systematic review

Description of studies

We identified a total of 8939 records in the initial search and removed 1457 duplicate publications. We excluded 7452 non-relevant records based on title or abstract screening. Full-text articles were retrieved for 34 publications and assessed for eligibility (Figure 2.1). Twelve English-language articles comprising 11 randomised controlled trials and one quasi-randomised controlled trial met the eligibility criteria.[37-48] One study presented data for both THR and TKR,[45] therefore eight interventions on TKR and five interventions on THR were included. Moreover, one TKR study presented data for 2 comparisons,[38] resulting in nine interventions in the TKR group. These 12 studies included a total of 737 patients (55% women), with a mean (SD) age of 66 (8) years and a Body Mass Index (BMI) of 31 (6).

The therapeutic exercise interventions prior to TKR and THR are described in Tables 2.2 and 2.3, respectively. Of the eight studies (n = 502) on therapeutic exercise prior to TKR, eight investigated resistance exercise[37-39,44-48] and one investigated aerobic exercise.[38] Typically, these interventions were carried out 3 times a week for 5 weeks, at an intensity of 7.2 METs·h^{-1}·wk^{-1} (see Table 2.2). Of the five studies (n=235) on therapeutic exercise prior to THR, four studied resistance exercise[40-42,45] and one examined functional exercise.[43] Typically, these interventions were carried out 2.5 times a week for a period of 6 weeks and at an intensity of 10.9 METs·h^{-1}·wk^{-1} (see Table 2.3).

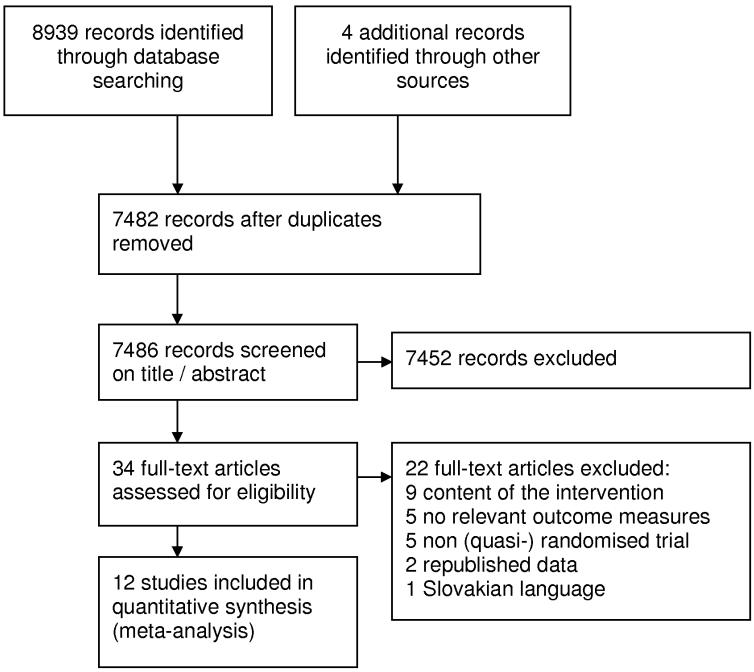

Figure 2.1 Selection of trials investigating preoperative exercise for total hip or knee replacement.

Risk of Bias and Publication Bias assessment

Table S2.4 shows the methodological quality assessment of individual studies. The initial agreement of the reviewers on the total risk of bias assessment was 85% (112 of 132 items), and Cohen's Kappa (95%-CI) was 0.77 (0.67-0.85). All disagreements were resolved in a consensus meeting. Ten studies were assessed as having a high risk of bias and two studies were assessed as having a low risk of bias.[37,43] The most prevalent limitations were found in items about blinding (patient, care provider, outcome assessor), allocation concealment, compliance and intention-to-treat analysis.

For the in-hospital recovery data, the Egger regression test suggested funnel plot asymmetry (*P*=0.07), indicating publication bias. After applying the trim-and-fill procedure, we estimated that two studies were missing, and the adjusted estimate of overall SMD was -2.43 (95% CI, -3.77 to -1.08, *P*<0.01). Contour-enhanced funnel plots and statistical tests did not show any publication bias for the short-term post-operative observational data (Egger: *P*=0.41 and Begg *P*=0.54) and the self-reported data (Egger: *P*=0.47 and Begg: *P*=0.18).

Table 2.2 Description of Supervised Exercise Intervention for patients awaiting Total Knee Replacement.

					Exercise group		Control group				Supervised exercise intervention				
Source, y	Study Location	Age, y[†]	Women, %	BMI[†]	No of sub-jects	Exercise intervention	No of sub-jects	Control intervention	Trial design	Deli-verer	Type	No. of times/ wk	No. of weeks	Intensity	MET, h/wk[‡]
Beaupre et al, 2004	Canada	67 (6.5)	55	31.5 (5.5)	65	Resistance exercise	66	No intervention	RCT	PT	Cycling, lower extremity weight training	3	4	AT: 7.5 minutes at low intensity. WT: 3 sets, 10-15 repetitions, 5 exercises, intensity unclear (progressively increased to patients' tolerance).	6.6
D'Lima et al, 1996	USA	69 (5.5)	60	NA	10	Resistance exercise	10	Education session and leaflet	RCT	PT	Lower & Upper extremity weight training	3	6	WT: 45 minutes at intensity tolerated by patient (adjusted with one repetition every third day).	6.5
Evgeniadis et al, 2008	Greece	68.3 (3.5)	61	34.1 (5.0)	24	Resistance exercise	24	No intervention	RCT	PT + OS	Core & Upper extremity weight training	3	4	WT: 3-4 sets, 10-14 repetitions, ? exercises, intensity based on patient's ability to perform 1 set of 8 repetitions (progressed when 15 repetitions are performed comfortably).	5.3
Rodgers et al, 1998	USA	67.6 (18.4)	55	NA	12	Resistance exercise	11	No intervention	Quasi RCT	PT	Cycling, lower extremity weight training	3	6	AT: ? minutes at intensity according to baseline capacity. WT: ? sets, ? repetitions, 6 exercises, intensity unclear (adjusted after 3 weeks).	?

Table 2.2 (continued)

					Exercise group		Control group				Supervised exercise intervention				
Rooks et al, 2006	USA	67.0 (8.2)	54	34.8 (7.9)	22	Resistance exercise	23	Education via leaflet and telephone	RCT	PT	Cycling, total body weight training (3 wks), aquatic training (3 wks)	3	6	AT: 10 minutes at moderate intensity. WT: 2 sets, 10 repetitions, 7 exercises, intensity tailored to person's fitness level and comfort with exercises (progression unclear).	10.0
Source, y	Study Location	Age, y†	Women, %	BMI†	No of sub-jects	Exercise intervention	No of sub-jects	Control intervention	Trial design	Deli-verer	Type	No. of times/ wk	No. of weeks	Intensity	MET, h/wk‡
Topp et al, 2009	USA	63.8 (6.8)	NA	32.1 (5.9)	26	Resistance exercise	28	No intervention	RCT	RES	Lower extremity weight training	3	4.3	WT: 2 sets, 10 repetitions, 9 exercises, intensity low (adjusted by increasing sets/resistance)	7.6
Weidenhielm et al, 1993	Sweden	63.5 (4.5)	52	29.6 (0.5)	20	Resistance exercise	20	No intervention	RCT	PT	Cycling, lower extremity weight training	3	5	AT: 10 minutes at 50 turns/min, unloaded. WT: 2 sets, 10 repetitions, 5 exercises, intensity against gravity to 3kg (progression 10RM principle).	6.4
Williamson et al, 2007	UK	69.8 (9.4)	53	32.7 (6.1)	60	Resistance exercise	61	Education leaflet	RCT	PT	Lower extremity weight training	1	6	WT: 60 minutes, ? sets, ? repetitions, 9 exercises, intensity unclear (progression unclear).	4.3
D'Lima et al, 1996	USA	70.6 (6.5)	35	NA	10	Aerobic exercise	10	Education session and leaflet	RCT	PT	Cycling, arm ergometry, aquatic training	3	6	AT: 45 minutes at a heart rate of Resting Heart Rate + 0.4-0.7·Heart Rate Reserve.	10.7
Total		66 (8)	54	32 (5)	249		253		8			2.8 (0.4)	5.3 (0.8)		7.2 (1.7)

Abbreviations: AT: Aerobic Training, BMI: Body Mass Index, MET: Metabolic Equivalent, OT: Occupational Therapist, PT: Physical Therapist, RCT: Randomised Clinical Trial, RES: Researcher, WT: Weight training. †Values are expressed as mean (SD). ‡Amount of energy expenditure per week during programmed exercise (1 metabolic equivalent equals 1 $kcal \cdot kg^{-1} \cdot hour^{-1}$).

Table 2.3 Description of supervised exercise intervention for patients awaiting total hip replacement.

					Exercise group		Control group				Supervised exercise intervention				
Source, y	Study Location	Age, y†	Women, %	BMI†	No of sub-jects	Exercise intervention	No of sub-jects	Control intervention	Trial design	Deli-verer	Type	No. of times/ wk	No. of weeks	Intensity	MET, h/wk‡
Ferrara et al, 2008	Italy	63.4 (7.8)	61	NA	11	Resistance exercise	12	No intervention	RCT	PT	Cycling, lower extremity weight training	5	4	AT: 12.5 minutes at low/moderate intensity. WT: 3-4 sets, 8-12 repetitions, ? exercises, intensity unclear (progression unclear).	16.0
Gilbey et al, 2003	Australia	65.2 (11.1)	65	27.9 (4.3)	37	Resistance exercise	31	No intervention	RCT	PT	Cycling / arm ergometry / rowing, + aquatic training	2	8	AT: 5 min cycling/arm/rowing (warming up), 10 min aquatic cycling/running. WT: 1-3 sets, 10 repetitions, ? exercises. All intensity according to ACSM guidelines (sets increased when patient improved).	7.4
Rooks et al, 2006	USA	62.0 (9.7)	58	29.3 (7.4)	32	Resistance exercise	31	Education via telephone + leaflet	RCT	PT	Cycling, total body weight training (3 wks), aquatic training (3 wks)	3	6	AT: 10 minutes at moderate intensity. WT: 2 sets, 10 repetitions, 7 exercises , intensity tailored to person's fitness level and comfort with exercises (progression unclear).	10.0
Gocen et al, 2004	Turkey	51.3 (13.6)	36	26.3 (3.9)	30	Resistance exercise	30	No intervention	RCT	PT	Upper extremity weight training	0.5	8	Three times a day over an eight week period, patients performed 10 repetitions of ? exercises. A PT visited the patients at a two week interval.	?
Hoogeboom et al, 2010	the Netherlands	76.0 (4.2)	67	31.6 (11.3)	10	Functional exercise	11	One education session	Pilot RCT	PT	Walking, cycling, lower extremity weight training, functional training	2	4.5	AT: 5 min walk (warming up), 25 min cycling. WT: 1 set, 15 repetitions, 2 exercises. FT: 3 sets, 15 repetitions, 10 exercises. Intensity for all exercises was moderate to high (13-14 RPE) and adjusted when patient's rated an exercise 12 RPE.	10.2
Total		62 (10)	56	28 (6)	120		115		5			2.5 (1.2)	6.1 (1.5)		10.9 (2.6)

Abbreviations: ACSM: American College of Sports Medicine, AT: Aerobic Training, BMI: Body Mass Index, MET: Metabolic Equivalent, OT: Occupational Therapist, PT: Physical Therapist, RCT: Randomised Clinical Trial, WT: Weight training. †Values are expressed as mean (SD). ‡Amount of energy expenditure per week during programmed exercise (1 metabolic equivalent equals 1 $kcal \cdot kg^{-1} \cdot hour^{-1}$).

Table 2.4 Methodological and therapeutic validity scores per study

Study	Methodological Validity (0-11)	Therapeutic Validity (0-9)
Beaupre et al. (2004)	7 (64%)	1 (11%)
D'Lima et al. (1996) (RE)	3 (27%)	1 (11%)
D'Lima et al. (1996) (AE)	3 (27%)	2 (22%)
Evgeniadis et al. (2008)	4 (36%)	2 (22%)
Ferrara et al. (2008)	5 (45%)	0 (0%)
Gilbey et al. (2003)	2 (18%)	1 (11%)
Gocen et al. (2004)	3 (27%)	0 (0%)
Hoogeboom et al. (2010)	7 (64%)	5 (56%)
Rodgers et al. (1998)	2 (18%)	2 (22%)
Rooks et al. (2006)	4 (36%)	3 (33%)
Topp et al. (2009)	3 (27%)	2 (22%)
Weidenhielm et al. (1993)	4 (36%)	0 (0%)
Williamson et al. (2007)	4 (36%)	1 (11%)

Abbreviations: AE = Aerobic exercise, RE = Resistance exercise.

Therapeutic validity assessment

Table S2.5 shows the therapeutic validity assessment score per individual study as assessed using the CONTENT scale. Cohen's kappa revealed a moderate agreement between the two raters of 0.70 (0.62–0.78); absolute agreement was 104 out of 117 items (89%). The item "Was the therapeutic exercise based on a-priori aims and intentions?" had the least agreement between the raters. All disagreements were resolved without consulting the third rater. The median score (IQR) and mean score (range) of the therapeutic quality of interventions was 1 (1) and 1.5 (0-5), respectively. None of the 13 interventions could be labelled as being therapeutically valid according to the cut-off score of six or higher. Both therapeutic validity and methodological validity scores are presented in Table 2.4.

The categories 'Setting and Therapist', 'Monitoring', and 'Adherence' had the lowest score; none of the interventions included these aspects in their intervention. The highest-scoring category was 'Rationale of the study', with nine out of 13 studies scoring 'Yes' (69%). Two studies (15%) provided a rationale for the content of the therapy. Patient selection was described in four interventions (31%), but only one intervention (8%) was in line with the described aims and intentions of the intervention. Intensity of the intervention was described adequately in three of the 13 interventions (23%).

Association between intervention and in-hospital functional recovery

None of the three studies (132 patients) in this category met the requirements for methodological and therapeutic validity.[39,43,45] Sensitivity analysis of the overall pooled effect of structured preoperative exercise vs. control in terms of functional recovery during the hospital stay was -1.19 (95% CI, -2.46 to 0.08; I^2, 96.2%; *P* for heterogeneity <0.001) (Figure 2.2). Similar pool effects were found when the analysis was separated

into THR (43,45) and TKR (40,45), albeit with broader 95% confidence intervals (Figure 2.2). Meta-regression did not demonstrate an association between the pooled effect and exercise volume (β=-1.70; 95%-CI -21.56-18.15)) or therapeutic validity score (β=0.32; 95%-CI -13.23-13.87)).

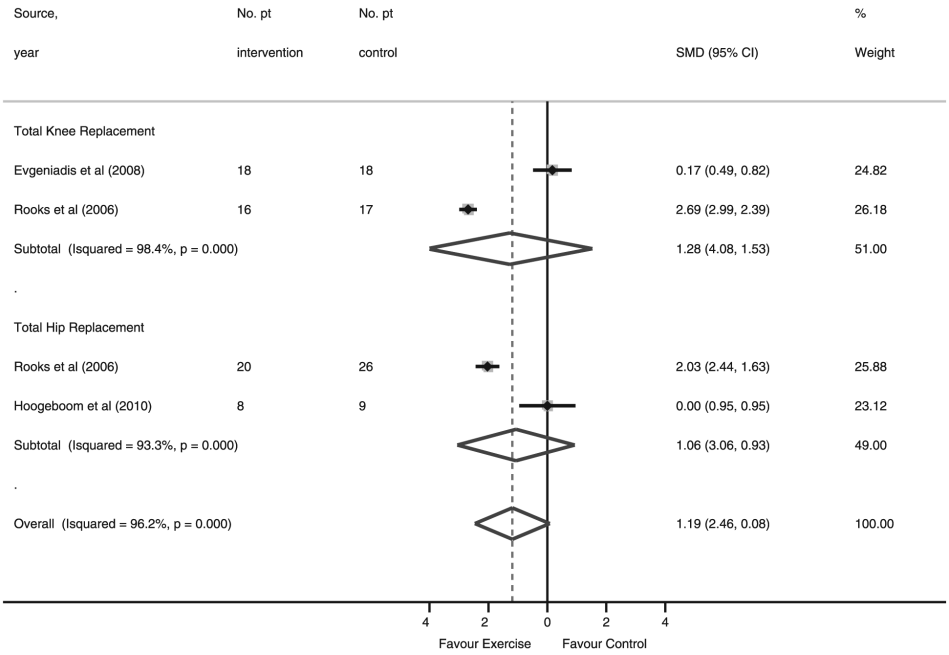

Figure 2.2 Functional recovery during hospital stay in individual studies of structured exercise training vs. control intervention.

Association between intervention and short-term observed functional recovery

None of the seven studies in this category met the requirements for methodological or therapeutic validity.[39,40,44-48] Disregarding any predetermined validity scores, sensitivity analyses found that overall short-term observed functional status was not associated with structured exercise; SMD -0.15 (95% CI, -0.42 to 0.12; I^2, 27.1%, *P* for heterogeneity =0.212) (Figure 2.3). For the TKR subgroup (6 studies, 230 patients) (39,44-48), random-effect modelling revealed a non-significant SMD for the effect of structured exercise on observed functional recovery, SMD -0.15 (95% CI, -0.41 to 0.11; I^2, 0.0%, *P* for heterogeneity =0.478). For the THR subgroup (2 studies, 72 patients),[40,45] a non-significant SMD of -0.31 (95% CI, 1.46 to 0.85, I^2, 80.2%, *P* for heterogeneity =0.024) was found for the effect of structured preoperative exercise on observed functional recovery. Meta-regression demonstrated no association between the

interventions' short-term effects on functional recovery and exercise volume (β=-0.15; 95%-CI -.364-0.07) or therapeutic validity (β=0.08; 95%-CI -0.09-0.26).

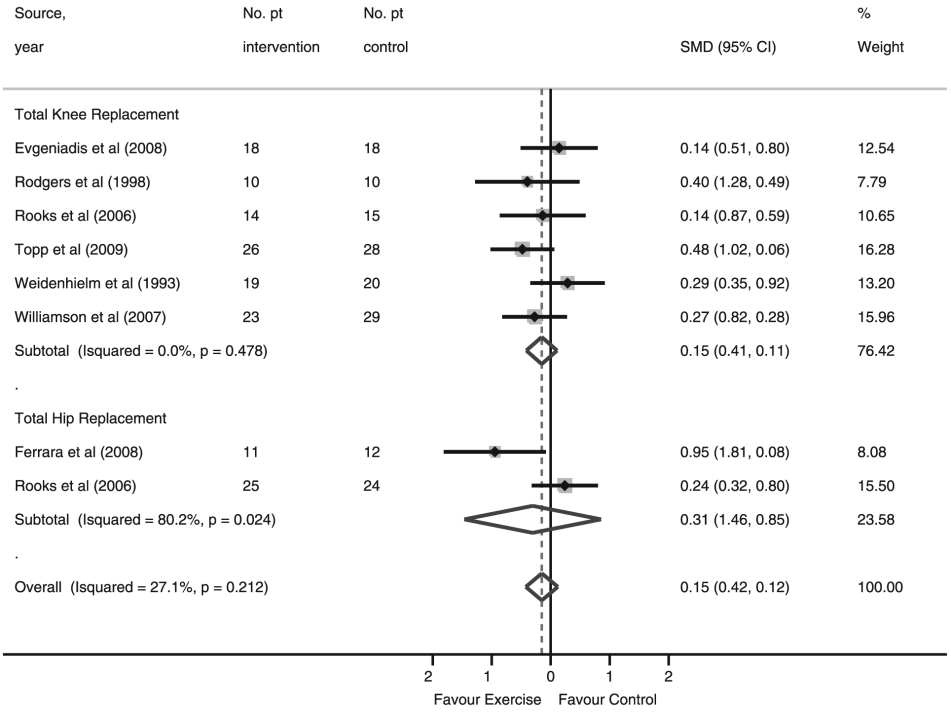

Figure 2.3 Short-term recovery of observed functioning in individual studies of structured exercise vs. control intervention.

Association between intervention and short-term self-reported functional recovery

Methodological validity was demonstrated in one of the seven studies in this category,[37] while therapeutic validity was found in none. Sensitivity analysis of the seven studies comparing structured exercise (205 patients) vs. control (203 patients),[37,38,40-42,45,48] showed that exercise was not associated with self-reported short-term functional recovery after major joint replacement; SMD -0.07 (95% CI, -0.35 to 0.21; I^2, 43.6%, *P* for heterogeneity =0.077) (Figure 2.4). For the TKR subgroup (37,38,45,48), the overall association between five structured therapeutic exercise programmes vs. control and short-term self-reported functioning was 0.14 (95% CI, -0.13 to 0.41; I^2, 0.0%, *P* for heterogeneity =0.638). For the THR subgroup,[40-42,45] random-effect models of four studies (188 patients) on structured exercise revealed a non-significant SMD in favour of structured exercise; SMD -0.37 (95% CI, -0.80 to 0.06;

I2, 51.0%, *P* for heterogeneity =0.106). Meta-regression showed no association between pooled effects and exercise volume (β=0.02; 95%-CI -0.15-0.19)) or therapeutic validity (β=-0.01; 95%-CI -0.18-0.15)).

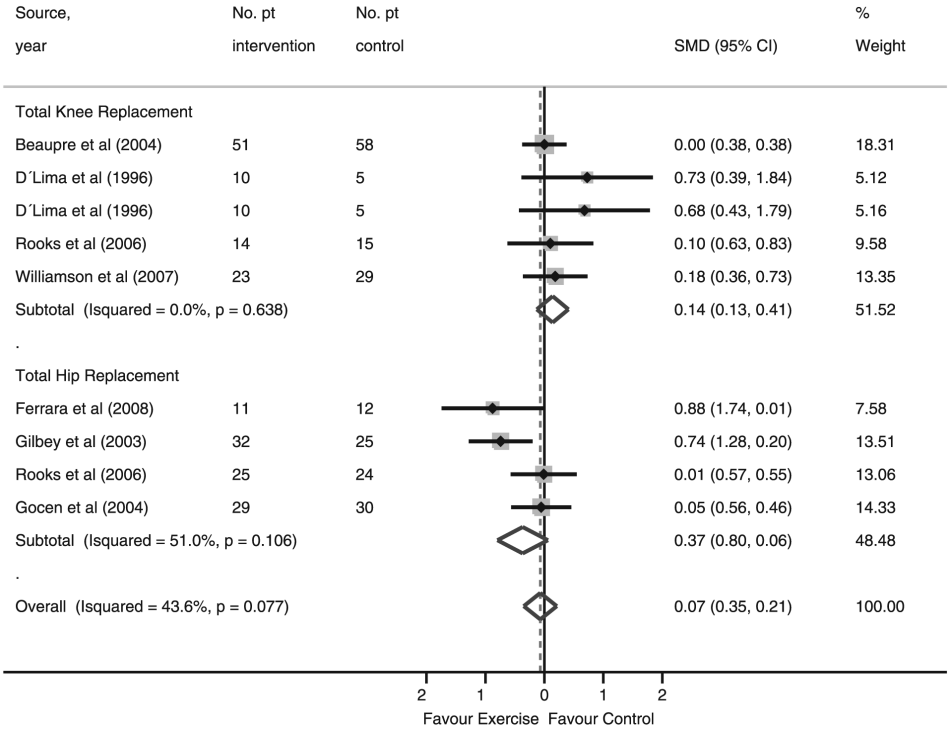

Figure 2.4 Short-term recovery of self-reported functioning in individual studies of structured exercise vs. control intervention.

Discussion

Our results demonstrate that the effectiveness of (highly) valid, structured therapeutic exercise training in individuals awaiting major joint replacement surgery remains unconfirmed. Of the 12 eligible studies, only two met the requirements for methodological quality and none met the prespecified requirements for therapeutic validity, highlighting a lack of quality in this field. Furthermore, pooling data from all eligible studies showed no benefit of preoperative therapeutic exercise therapy in terms of functional recovery after THR or TKR. These findings should, however, be interpreted with caution.

Expert opinion in our Delphi rounds identified five critical areas, comprising a total of 9 items, as being important for the therapeutic validity of a therapeutic exercise intervention. These five critical areas are patient selection, therapist and setting selection, rationale, content, and adherence, and are supported by evidence from the literature. For example, several studies have demonstrated that adequate patient selection can be of great importance in treatment effectiveness, as some patients respond differently to non-pharmacological interventions than others.[49-51] Thus, proper patient selection might result in greater therapy gains.[52] In addition, the selection of therapist and setting are also both known to influence treatment effects.[53] Furthermore, a plausible rationale regarding the benefits of the therapeutic exercise programme - especially if there is little or no previous experience with the intervention - is thought to be necessary to achieve therapy effects.[54] In fact, studies lacking a clear rationale are even considered to be unethical.[55] Adequate intervention content, characterised by sufficient dosing based on theoretical or argued choices, monitoring and personalisation, is perhaps the most important factor in yielding therapy effects. For example, evidence shows that strength training programmes produce the greatest increases in muscle strength if the training load is high[22] without the consideration of frailty.[56] The use of intermediate outcomes is also essential to optimally dose the therapeutic exercise intervention, to achieve therapy progress, and to prevent therapy failure.[57] Finally, the last critical area identified by the Delphi group was adherence to the intervention. Adherence to the exercise programme determines the extent to which therapy dosing is indeed achieved.[58] Therefore, it has been recommended that exercise programmes should be described in sufficient detail to enable readers to understand how the intervention was actually carried out.[11] In conclusion, each of the five aspects of therapeutic validity identified by the Delphi study is supported by the literature.

Our finding that preoperative therapeutic exercise has no beneficial effect on functional recovery after joint replacement surgery is in line with our hypothesis that suboptimal therapeutic exercise elicits no effect. None of the included studies met the predetermined requirements for therapeutic validity. An apposite example demonstrating this lack of therapeutic validity is that, although nine out of 13 exercise interventions provided a rationale for why preoperative exercise would elicit beneficial effects, only one group[43] actually applied their rationale to their patient selection criteria (i.e. by including patients with a high risk of delayed functional recovery), and only two studies[43,45] applied this rationale to their exercise programme (i.e. by selecting their exercise dosing accordingly). Moreover, none of the included interventions monitored therapy dosing to achieve and maintain optimal exercise dosing,[57] as is further illustrated by the finding that only three studies[38,40,43] reported a supervised exercise dose greater than the regularly prescribed weekly amount of physical activity (i.e. 10 METs$\cdot h^{-1}\cdot wk^{-1}$).[59] Finally, adherence was often not, or only marginally, reported. Apart from the number of attended sessions, authors should provide information on the prespecified exercise protocol and whether the intended exercise intensity was

reached. In conclusion, we recommend that future studies on preoperative therapeutic exercise develop a highly valid therapy protocol, for which our rating scale could be used as a blueprint.

For an exercise programme to be considered therapeutically valid, we arbitrarily chose a cut-off value of six out of nine items on the CONTENT scale. Lowering the cut-off score to five or even four points would not have altered the our conclusions regarding short-term postoperative functional recovery. Regarding the in-hospital functional recovery, lowering the cut-off score to four or five would have identified one pilot trial[43] that was insufficiently powered to assess differences in postoperative recovery. Whether the current cut-off value represents a true threshold for therapeutic validity needs to be further investigated.

Ten out of 12 studies were considered to have a high risk of bias. Allocation concealment and blinding were the lowest scoring items in the risk of bias assessment. Because most of the studies lack allocation concealment, readers should be aware that these studies are more susceptible to selection bias, and this may affect the generalisability of our results. Moreover, given that most studies were insufficiently blinded and that the majority of studies did not use intention-to-treat analysis, the apparent results of our meta-analysis may have been inflated.[60,61]

Since effectiveness in randomised trials depends on the quality of the intervention, the lack of criteria to assess this quality is surprising. To date, some systematic reviews have investigated the relationship between exercise intensity and therapeutic effectiveness post-hoc,[30,62] with varying effects. One limitation of our study is that we were unable to draw conclusions regarding the validity of our rating scale, as none of the included studies could be classified as being highly valid. In fact, the majority of the interventions scored in the lowest tertile of the scale, preventing us from evaluating the relationship between therapy outcomes and therapy validity. Another limitation is that the CONTENT-scale might not only evaluate the therapeutic validity of an exercise program but also how well the exercise program was justified and how completely the justification was reported. Perhaps some of the studies employed adequate exercise programs but scored poorly on the scale because the study reports did not include a complete justification of the exercise programs.

So far, several systematic reviews,[7,8,63] narrative reviews,[9,64] and meta-analyses[10,65] have been published on preoperative exercise in patients awaiting joint replacement, but none of these reviews assessed the quality of the included interventions.[11] Taken the therapeutic validity into account, we have reached a similar conclusion to previous reviews, namely that the current intervention studies, which is mainly of low methodological validity, does not show that therapeutic exercise has beneficial effects on postoperative outcomes. However, what our review adds is that readers should also take the low therapeutic validity into consideration when interpreting these conclusions. Future studies should therefore specifically aim to include patients at need, that is those at risk for postoperative delayed recovery (based on a validated clinical decision rule),[52] provide a (piloted)[23] therapeutically sound and feasible exercise

programme of sufficient, titrated dosing[57] and evaluated on relevant and amendable parameters (for instance heart rate recovery).[66] The preoperative exercise program for patients awaiting coronary artery bypass grafting reported by Hulzebos et al. (2006) is an illustration of the systematic development of an exercise program while addressing critical areas for therapeutic validity.[20]

In conclusion, none of the 13 included therapeutic exercise programmes met our predetermined criteria for high therapeutic validity, making it unlikely that the interventions evaluated in these studies would have elicited relevant effects. In our view, the interpretation and development of therapeutic exercise programmes would be facilitated if international consensus could be reached on a select number of mandatory criteria for therapeutic validity. Finally, we recommended that future review studies on therapeutic exercise should not only determine the methodological validity, but also the therapeutic validity of the included trials.

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Supplemental tables

Table S2.1 Full bibliography of the electronic searches.

Search History PUBMED

ID	SEARCH	HITS
#12	#5 AND #8 AND #11	1469
#11	#9 NOT #10	2489722
#10	(animals[MeSH Terms]) NOT humans[MeSH Terms]	3629850
#9	randomized controlled trial[Publication Type]) OR controlled clinical trial[Publication Type]) OR randomized[Title/Abstract]) OR placebo[Title/Abstract]) OR drug therapy[MeSH Subheading]) OR randomly[Title/Abstract]) OR trial[Title/Abstract]) OR groups[Title/Abstract]	2908964
#8	exercise[MeSH Terms]) OR exercise therapy[MeSH Terms]) OR hydrotherapy[MeSH Terms]) OR physical fitness[MeSH Terms]) OR physical therapy[MeSH Terms]) OR physical therapy modalities[MeSH Terms]) OR rehabilitation[MeSH Terms]) OR gymnastics[MeSH Terms]) OR exercise*[Text Word]) OR training*[Text Word]) OR gymnast*[Text Word]) OR exercise therapy[Text Word]) OR hydrotherap*[Text Word]) OR water therap*[Text Word]) OR swim*[Text Word]) OR rehabilitation*[Text Word]) OR physical therap*[Text Word]) OR physiotherapy[Text Word]	769712
#5	arthroplasty OR joint prosthesis OR arthroplasty, replacement, hip OR arthroplasty, replacement, knee [MeSH Terms]) OR hip prosthesis[MeSH Terms]) OR knee prosthesis[MeSH Terms]) OR arthroplasty[Text Word]) OR total joint*[Text Word]) OR total hip*[Text Word]) OR total knee*[Text Word]	61631

Search string Embase

ID	SEARCH	HITS
#18	#7 AND #13 AND #17	3053
#17	'exercise'/exp OR 'exercise' OR 'kinesiotherapy'/exp OR 'kinesiotherapy' OR 'hydrotherapy'/exp OR 'hydrotherapy' OR 'physiotherapy'/exp OR 'physiotherapy' OR 'fitness'/exp OR 'fitness' OR 'physical education'/exp OR 'physical education' OR 'training'/exp OR 'training' OR 'physical therapy'/de OR 'physical therapy' OR 'gymnastics'/de OR 'gymnastics' OR 'exercise therapy'/de OR 'exercise therapy'	698107
#13	#11 NOT #12	13217635
#12	'animal'/exp NOT 'human'/exp	1666924
#11	'randomized controlled trial'/exp OR 'randomized controlled trial' OR 'controlled clinical trial'/exp OR 'controlled clinical trial' OR 'randomized' OR 'placebo'/de OR 'placebo' OR 'drug therapy'/exp OR 'drug therapy' OR 'randomly' OR 'trial' OR 'groups'	14625836
#7	'arthroplasty'/exp OR 'arthroplasty' OR 'arthroplasty'/de OR 'joint prosthesis'/exp OR 'joint prosthesis' OR 'joint prosthesis'/de OR 'hip arthroplasty'/exp OR 'hip arthroplasty' OR 'hip arthroplasty'/de OR 'knee arthroplasty'/exp OR 'knee arthroplasty' OR 'knee arthroplasty'/de OR 'total knee replacement'/exp OR 'total knee replacement' OR 'total knee replacement'/de OR 'knee prosthesis'/exp OR 'knee prosthesis' OR 'knee prosthesis'/de OR 'hip prosthesis'/exp OR 'hip prosthesis' OR 'hip prosthesis'/de OR 'total hip prosthesis'/exp OR 'total hip prosthesis' OR 'total hip prosthesis'/de OR 'total joint replacement'/de OR 'total joint replacement' OR 'total joint prosthesis'/de OR 'total joint prosthesis'	73551

Table S2.1 (continued)

Search string Central (Cochrane Clinical Trials)

ID	SEARCH	HITS
#1	"accession number" near pubmed in Clinical Trials	377640
#2	"accession number" near embase in Clinical Trials	118524
#3	(**#1** OR **#2**)	434845
#4	arthroplasty:kw OR arthroplasty OR joint prosthesis:kw OR knee prosthesis:kw OR hip prosthesis:kw OR arthroplasty near replacement* OR total near joint* OR total near hip* OR total near knee* OR hip near replacement OR knee near replacement in Clinical Trials	5092
#5	exercise:kw OR exercise therapy:kw OR hydrotherapy:kw OR physical therapy:kw OR physical fitness:kw OR physical therapy modalities:kw OR rehabilitation:kw OR gymnastics:kw OR exercise* OR hydrotherap* OR water near therap* OR swim* OR rehabilitation* OR physical near therap* OR physiotherapy in Clinical Trials	53282
#6	(#4 AND #5)	701
#7	(#6 AND NOT #3)	38

Search string CINAHL

ID	Search	Hits
S6	#S1 AND #S2 AND #S5	611
S5	(#S3 NOT #S4)	237365
S4	(MH "Animals") NOT (MM "Human")	21209
S3	(PT Randomized controlled trial) OR (PT Clinical trials) OR (TX randomized) OR (TX placebo) OR (MM "Drug therapy") OR (TX randomly) OR (TX trial) OR (TX groups)	239922
S2	(MM "Exercise+") OR (MM "Therapeutic exercise+") OR (MM "Physical fitness+") OR (MM "Physical therapy+") OR (MM "Hydrotherapy+") OR (MM "Rehabilitation+") OR (MM "Gymnastics+") OR (TX exercise*) OR (TX training*) OR (TX exercise N5 therapy) OR (TX water N5 therapy) OR (TX rehabilitation) OR (TX hydrotherap*) OR (TX physiotherapy)	284449
S1	(MM "Arthroplasty+") OR (MM "Arthroplasty, Replacement+") OR (MM "Arthroplasty, Replacement, Hip+") OR (MM "Arthroplasty, Replacement, Knee+") OR (TX Arthroplasty) OR (TX hip N5 prosthesis) OR (TX knee N5 prosthesis) OR (TX total joint*) OR (TX total knee*) OR (TX total hip*)	11585

Search string Web of Science

ID	SEARCH	HITS
# 7	#6 AND Document Type=(Article) Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years	3091
# 6	#1 AND #2 AND #5 Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years	3367
# 5	#3 NOT #4 Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years	3247611
# 4	TS=(animals) NOT TS=(humans) Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years	525626
# 3	TS=(randomized controlled trial OR controlled clinical trial OR randomized OR placebo OR drug therapy OR randomly OR trial OR groups) Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years	3382798
# 2	TS=(exercise OR exercise therap* OR hydrotherap* OR physical fitness OR physical therap* OR rehabilitation OR gymnastic* OR training* OR physiotherap* OR water therap* OR swim*) Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years	674360
# 1	TS=(arthroplasty OR joint prosthesis OR joint replacement OR knee replacement OR hip replacement OR hip prosthesis OR knee prosthesis OR total joint* OR total hip* OR total knee*) Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH Timespan=All Years	88640

Table S2.1 (continued)

Search string PEDro

id	search	hits
#1	*arthroplasty AND “clinical trial”	172
#2	*prosthesis AND “clinical trial”	37
#3	*replacement AND “clinical trial”	209

Search string Clinical trials (www.clinicaltrials.gov)

ID	Search	hits
#1	arthroplasty OR total hip replacement OR total knee replacement OR replacement OR prosthesis	2591
#2	exercise OR “exercise therapy” OR hydrotherapy OR “physical fitness” OR “physical therapy” OR training OR physiotherapy OR rehabilitation	21643
#3	#1 AND #2	259

Table S2.2 Assessment of risk of bias scale.

Items		Judgment
A) Sequence generation		
1	Was the method of randomization adequate?	Yes No Unsure
	A random (unpredictable) assignment sequence. Examples of adequate methods are coin toss (for studies with two groups), rolling a dice (for studies with two or more groups), drawing of balls of different colors, drawing of ballots with the study group labels from a dark bag, computer-generated random sequence, pre-ordered sealed envelopes, sequentially-ordered vials, telephone call to a central office, and pre-ordered list of treatment assignments Examples of inadequate methods are: alternation, birth date, social insurance/security number, date invited to participate in the study, hospital registration number, etc..	
B) Allocation concealment		
2	Was the treatment allocation concealed?	Yes No Unsure
	Assignment generated by an independent person not responsible for determining the eligibility of the patients. This person has no information about the persons included in the trial and has no influence on the assignment sequence or on the decision about eligibility of the patient.	
C) Blinding of participants, personnel and outcome		
3	Was the patient blinded to the intervention?	Yes No Unsure
	This item should be scored “yes” if the index and control groups are indistinguishable for the patients or if the success of blinding was tested among the patients and it was successful.	
4	Was the care provider blinded to the intervention?	Yes No Unsure
	This item should be scored “yes” if the index and control groups are indistinguishable for the care providers or if the success of blinding was tested among the care providers and it was successful.	
5	Was the outcome assessor blinded to the intervention?	Yes No Unsure
	Adequacy of blinding should be assessed for the primary outcomes. This item should be scored “yes” if the success of blinding was tested among the outcome assessors and it was successful or: *For patient-reported outcomes* in which the patient is the outcome assessor (e.g., pain, disability): the blinding procedure is adequate for outcome assessors if participant blinding is scored “yes”. *For outcome criteria assessed during scheduled visit and that supposes a contact between participants and outcome assessors* (e.g., clinical examination): the blinding procedure is adequate if patients are blinded, and the treatment or adverse effects of the treatment cannot be noticed during clinical examination. *For outcome criteria that are clinical or therapeutic events* that will be determined by the interaction between patients and care providers (e.g., co-interventions, length of stay, treatment failure), in which the care provider is the outcome assessor: the blinding procedure is adequate for outcome assessors if item “E” is scored “yes”. *For outcome criteria that are assessed from data of the medical forms*: the blinding procedure is adequate if the treatment or adverse effects of the treatment cannot be noticed on the extracted data	
D) Incomplete outcome data		
6	Was the drop-out rate described and acceptable?	Yes No Unsure
	The number of participants who were included in the study but did not complete the observation period or were not included in the analysis must be described and reasons given. If the percentage of withdrawals and drop-outs does not exceed 20% for during follow-up and does not lead to substantial bias a ‘yes’ is scored. (N.B. these percentages are arbitrary, not supported by literature).	
7	Were all randomized participants analyzed in the group to which they were allocated?	Yes No Unsure
	All randomized patients are reported/analyzed in the group they were allocated to by randomization for the most important moments of effect measurement (minus missing values) irrespective of non-compliance and co-interventions.	

Table S2.2 (continued)

Items		Judgment		
E) Other sources of potential bias				
8	Were the groups similar at baseline regarding the most important prognostic indicators? In order to receive a "yes", groups have to be similar at baseline regarding demographic factors, severity of complaints, and value of main outcome measure(s).	Yes	No	Unsure
9	Were co-interventions avoided or similar? This item should be scored "yes" if there were no co-interventions or they were similar between the index and control groups.	Yes	No	Unsure
10	Was the compliance acceptable in all groups? The reviewer determines if the compliance with the interventions is acceptable, based on the reported intensity, duration, number and frequency of sessions for both the index intervention and control intervention(s). For example, physiotherapy treatment is usually administered over several sessions; therefore it is necessary to assess how many sessions each patient attended. For single-session interventions (for ex: surgery), this item is irrelevant.	Yes	No	Unsure
11	Was the timing of the outcome assessment similar in all groups? Timing of outcome assessment should be identical for all intervention groups and for all important outcome assessments.	Yes	No	Unsure

Table S2.3 Summary of the statements generated by the Delphi panel.

	Round 1 number of items	Round 2 Consensus	Round 3 & 4 Consensus
Patient characteristics	6	4	3
Therapist eligibility	4	3	2
Therapy setting	1	1	1
Exercise intensity	8	3	4
Therapy content	8	4	4
Co-interventions	4	0	0
Therapy monitoring	8	4	4
Therapy evaluation	4	1	1
Follow-up time	2	0	0
Exercise adherence	4	3	3
Total	49	23	22

TableS2.4 Assessment of risk of bias per individual study per scale item.

Study	Adequate randomi-sation	Allocation concealed	Blinding			Drop-out rate described	Intention to treat analysis	Groups similar at baseline	Cointer-ventions avoided	Compliance acceptable	Timing of outcome assessment similar	Total score
			Patient	Care provider	Outcome assessor							
Beaupre et al. (2004)	Yes	Unsure	No	No	Unsure	Yes	Yes	Yes	Yes	Yes	Yes	7
D'Lima et al. (1996)	Yes	Unsure	No	No	No	No	Unsure	Unsure	Yes	Unsure	Yes	3
Evgeniadis et al. (2008)	Yes	Unsure	No	No	No	No	Yes	Yes	Unsure	Unsure	Yes	4
Ferrara et al. (2008)	Yes	Unsure	No	No	No	Yes	Unsure	Yes	Yes	Unsure	Yes	5
Gilbey et al. (2003)	Unsure	Unsure	No	No	No	No	Unsure	Unsure	Unsure	Yes	Yes	2
Gocen et al. (2004)	Yes	Unsure	No	No	No	Yes	Unsure	No	Yes	Unsure	No	3
Hoogeboom et al. (2010)	Yes	Yes	No	No	Unsure	No	Yes	Yes	Yes	Yes	Yes	7
Rodgers et al. (1998)	No	No	No	No	No	Yes	Unsure	Unsure	Yes	Unsure	No	2
Rooks et al. (2006)	Unsure	Unsure	No	No	No	No	Yes	Yes	Unsure	Yes	Yes	4
Topp et al. (2009)	Unsure	Unsure	No	No	No	Yes	Unsure	Unsure	Yes	No	Yes	3
Weidenhielm et al. (1993)	Yes	Unsure	No	No	No	Yes	Unsure	Unsure	Yes	Unsure	Yes	4
Williamson et al. (2007)	Yes	Yes	No	No	Unsure	No	Unsure	Yes	No	Unsure	Yes	4
Total score	8 (67%)	2 (17%)	0 (0%)	0 (0%)	0 (0%)	6 (50%)	4 (33%)	6 (50%)	8 (67%)	4 (%33)	10 (83%)	

Table S2.5 Assessment of therapeutic validity per individual study per scale item.

	Patient eligibility			Rationale		Content				
Study	Described	Adequate	Setting and therapist	Study	Intervention	Intensity	Monitored	Personalized	Adherence	Total score
Beaupre et al. (2004)	no	no	no	yes	no	no	no	no	no	1 (11%)
D'Lima et al. (1996)	no	no	no	yes	no	no	no	no	no	1 (11%)
D'Lima et al. (1996)	no	no	no	yes	no	yes	no	no	no	2 (22%)
Evgeniadis et al. (2008)	yes	no	no	yes	no	no	no	no	no	2 (22%)
Ferrara et al. (2008)	no	no	no	no	no	no	no	no	no	0 (0%)
Gilbey et al. (2003)	no	no	no	no	no	yes	no	no	no	1 (11%)
Gocen et al. (2004)	no	no	no	no	no	no	no	no	no	0 (0%)
Hoogeboom et al. (2010)	no	yes	no	yes	yes	yes	no	yes	no	5 (56%)
Rodgers et al. (1998)	yes	no	no	yes	no	no	no	no	no	2 (22%)
Rooks et al. (2006)	yes	no	no	yes	yes	no	no	no	no	3 (33%)
Topp et al. (2009)	yes	no	no	yes	no	no	no	no	no	2 (22%)
Weidenhielm et al. (1993)	no	no	no	no	no	no	no	no	no	0 (0%)
Williamson et al. (2007)	no	no	no	yes	no	no	no	no	no	1 (11%)
Total score	4 (31%)	1 (8%)	0 (0%)	9 (69%)	2 (15%)	3 (23%)	0 (0%)	1 (8%)	0 (0%)	

3

Preoperative prediction of inpatient recovery of function after total hip arthroplasty using performance-based tests: a prospective cohort study

Oosting E
Hoogeboom TJ
Vriezekolk JE
Appelman-de Vries SA
Swets A
Dronkers JJ
van Meeteren NLU

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Abstract

Purpose
The aim of this study was to evaluate the value of conventional factors, the Risk Assessment and Predictor Tool (RAPT), and performance-based functional tests as predictors of delayed recovery after total hip arthroplasty (THA).

Method
A prospective cohort study in a regional hospital in the Netherlands with 315 patients attending for THA in 2012. The dependent variable recovery of function was assessed with the Modified Iowa Levels of Assistance scale. Delayed recovery was defined as taking more than 3 days to walk independently. Independent variables were age, sex, BMI, Charnley score, RAPT score, and scores for four performance-based tests (2-minute walk test (2MWT), timed up and go test (TUG), 10-meter walking test (10mW), and hand grip strength (HGS).

Results
Regression analysis with all variables identified older age (>70 years), Charnley score C, slow walking speed (10mW>10.0 s), and poor functional mobility (TUG>10.5 s) as the best predictors of delayed recovery of function. This model (AUC 0.85, 95% CI 0.79-0.91) performed better than a model with conventional factors and RAPT scores, and significantly better (*P*=0.04) than a model with only conventional factors (AUC 0.81, 95%CI 0.74-0.87).

Conclusions
The combination of performance-based tests and conventional factors predicted inpatient functional recovery after THA.

Introduction

Total hip arthroplasty (THA) reduces pain and improves function and health-related quality of life in patients with end-stadium osteoarthritis.[1] The growing demand for THA and rising healthcare costs highlight the need to shorten the length of hospital stay (LOS) and to plan discharge efficiently and appropriately. Current care pathways aim to limit the LOS by making use of accelerated rehabilitation and functional discharge criteria, so that most patients can be discharged to home within 2-4 days.[2] Yet variance in LOS[3] and recovery of function remains,[4] and patients are not always discharged when they meet functional discharge criteria.[5] The identification of predictive factors for inpatient recovery of function is the first step in developing a clinical prediction rule[6] to identify people at risk for delayed postoperative recovery. Such a prediction rule might aid timely discharge planning and preoperative optimization. Additional therapeutic exercise before or during hospitalization for those at risk for delayed recovery might augment the postoperative outcomes and reducing rehabilitation rate, prolonged hospitalization and complication rate.[7]

Previous studies have mainly looked at the predictive value of conventional patient-related factors, such as age, sex, body mass index (BMI), and comorbidity,[8] but these factors explain only a small portion of the variance in postoperative functional recovery. In order to optimize preoperative risk screening, Oldmeadow *et al* developed a prediction tool, the Risk Assessment and Predictor Tool (RAPT), to aid decision-making regarding discharge destination after major joint replacement.[9–11] Several studies have shown that the RAPT score is associated with LOS,[12,13] postoperative complications,[14] and discharge destination.[9,10,12] The relation between RAPT scores and functional discharge criteria has not been studied. As the RAPT measures self-reported functioning only, and it is recognized that performance-based tests are important for predicting postoperative recovery,[15] we thought the combination of the RAPT and performance-based tests would improve the prediction of independency of walking, an important functional discharge criterion.[16–18] Therefore the aim of this study was to evaluate the value of 1. conventional factors (such as age, sex and BMI), 2. conventional factors and the RAPT scale, and 3. conventional factors, the RAPT scale, and performance-based functional tests for predicting delayed inpatient recovery of function (i.e., the inability to walk independently with a walking aid in less than 3 days) after THA.

Methods

Design, participants, and procedure

In this prospective cohort study, patients scheduled for THA were referred by the orthopedic surgeon for screening between February 2012 and December 2012 by a

physical therapist approximately 6 weeks before surgery in the Gelderse Vallei Hospital in the Netherlands. All measurements were collected during regular clinical practice. All patients received postoperative rehabilitation once or twice a day, initiated the day after surgery. Patients were transferred out of bed within 24 hours after surgery and started walking with crutches (or a wheeler), if possible, on postoperative day 1. Physical therapy consisted of progressively improving walking ability, other functional activities and walking stairs, based on the individual patient's needs and progress. Discharge criteria were the ability to walk independently with a walking aid, being in a stable medical condition, and adequate wound healing. A supervised exercise program by a physical therapist was only continued at home on indication. Other patients received a home exercise program and were monitored. Patients referred to inpatient rehabilitation were discharged on postoperative day 4 if they were medically stable. Type of surgery, social status, discharge destination, and LOS (counted as nights in hospital after surgery) were recorded. Use of clinical data was approved by the local medical ethics committee of Gelderse Vallei Hospital (BCWO 1304-180).

Dependent variables

The dependent variable was walking ability, measured with the Modified Iowa Levels of Assistance scale,[19] where a score of 6 or lower indicates that a patient can walk independently for more than 4.6 meters (with or without walking aid). Climbing stairs was not scored because not all patients needed to do so in their home situation. Independence in walking was dichotomized as normal recovery (walking independently within 3 days of surgery) and delayed recovery (taking 4 or more days to walk independently). As the mean targeted LOS is 4 days, 3 days was chosen as limit to reach functional independence.

Independent variables

Patients were screened preoperatively using conventional factors, the RAPT scale, and four performance-based tests. Conventional factors were age (in years), BMI (kg/m^2), sex, and comorbidity. The Charnley score was used to evaluate comorbidity in relation to levels of activity[20]: score A means single joint problems and no significant medical comorbidity that affects activity; B means multiple joint problems and no significant medical comorbidity that affects activity; and C means multiple joints in need of arthroplasty, or significant medical or psychological impairment that affects activity.

The RAPT score is derived from the six items in the RAPT questionnaire, namely, age, sex, ambulatory status, use of walking aids, community support (home help), and patient's choice to live with a caregiver following surgery.[10] The original test classified patients into three groups: low risk (score 10-12), medium risk (score 6-9), and high risk (score 0-5).[10]

The performance-based functional tests comprised the timed up and go (TUG) test, the 2 minutes' walk (2MW) test, hand grip strength (HGS), and habitual walking speed,

measured with the 10-meter walking test (10mW). The TUG and 2MW are valid measures of functional mobility, exercise capacity, and responsive outcome measures in older persons receiving rehabilitation.[21] The TUG test is recommended by OARSI[17] and scores correlate with functional recovery after THA.[22] The TUG test measures the domain of functional mobility. Participants were asked to rise from a chair, walk three meters, turn, return, and sit down, all as fast as possible. A lower score (in seconds) reflects better functional mobility. For the 2MW test we asked participants to walk as far as they could in 2 minutes using their customary walking aid. A higher score (in meters) reflects better exercise capacity. The HGS of both hands was measured using the Jamar dynamometer with the person seated in a chair with shoulders adducted and neutrally rotated and elbow flexed at 90°. Hand dynamometry is useful for determining functionality[23] and scores are associated with LOS.[24] The maximal grip score of three trials was used.[23] The 10mW test is a reliable and valid instrument to measure walking speed.[25] Patients were asked to walk 10 meters at their usual walking speed using their customary walking aid. Time was measured with a stopwatch in seconds. A higher score (in seconds) means a slower walking speed. HGS and walking speed are easy to measure and are valid indicators of frailty. Scores are linked with functional decline and disability.[26,27]

Statistics

The sample size was based on five events per variable.[28,29] Assuming that 20% of patients would be at risk of delayed recovery, the required sample would be 250 patients for 10 variables. The results of the performance-based tests were dichotomized with the best discriminatory point on a receiver operating characteristic (ROC) curve using independence in walking as outcome, based on the MILAS.[30] This is because the data were not normally distributed, because missing values could be interpreted as “negative” if people could not perform the test because of limited mobility, and because cut-off scores are useful in a practical setting.

The association between the individual independent variable and dependent variable was assessed using univariate logistic regression. The variance inflation factor (VIF, cut-off >10) and the correlation matrix (cut-off >0.8) were used to test for multicollinearity.[28] Multiple logistic regression analysis was used to determine the best predictors of inpatient recovery. First, all conventional factors – with a univariate p value of <0.10 – were entered in a backward stepwise regression model (p value for removal 0.157)[28] with recovery of function as the dependent variable. Second, RAPT scores were subsequently entered into the model together with the conventional factors, followed by performance-based test scores. Lastly, all factors were entered in the backward stepwise regression model to come to the final prediction model. Complete case analyses were used, and differences between the complete case group and the missing data group were tested, using t-test for age and Chi Square statistics for sex and surgical approach. Goodness of fit was tested with the Hosmer & Lemeshow test and Nagelkerke R^2 statistics. ROC curves were constructed with the logistic

regression model to assess their predictive value (area under the curve, AUC), and significance between the AUCs was calculated as the difference in performance between models. The possible interaction between surgical approach (i.e., posterolateral or anterior minimal invasive) and inpatient recovery of function was determined by entering this factor in the final model, to see if it changed the model's performance significantly (difference between AUCs).

We used SPSS Statistics 22 and Stata/IC 12.0 for all statistical analyses.

Results

Preoperative data of 330 patients and postoperative data of 315 patients (Table 3.1) were analyzed (in 12 cases, surgery was cancelled or delayed and in 3 cases Girdlestone surgery was performed because of infection). The mean time to recovery of function was 2.55 days (SD 0.87, n=297); 18 patients were not functionally independent before they were transferred to outpatient rehabilitation.

Table 3.1 Preoperative characteristics including all risk factors in 315 patients.

	n	
Age in years (mean, SD)	315	68.8 (11.0)
Sex (%female)	315	68.6
BMI (kg/m^2, mean, SD)	311	26.8 (4.0)
Approach	315	
Postero-lateral (%)		47.3
Anterior (%)		49.2
Revision (%)		3.5
Social status	315	
Living alone (%)		34.6
Living together (%)		65.4
Charnley score	315	
A (%)		57.1
B (%)		9.8
C (%)		33.0
TUG in seconds (mean, SD)	302	12.0 (6.2)
HGS in kg (mean, SD)	302	28.4 (12.4)
10mW in seconds (mean, SD)	302	11.2 (5.1)
2MWT in meters (mean, SD)	297	111.0 (32.8)
LOS in days (mean, SD)	315	4.1 (1.6)
Discharge (%rehabilitation)	315	18.7
Recovery of functioning >3 days (%)	315	14.9

TUG: Timed up and go test, HGS: Hand Grip Strength, 10mW: 10-meter walking test, 2MWT: 2 minutes walking test, LOS: length of hospital stay

Two-hundred and ninety-four cases were included (21 patients with missing data, Table 3.2) in the final model. The age (*P*=0.58), sex (*P*=0.95), and surgical approach (*P*=0.92) of patients with missing data were not significantly different from those of the

included patients. Twenty-one patients with missing data who had mobility restrictions or serious impairments were recorded as patients with a delayed recovery. ROC curve analyses generated the following cut-offs for delayed recovery of function (>3 days): TUG 10.5 s, 10mW 10.0 s, HGS 22 kg, and 2MW 105 m. For age continuous data were used, but 70 years was the cut off point. Although there was a strong correlation between TUG and 10mW (rho 0.75), scores did not exceed cut-off values for collinearity (VIF for TUG 2.60, for 10mW 2.34).

Univariate regression

Univariate logistic regression revealed that all factors (conventional, RAPT, and performance based) except sex were significantly associated with functional recovery. Odds ratios and relative risks are listed in Table 3.2. The logistic regression demonstrated that the odds increased by a factor of 15.01 with a 10mW over 10.5 s, by a factor 8.63 with a TUG over 10.5 s and by a factor 24.39 with a RAPT score of 0-5 compared to a score of 0-5. For age the odds increased by a factor of 1,13 as the age increased by one year, and when using age as a dichotomous factor, the odds increased a factor 9.47 when being over 70 years old.

Predictive value of conventional factors

Backward regression with the conventional factors yielded a model including higher age, higher BMI, and Charnley score (C) as contributing to delayed functional recovery (AUC=0.81 (95%CI 0.74-0.87)) (Table 3.2.).

Predictive value of conventional factors and RAPT

Backward regression with the conventional factors and RAPT score identified the same three conventional factors and RAPT score as contributing to delayed functional recovery. The inclusion of the RAPT score increased the model's predictive value: AUC 0.83 (95% CI 0.78-0.89), but not significantly (*P*=0.09) (Table 3.2.)

Predictive value of conventional factors, RAPT, plus performance-based tests

Addition of performance-based test scores to the model of conventional factors and RAPT identified older age, Charnley score C, a 10mW more than 10.0 seconds, and a TUG of more than 10.5 seconds as predictors of delayed recovery of function. The performance of the model (AUC 0.85, 95% CI 0.79-0.91) was better than that of the two other models, but only significantly better than the model with only conventional factors (*P*=0.04). The sensitivity of the model was 71.4% and the specificity 87.8%.

Table 3.2 Univariate and multivariate logistic regression analyses for associations between conventional factors, RAPT and performance based tests and recovery of functioning after total hip surgery.

			Univariate regression		CF [a] n=311	CF + RAPT[†] n=311	CF + RAPT + PBT[‡] n=290
			OR (95%CI)	RR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Conventional factors		n					
Sex	Female	315	1.10 (0.56-2.15)	1.07 (0.66-1.71)	X[††]	X	X
Age	Years	315	1.13 (1.08-1.18)*		1.14 (1.08-1.19)	1.09 (1.03-1.15)	1.08 (1.03-1.13)
BMI [§]	Kg/m^2	311	1.09 (1.01-1.17)*		1.10 (1.02-1.20)	1.10 (1.01-1.20)	X
Charnley score	A	315	reference	reference	reference	reference	reference
	B		1.42 (0.44-4.54)	1.06 (0.85-1.31)	1.79 (0.52-6.16)	1.81 (0.51-6.43)	2.14 (0.56-8.17)
	C		3.20 (1.64-6.24)*	1.71 (1.17-2.50)	2.93 (1.41-6.10)	2.42 (1.14-5.16)	2.41 (1.07-5.44)
RAPT		315					
RAPT score	10-12		reference	reference		reference	X
	6-9		8.40 (2.47-28.57)*	1.79 (1.50-2.15)		4.39 (1.18-16.30)	X
	0-5		24.39 (6.76-90.91)*	4.18 (2.93-5.95)		6.46 (1.48-28.16)	X
Performance based tests							
10mW[‖]	>10.0 sec	313	15.01 (5.24-43.03)*	6.85 (2.67-17.58)			4.19 (1.22-14.40)
TUG	>10.5 sec	311	8.63 (3.72-20.01)*	3.99 (2.01-7.95)			2.74 (0.92-8.17)
2MW	<105 meters	310	7.04 (3.33-14.87)*	3.01 (1.73-5.23)			X
HGS	<22.0 kg	302	4.53(2.32-8.83)*	1.92 (1.31-2.80)			X
Goodness of fit							
Nagelkerke's R^2					0.28	0.31	0.35
AUC (95%CI)					0.81 (0.74-0.87)	0.83 (0.78-0.89)	0.85 (0.79-0.91)
Hosmer-Lemeshow test					10.09 (*P*=0.26)	4.28 (*P*=0.83)	11.13 (*P*=0.19)
Difference in AUC compared with CF-model						Chi^2 2.94 (*P*=0.09)	Chi^2 4.11 (*P*=0.04)
Difference in AUC compared with CF/RAPT-model							Chi^2 0.64 (*P*=0.42)

[*] *P*<0.05, [a] CF= Conventional factors, RAPT= Risk Assessment and Predictor Tool, BPT= Performance based tests, BMI= Body mass index, 10mW=10 meters walk test, TUG= Timed up and go test, 2MW= 2 minutes' walk test, HGS= Hand Grip Strength, X=factors that were removed from the model after logistic regression (*P*<0.157).

Subanalyses

Exclusion of TUG scores from the final model (because of the high correlation with 10mW) resulted in a model with the factors age, Charnley score, 10mW, and HGS (R^2 0.34, AUC 0.85, 95% CI 0.78-0.91).

Surgical approach (OR 3.72, 95% CI 1.80-7.69) was significantly associated with time to recovery, with more patients having a normal recovery time (<4 days) if they underwent minimally invasive surgery with via the anterior approach rather than surgery via the posterolateral approach. Inclusion of surgical approach as a categorical variable improved the predictive value of the model (R^2=0.42, AUC=0.88, 95% CI 0.83-0.92).

Discussion

In this cohort study we found that a combination of conventional factors (i.e., old age (>70 years) and comorbidity (Charnley score C)) and performance based tests (i.e., low functional mobility (TUG>10.5 s) and slow walking speed (10mW>10.0 s)) predict recovery of function after THA best. The RAPT did not significantly improve the ability of conventional factors (older age, greater BMI, disabling comorbidity) to predict inpatient recovery of function after THA.

There have been few studies of the association between preoperative factors and inpatient functional recovery; most studies have focused on the time spent in hospital.[8] Unnanuntana *et al.* also found that older age (β Coefficient Unstandardized −1.947, 95% CI −3.407 to −0.488) and higher BMI (−2.606, 95% CI −5.183 to −0.03) were significantly associated with inpatient functional recovery (in their study measured as the distance walked on the day of discharge). However, we did not replicate their finding that women are at greater risk of delayed inpatient recovery.[31] This discrepancy might be because women may have had a greater disability[32] and therefore sex was a predictor by absence of measures of functioning. To our knowledge, no studies have investigated the predictive value of the combination of conventional factors, RAPT score, and performance-based measures on inpatient functional recovery. Our data show that preoperative function is a strong independent predictor of inpatient recovery. The RAPT score is probably more appropriate for predicting discharge destination,[9,10,12] because factors such as 'community support' and 'informal care' have a heavy weighting in the total score but are of less relevance to functional recovery. The RAPT assesses self-reported functioning, which is a very different construct from observed functioning.[16–18] One study investigating the predictive capacity of performance-based tests on inpatient recovery after THA also found that poor preoperative functional mobility (as measured with the TUG) was predictive of delayed discharge (more than 3–5 days).[34] Considering our findings in relation to currently available literature, we conclude that measures of preoperative physical function can

be used to make treatment decisions and to monitor the physical function of individual patients in clinical practice and as predictors and outcome measures in research.[17,27]

Surprisingly, HGS was not an independent predictor of inpatient functional recovery. It has repeatedly been proposed as potential screening tool for frail older patients at high risk of adverse surgical outcomes.[26,35] Shyam Kumar *et al*. found that patients with an HGS less than 15 kg stayed in hospital longer than patients with an HGS of 15 kg or more (10.8 versus 9.2 days, respectively).[24] They also found HGS to be is associated with recovery after THA in univariate analyses.

We found surgical approach to be associated with the speed of functional recovery after THA. A-priori we did not select surgical approach as an independent predictor of inpatient functional recovery, since studies comparing minimal and standard invasive THA typically yield inconclusive findings regarding the best approach.[36,37] We found that recovery time tended to be shorter with the minimally invasive anterior approach. Other studies comparing surgical approaches found minimal differences in LOS but no differences in self-reported function.[45,46] Furthermore, performance-based physical function has not been studied yet as an outcome to compare different surgical approaches. Inpatient recovery of function is probably a more relevant outcome than LOS, as it is not influenced by logistic factors. Most of the anterior procedures were performed by a single orthopedic surgeon, which could contribute to the predictive value.[38] Future studies might need to account for surgical approach combined with surgeon volume in their prediction models.

Our findings suggest that older patients with a poor functional performance before surgery and with comorbidity are at risk of delayed inpatient functional recovery after THA. This finding is in line with the work of Hawker *et al*., who demonstrated that patients, especially those with more comorbidity, had poor outcomes in terms of pain and functioning.[4] Knowing which people need more time to recover could help to plan discharge and rehabilitation accurate. For those at risk postoperative inpatient rehabilitation could be planned in advance, however home rehabilitation is preferable in most cases. Oldmeadow et al. demonstrated that targeted postoperative care can improve outcomes and can result in more patients being discharged home.[9] Furthermore therapeutic exercise before surgery could improve functional performance before surgery for those with a low walking speed and high TUG scores. Several studies have demonstrated that the identification of patients at high risk and therapeutic exercise for these patients can increase the success of THA, reduce LOS,[39,40] and reduce costs in the postoperative phase.[41] We have previously demonstrated that an intensive functional exercise program at home before THA is feasible for these high-risk elderly patients.[42]

Study limitations

The prediction model is based on data from a single center. To increase generalizability, the model will need internal and external validation and an impact analysis,[6] preferably in a multicenter study, with optimal organization of THA pathways. Furthermore, the

physical therapists who assessed functioning before surgery in many cases also assessed functional recovery after surgery, which could influence the intervention or outcome measures. We believe this potential bias was minimal because all patients were treated according to the same protocol, which aimed to progressively increase patients' independence in walking, based on their ability. We did not include personal factors like coping and expectations, but these could have an impact on recovery after THA.[43,44]

Conclusions

The current emphasis of care pathways is to minimize LOS and to discharge patients to a rehabilitation setting.[2] This necessitates a quick and full recovery of function while patients are in hospital.[5] The results show that preoperative performance-based tests can be used to predict postoperative recovery of function after THA. Older patients with comorbidity and poor functional performance before surgery are at risk of delayed recovery. With two easy and quick tests (TUG and 10mwt) added to a more conventional screening with age and the Charnley score, we can select those risk patients, which enables us to start timely pre- and postoperative targeted interventions and accurate discharge planning. These interventions could result in more patients being discharged to their home and a shorter LOS.

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4

The influence of muscle weakness on the association between obesity and inpatient recovery from total hip arthroplasty

Oosting E
Hoogeboom TJ
Dronkers JJ
Visser M
Akkermans RP
van Meeteren NLU

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Abstract

Background
There is ongoing discussion about whether preoperative obesity is negatively associated with inpatient outcomes of total hip arthroplasty (THA). The aim was to investigate the interaction between obesity and muscle strength and the association with postoperative inpatient recovery after THA.

Methods
Preoperative obesity (body mass index (BMI)>30 kg/m^2) and muscle weakness (hand grip strength <20 kg for woman and <30 kg for men) were measured about 6 weeks before THA. Patients with a BMI<18.5 kg/m^2 were excluded. Outcomes were delayed inpatient recovery of activities (>2 days to reach independence of walking) and prolonged length of hospital stay (LOS, >4 days and/or discharge to extended rehabilitation). Univariate and multivariable regression analyses with the independent variables muscle weakness and obesity, and the interaction between obesity and muscle weakness, were performed and corrected for possible confounders.

Results
297 patients were included, 54 (18%) of whom were obese and 21 (7%) who also had muscle weakness. Obesity was not significantly associated with prolonged LOS (odds ratio (OR) 1.36, 95% confidence interval (CI) 0.75-2.47) or prolonged recovery of activities (OR 1.77, 95% CI 0.98-3.22) but the combination of obesity and weakness was significantly associated with prolonged LOS (OR 3.59, 95% CI 1.09-11.89) and prolonged recovery of activities (OR 6.21, 95% CI 1.64-23.65).

Conclusions
Obesity is associated with inpatient recovery after THA only in patients with muscle weakness. The results of this study suggest we should measure muscle strength in addition to BMI (or body composition) to identify patients at risk of prolonged LOS.

Introduction

Orthopedic surgeons have expressed their concern about the medical management and negative functional outcomes of total hip arthroplasty (THA) in people who are obese.[1,2] There is debate about whether preoperative obesity is negatively associated with the outcomes of THA.[3,4] While some studies have shown that obesity is indeed a risk factor for postoperative complications,[3,5] longer operation time,[6] longer length of hospital stay (LOS),[6,7] and higher hospital costs,[6] other studies have demonstrated that obese individuals benefit as much as nonobese individuals from THA in terms of physical function.[8–11]

Perhaps the way obesity is classified in the literature explains why results are conflicting. Obesity is usually defined in terms of the body mass index (BMI),[12] which may be too simplistic because BMI does not provide information about body composition (i.e., fat mass and fat-free mass) or function. Patients who are both obese and weak fulfill criteria for the obesity/muscle impairment syndrome,[13] which is linked to the sarcopenic obesity phenotype.[14] This phenotype is associated with a higher risk of functional decline and other negative health outcomes, mainly in older people.[13–15] Although muscle mass is used to define sarcopenia,[14] some studies support the use of field-based measurements such as handgrip strength (HGS),[16,17] because muscle strength may be a better predictor of clinical outcomes than muscle mass.[18,19] Furthermore, HGS is associated with inpatient outcomes after THA[20] and is a performance-based measure to detect frailty before surgery.[21]

We therefore hypothesized that patients with obesity and muscle weakness are at higher risk of poor outcomes (in terms of recovery of activities and LOS) after THA than those with normal muscle strength. The aim of this study was to investigate whether the association between obesity and postoperative inpatient recovery of activities and LOS after THA is modified by muscle strength, measured by HGS.

Materials and methods

Study population

For this study, we used data from a prospective cohort study.[22] Preoperative data from all people scheduled for THA surgery at the Gelderse Vallei Hospital between January and November 2012 were collected during regular clinical screening by a physical therapist. Underweight individuals (BMI<18.5) were excluded. Surgery was performed by an anterior or posterolateral approach. The use of a general vs spinal anesthesia was at the discretion of the anesthesiologist and patient. All patients received usual care, consisting of preoperative recommendations to maintain or improve activities before surgery and postoperative inpatient rehabilitation once or twice a day, starting within 24 h of surgery, with the intention to progressively improve walking ability, based on

the individual patient's progress on functional milestones measured with the Modified Iowa Levels of Assistance scale (MILAS).[23] All patients were expected to ambulate as soon as possible, using an aid if necessary. We collected data on the routine preoperative assessment from the patient medical records. Use of clinical data was approved by the local medical ethics committee of Gelderse Vallei Hospital. This study is reported in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) statement.

Dependent variable

The primary outcomes were recovery of activities and LOS after THA. Delayed recovery of activities was defined as taking more than 2 days (the median score) to reach independence in walking (to the toilet) with a walking aid, measured with the Modified Iowa Levels of Assistance scale. LOS was dichotomized, with prolonged LOS being defined as a hospital LOS longer than 4 days (the targeted LOS in the pathway) or discharge to inpatient rehabilitation. Patients were discharged from hospital in consultation with their caregivers, surgeon, and physical therapist, based on the following criteria: the ability to walk independently with a walking aid and, if necessary, climb stairs, being in a stable medical condition, and adequate wound healing.

Independent variables

BMI was dichotomized into nonobese (normal weight or overweight, BMI between 18.5 and 30.0 kg/m^2) and obese (≥30.0 kg/m^2),[24] a classification often used in the orthopedic literature (3). HGS was measured as an estimate of general muscle strength.[14,25]. HGS of both hands was measured using the Jamar® dynamometer with the person seated in a chair with shoulders adducted and neutrally rotated and elbow flexed at 90°.[25] The maximal grip score of 3 trials was used.[25] Muscle strength was dichotomized into weakness or no weakness, using the cut-off point defined by the European Working Group on Sarcopenia in Older People,[14] which is <30 kg for men and <20 kg for women.

Age, comorbidity, and physical function were recorded as patient characteristics. The Charnley score was used to evaluate comorbidity in relation to 3 global levels of activity[26]: score A means single joint problems and no significant medical comorbidity that affects activity; B means multiple joint problems and no significant medical comorbidity that affects activity; and C means multiple joints in need of arthroplasty, or significant medical or psychological impairment that affects activity.

Statistical analysis

Data were used from another cohort study which was initially powered for 250 patients.[22] Descriptive statistics were used to describe the characteristics of the total study population and of the four subgroups: nonobese/no weakness, obese/no weakness, nonobese/weakness, and obese/weakness.

Univariate logistic regression was used to assess the association between the independent variables and postoperative recovery. Thereafter multivariable logistic regression with obesity, weakness, and the interaction obesity*weakness was performed. Significance was set at $P<0.05$. The interaction was adjusted for the following confounders: age, gender and comorbidity (Charnley score). If the inclusion of potential confounding variables in the model caused the interaction to change by 10% or more, the additional variables were considered relevant confounders.[27] After studying the relevance of the interaction obesity*weakness, we calculated adjusted odds ratios for the four subgroups as a categorical variable, with nonobese/no weakness as reference variable to show the differences between the 4 subgroups (descriptive). We used SPSS Statistics 22 for all statistical analyses.

Results

Of the 315 patients screened preoperatively, 2 were excluded because they were underweight (BMI<18.5 kg/m^2) and 16 had missing data (BMI in 4 patients (1.3%) and HGS in 13 patients (4.1%)). Data on postoperative outcomes were not missing. A complete case analysis was performed, using the pre- and postoperative data of 297 patients (Table 4.1).

Overall, 105 patients (35%) had a normal weight and 138 (47%) were overweight (BMI>25 kg/m^2 and <30 kg/m^2). Forty-four patients (15%) had class 1 obesity (BMI>30 kg/m^2), six (2%) class 2 obesity (BMI>35 kg/m^2), and four (1%) class 3 obesity (BMI>40 kg/m^2). All patients with class 3 obesity had delayed recovery of activities and 2 of them a prolonged hospital stay. Muscle weakness was present in 99 patients (33%), 76 (77%) of whom were women. Of the 21 patients with both obesity and weakness, 18 (86%) had delayed functional recovery and 16 (76%) had prolonged LOS (Table 4.2).

Half (n=149) of the operations were performed using a posterolateral approach and half (n=148) an anterior minimally invasive approach. More people in the posterolateral group than in the anterior group had a delayed recovery of activities (57% vs. 34%, $P<0.05$) or a prolonged LOS (54% vs. 23%, $P<0.05$). In the posterolateral group, 14 patients (9.4%) had both obesity and weakness, 12 (86%) of whom had a delayed recovery of activities and 11 (79%) a prolonged LOS. In the anterior group, 7 patients (4.7%) had both obesity and weakness, of whom 6 (86%) had a delayed recovery of activities and 5 (71%) a prolonged LOS.

Table 4.1 Preoperative characteristics.

	Non-obese[a]		Obese[b]		Total
	No weakness[c]	Weakness[d]	No weakness[c]	Weakness[d]	
	n=165	n=78	n=33	n=21	n=297
Age, mean (SD)	66 (12)	74 (10)	65 (8)	74 (10)	69 (11)
Gender (female), n (%)	104 (63)	59 (76)	22 (67)	17 (81)	201 (68)
BMI (kg/m2), mean (SD)	25.4 (2.3)	25.3 (2.3)	33.3 (3.2)	33.2 (3.8)	26.8 (4.0)
HGS (kg), mean (SD)	34.3 (11.1)	17.3 (5.6)	33.5 (8.9)	15.3 (6.1)	28.4 (12.4)
Comorbidity					
Charnley A/B, n (%)	128 (78)	45 (58)	20 (61)	8 (38)	201 (68)
Charnley C, n (%)	37 (22)	33 (42)	13 (39)	13 (62)	96 (32)
Ten-meter walk test (sec), mean (SD)	9.7 (3.0)	12.3 (4.6)	11.3 (4.3)	14.5 (5.4)	10.9 (4.1)

SD, standard deviation, BMI= body mass index, HGS= handgrip strength, a BMI<30.0 kg/m^2, b BMI>30.0 kg/m^2, c HGS ≥30 kg for men and ≥20 kg for women, d HGS <30 kg for men and < 20 kg for women

Table 4.2 Postoperative outcomes .

	Non-obese[a]		Obese[b]		Total
	No weakness[c]	Weakness[d]	No weakness[c]	Weakness[d]	
	n=165	n=78	n=33	n=21	n=297
Prolonged LOS, n (%)	50 (30)	40 (51)	8 (24)	16 (76)	114 (38)
Delayed recovery of activities, n (%)	58 (35)	47 (60)	13 (39)	18 (86)	136 (46)
LOS, mean (SD)	3.9 (1.6)	4.4 (1.3)	4.0 (1.7)	4.9 (1.7)	4.1 (1.6)
Discharge home, n (%)	148 (90)	55 (71)	32 (97)	10 (48)	245 (83)

SD, standard deviation, LOS= length of hospital stay in days, [a] BMI<30.0 kg/m^2, [b] BMI>30.0 kg/m^2, [c] HGS ≥30 kg for men and ≥20 kg for women, [d] HGS <30 kg for men and <20 kg for women

Univariate regression

Univariate logistic regression showed that obesity was not significantly associated with a delayed recovery of activities (OR 1.77, 95% CI 0.98-3.22, *P*=0.06) or with a prolonged LOS (OR 1.36, 95% CI 0.75-2.47, *P*=0.31), whereas weakness was significantly associated with a delayed recovery of activities (OR 3.42, 95% CI 2.06-5.67, *P*=0.00) and a prolonged LOS (OR 3.14, 95% 1.90-5.19, *P*=0.00).

Multivariate regression

Multivariable logistic regression with three variables (obesity, weakness, and the obesity*weakness interaction) showed that the obesity*weakness interaction was significantly associated with a prolonged LOS (Table 4.3). After correction for possible confounders, the obesity*weakness interaction was still significant and relevant as the B-coefficient changed less than 10% (Table 4.3). Table 4.4 shows the adjusted odds ratios for the four subgroups of delayed recovery of activities and prolonged LOS (Table 4.4.)

Table 4.3 Logistic regression model for the association between obesity, weakness, and the interaction obesity*weakness and delayed recovery of activities and prolonged hospital stay.

	Crude Model			Adjusted Model[a]		
	B-coef	*P*-value	OR (95%CI)	B-coef	*P*-value	OR (95%CI)
Prolonged hospital stay						
Obesity	-0.307	0.486	0.74 (0.31-1.74)	-0.456	0.351	0.63 (0.24-1.65)
Weakness	0.884	0.002	2.42 (1.39-4.22)	0.116	0.662	1.17 (0.62-2.23)
Obesity*Weakness	1.418	0.046	4.13 (1.02-16.69)	1.574	0.048	4.83 (1.02-22.95)
Delayed recovery of activities						
Obesity	0.182	0.643	1.20 (0.56-2.58)	0.073	0.863	1.08 (0.47-2.46)
Weakness	1.029	0.000	2.80 (1.61-4.87)	0.496	0.112	1.64 (0.89-3.03)
Obesity*Weakness	1.194	0.122	3.30 (0.73-14.99)	1.257	0.124	3.52 (0.71-17.44)

[a]Corrected for age, gender, comorbidity (Charnley score) and type of surgery (anterior vs. posterior).

Table 4.4 Adjusted odd ratios for prolonged hospital stay and delayed recovery of activity.

	Non-obese[a]		Obese[b]	
	No weakness[c]	Weakness[d]	No weakness[c]	Weakness[d]
	n=165	n=78	n=33	n=21
Prolonged hospital stay	ref	1.17 (0.62-2.23)	0.63 (0.24-1.65)	3.59 (1.09-11.89)[e]
Delayed recovery of activities	ref	1.08 (0.47-2.46)	1.64 (0.89-3.03)	6.21 (1.64-23.65)[e]

All odds ratios were adjusted for age, gender and comorbidity (Charnley score). [a] BMI<30.0 kg/m^2, [b] BMI>30.0 kg/m^2, [c] HGS ≥30 kg for men and ≥20 kg for women, [d] HGS <30 kg for men and <20 kg for women, [e] *P*<0.05.

Discussion

As hypothesized, we found that there is an interaction between muscle strength and BMI. The combination of weakness and obesity, which could be linked to sarcopenic obesity, was associated with delayed inpatient recovery after THA. People with both muscle weakness and obesity had a higher risk of delayed recovery of inpatient activities or a LOS longer than 4 days after THA than did people without obesity and muscle weakness or people with only muscle weakness or only obesity.

We did not find obesity to be associated with outcomes after THA. In contrast, many studies have reported obesity to be associated with a higher risk of longer LOS, but this was the case for patients with morbid obesity.[3,6,7,9] We did not do a subgroup analysis for the morbidly obese group (BMI>40) because there were only 4 patients in this group. Although these patients had a delayed recovery of activities, we did not find a significant association between obesity and recovery of activities. Two earlier studies reported that a higher BMI was associated with a worse inpatient recovery of function.[28,29] Unnanuntana et al.[29] used walking distance at discharge as outcome, which is not directly related to achieving functional milestones and LOS, but it may be more sensitive to differences between patients. Some studies have suggested that obesity is associated with a better survival and long-term outcomes after surgery.[30,31]

These somewhat counterintuitive findings are often described as the “obesity paradox”.

To the best of our knowledge, this is the first study to investigate the combination of obesity and muscle strength as a predictor of THA outcomes. In cardiac surgery, Visser et al.[32] found that the presence of sarcopenic obesity (i.e., low fat free mass and high fat mass, measured with bioelectrical impedance) was associated with a higher risk of infections after surgery. We did not have data on infections, but the presence of infections or prolonged wound healing, which could affect LOS, might explain the association between the sarcopenic obesity phenotype and prolonged LOS.

A potential limitation of this study is the way in which we defined obesity and muscle weakness. Although the use of muscle mass is recommended to define sarcopenia,[14] we used HGS, a simple field-based performance measure, a choice supported by other studies.[16–18] Another option would be to measure lower extremity muscle function. Although lower extremity muscle function is more relevant than handgrip strength for gait and physical function, handgrip strength has been widely used, is well correlated with relevant outcomes,[14] and is less influenced by limb pain. Moreover, it is a practical assessment in daily practice and, like muscle weakness, it is an indicator of undernutrition.[33] Undernutrition is defined as a state of nutrition in which primarily a deficiency of energy and/or protein causes measurable adverse effects on body composition, function, and clinical outcomes.[34] Thus it is possible that the obese patients with muscle weakness in our study were undernourished, which would not have been identified by measuring the BMI alone. We used BMI to define obesity, but this measure does not provide information about body composition. For example, patients with a normal BMI may still have a relatively high fat mass. This could explain the lack of an association between obesity and outcomes in our study. Ledford et al. found that a higher percentage of body fat, measured by bioelectric impedance, was associated with an increased LOS and a higher rate of discharge to an extended care facility, whereas they did not find an association with BMI alone.[35]

This study only highlighted obesity and the interaction with muscle weakness as a relevant risk factor for delayed recovery after THA and was not well enough powered to study several other relevant interactions. Type of surgery might be an interesting confounder as patients with the anterior approach seems to have a shorter LOS.[36] However the advantages of the anterior approach are not yet obvious and the success of type of surgery is often biased by patient selection (obese patients are often excluded from this approach) and preferences and experience of the surgeon.[37] For these reasons and because of the limited size of the groups after stratification, we did not analyze the differences in results between the anterior and posterior group in our study. We did correct for age, sex and comorbidity as confounders as these are also associated with body composition and predictors of recovery THA.[12,22] Elings et al. found that for the prediction of LOS there was a strong level of evidence for the American Society of Anaesthesiologists score, number of comorbidities, and presence

of heart or lung disease.[12] In future research all the above factors should be investigated in a large study on their consistency, interactions and relevance.

The identification of patient characteristics associated with outcomes after THA would make it possible to develop a personalized risk assessment and to devise interventions to reduce postoperative risks and to improve functional outcomes.[38] We should probably not ask all obese patients to lose weight before THA, but instead emphasize the importance of exercises to improve muscle strength for individuals with obesity and muscle weakness. Weight loss, or even bariatric surgery, is often advised prior to THA, but there is limited evidence to support this recommendation.[39,40] Losing weight may even promote sarcopenia as a result of the loss of muscle mass.[16] Probably the most optimal intervention is a combination of a nutritional intervention and exercise training.[16,38,41] To develop a tailored preventive intervention, we need more knowledge about the underlying (physiological) mechanism of the synergistic effect of obesity and muscle weakness on adverse outcomes after THA. As we used only LOS and inpatient functional recovery as outcomes, we cannot draw conclusions about the association between obesity/weakness and postoperative complications or long-term activities. Therefore, future studies should focus on these important topics.

Conclusions

With the growing number of obese people and the number of THAs,[1] there is a need for a better understanding of the association between obesity and adverse outcomes after THA. We found that not obesity but instead the interaction between obesity and muscle weakness was associated with delayed inpatient recovery after THA. Measurements of muscle strength should be considered in the preoperative assessment of obese patients beyond simple calculation of BMI in order to identify patients who are at risk of a prolonged LOS after orthopedic surgery.

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5

Personal meaning in relation to daily functioning of a patient in physical therapy practice

Oosting E
Dronkers J
Hoogeboom T
van Meeteren N
Speelman W-M

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Abstract

Purpose
To get insight into personal meaning of a person involved in a physical therapy intervention.

Methods
Mrs. A, a 76-year-old woman is referred to a physical therapist (PT) for assessment of functioning and training before total hip arthroplasty (THA). The patient, her daughter and PT were asked to write a story about their daily life. Stories were analyzed according to the narrative scheme based on a method to find meaning in daily life, which consists of four phases: 1.Motivation; 2.Competences; 3.Performance; and 4.Evaluation.

Results
Mrs. A was mainly motivated by her will to do enjoyable social activities and stay independent. Although she tried her best to undertake activities (performance) that made her proud (evaluation), her pain and physical limitations were anti-competences that motivated her to attend healthcare. Although the PT seemed to be aware of personal participation goals, her main motivation was to improve and evaluate functions and activities. The daughter was motivated by good relationships and did not see herself as informal caregiver.

Conclusions
The narrative method was a valuable tool to clarify motivations, competences and values in the process of creating personal meaning related to functioning. This knowledge could help caregivers in applying patient centered goal setting and treatment on a participation level.

Background and purpose

Healthcare is changing. There is a shift from treating disease toward managing daily functioning and disease in the light of patients' values, choices, and decisions.[1,2] This requires not only a different approach to therapy, but also a new method to assess the impact of disease and its treatment on the person's life. Although patient-reported outcome measures (PROMs) can be used to determine the impact of a disease (and its treatment) on patients' lives,[3] these instruments are often generic and lack information about the ICF component "personal factors".[4] Yet personal factors, such as mental function, quality of life, social participation, and spirituality, are important components in a new conceptualization of health – the ability to adapt and self-manage in the face of social, physical, and emotional challenges.[5] Personal meaning is an aspect of spirituality and addresses questions as "What is worth living for, for you?" and "What is the purpose in life for you?" and is considered to be a key factor in the buffering of stress, in the enhancement of physical, psychological, and mental well-being; and is the key factor in the motivation and the performance of the patient.[6] Personal meaning is very important to patients but tend to be undervalued by caregivers.[7] Creating meaning in one's life is about realizing values that are important for each individual on one's own close context and in society at large. Being motivated to reach those values by obtaining competences is part of the process of creating a meaningful participation. Physical therapists (PTs), but also family members, may probably at best guide people with disabilities during their recovery of functioning by focusing on meaningful participation goals chosen by the disabled persons themselves.

While quantitative instruments measuring spirituality or meaning have limited value in measuring the current spiritual state of people,[8] a qualitative analysis of spirituality could help to assess individual meaning given to life. A qualitative method was developed by Speelman to identify a person's motivations, competences, and values within the meaning of life, based on their narrative of everyday life.[9–11] Narrative approaches have been successfully used before to retrieve relevant information regarding meaning and values in people with serious illness,[12–14] but tend to focus on people with a life-threatening illness and on patient stories solely. Like other persons the patient is not an individual on his own, but always a person with a personal meaning in the context of his relations. As family and care professionals are closely involved in rehabilitation, they may also have a role in the motivations or competences in the process of personal meaning.

Therefore, the purpose of this study was to gain insight into personal meaning in relation to daily functioning of a person receiving physical therapy prior to total hip arthroplasty (THA) by use of narrative of the patient in relation to the narratives of a close family members and her PT.

Case description

Patient information

Mrs. A. was selected as a purposive sample, as the aim was to include a patient from our daily practice with severe problems in daily functioning. Mrs. A, 76 years old, with cardiac and musculoskeletal comorbidity (Table 5.1), suffered from progressive pain and functional limitations. Hip osteoarthritis was confirmed by X-ray, but because Mrs. A had a history of severe muscle and joint pain, degenerative changes of the back, and breast cancer, she was first referred to a rheumatologist and for a bone scan to rule out other diagnoses. The patient and the orthopedic surgeon agreed to schedule total hip arthroplasty (THA) for 2015.

Permission to perform the case study was given by the local research committee of Hospital Gelderse Vallei (BC/1312-685). The patient, her daughter, and the primary care PT provided their written informed consent.

Table 5.1 Patient characteristics: measurements and information of the preoperative assessment (see supplementary material 5.1. for detailed information about the tests, questionnaires and references).

	Domain	Measurement	Score
General PROM	Quality of life	EQ-5D	22222
		EQ-5D VAS (self-rated health) (range 0-10)	5.5
	Pain	NPRS at rest (range 0-10)	3
		NPRS during activity (range 0-10)	7
Disease specific PROM	Physical function	HOOS-PS personal interval score (range 0-100)	50.8
	Function and pain	Oxford hip score (range 12-60)	22
Performance based measurements	Functional mobility	Timed up and go (in seconds)	16.75
	Walking capacity	2 minutes' walk test (in meters)	95
	Walking speed	10 meters walk test (in seconds)	10.18
Patient specific complaints	Bed transfers	Limitation in activity (in mm, range 0-100)	60
	Walking to town		60
	Cycling		80
Risk screening	Comorbidities	ASA (I-VI)	III
		Charnley score (A-C)	C
		Musculoskeletal: Fibromyalgia, polyarthritis, THA (right side, 2011) degenerative lumbar deviations (lumbar laminectomy 2012)	
		Cardiac: PTCA (1995, 2000, 2011), CABG (2007)	
		Other: mamma carcinoma with surgery and radiotherapy (2011)	
	Geriatric risk screening	ISAR (0-6)	3

Table 5.1 (continued)

Additional anamnesis by the primary care PT	
Activities	Mrs. A. is independent, but limited, in transfers and walking. She fell a few times last year. Indoors she uses 1 crutch, outdoors she uses a walker. Walking distance is limited to a walk to the shops (about 600m) but because of progression in pain and fatigue, she avoids doing it. She bought an electric bike a few years ago but because of a fall she no longer dares to cycle.
Participation	Mrs. A. is doing the shopping by herself with help of her 89-year-old neighbour. Light housework and cooking is done by herself and she has a domestic help once a week. She is able to drive her car to her (grand)children and does some social activities with other residents like serving coffee and recreational activities.
Environmental factors	Mrs. A. lives in an adapted apartment with a raised toilet and bed, brackets and an elevator. She doesn't want to ask her children for informal care, although her daughter wants to help her if necessary.
Personal factors	Mrs. A. experiences pain and fatigue and she is not sleeping well. She uses pain medication every day. Mrs. A. finds it difficult to handle with her functional decline, but is nevertheless positive and active in life. She lived 18 years in the tropics and has been through a lot. She says this made her strong: she is not easily scared and is used to find solutions during hard times

PROM= patient reported outcome measure, EQ-5D= EuroQol five dimensions questionnaire, NPRS=numeric pain rating scale, HOOS-PS= Hip disability and Osteoarthritis Outcome Score – Physical Function Shortform, ASA = The American Society of Anesthesiologists score, ISAR= Identification of senior at risk, THA= total hip arthroplasty, PTCA= percutaneous transluminal coronary angioplasty, CABG= Coronary artery bypass grafting.

Preoperative assessment

Mrs. A was eligible for THA on the basis of a standard preoperative assessment by an anesthetist, nurse, and PT. Screening for general PROMs, disease-specific PROMs, functional measures, and risk factors was performed (Table 5.1 and Supplementary Material 5.1). The patient had moderate functional limitations and a poor quality of life and functional mobility. Because of her severe systemic disease (American Society of Anesthesiologists [ASA] classification III), history of mild cognitive problems (she consulted a geriatrician once who made the diagnosis: amnestic mild cognitive impairment, probably based on mood- and acceptance problems) and falling, and with an Identification of Seniors at Risk (ISAR) score of 3, she was considered at risk of complications during hospitalization[15] and of a poor recovery of activities in the clinical period.[16] As Mrs. A preferred to convalesce at home after surgery, her social status and living situation (living alone in a senior apartment without stairs) were discussed with a social worker and home care was planned in advance. Surgery was planned in 2.5 months. The hospital physical therapist (PT) and patient discussed how to prepare optimally for discharge home, agreeing on a preoperative training program to decrease the risk of delayed recovery and to prepare for discharge home.[17,18] Another PT carried out the preoperative training program and took her history to gain more insight into her activities, participation, and personal and environmental factors (Table 5.1). The Patient Specific Complaints questionnaire is a feasible tool to support patient participation in the physiotherapy goal setting and was used to determine treatment goals and evaluate limitations in physical activities relevant for her functioning. With

this questionnaire the patient listed three activities that were very difficult or impossible, but important, for her: walking to town with a rollator (30 minutes), bed transfers, and cycling.[19]

Personal meaning in THA rehabilitation

Preparing for and recovering from surgery is a complex construct, and many older patients experience personal and contextual barriers on their road to better functioning.[20–22] Spiritual coping styles may be used by patient in the rehabilitation process and meaning and values may even change during the process.[23] The preoperative assessment identified a number of personal factors, related to personal meaning, that could influence the recovery during and following hospitalization and return to participation in activities.[22] For example it seems that Mrs. A. tries to maintain a positive outlook but she also has some problems to accept her limitations (Table 5.1). Maintaining a positive mental attitude facilitates a successful discharge home and the confidence to increase independence and participation.[21,22] Communication, information, the social context and the role of family members are very important in the rehabilitation process but may be experienced different between the involved individuals.[20,21] For example, family members provide social and emotional support, but on the other hand having family providing care in the home is not always without tension.[21,24] Therefore, insight in the perspective of family and health professionals (as part of the context) may be very helpful in the rehabilitation process.

To gain deeper insight into personal meaning of the patient within her context, we performed a narrative analysis with stories of the patient, a close family member and the PT.

Methods

The patient was interviewed with an open starting question: “The physiotherapist came last week: can you tell me about it?” at her own residence, because she found it difficult to describe her day in writing. The interviewer interrupted as little as possible and used only non-verbal or paralinguistic encouragements in order to let the patient tell her own story.[25] After the open starting question, we only had one additional question during the interview about her expectations about the PT. As Mrs. A. kept telling her own story, we did not have to add more questions. The interview lasted about 45 minutes and was transcribed from the tape recording. The patient’s daughter and her PT were asked to describe, in writing, their day (what happened, their thoughts) on one of the days the patient had physical therapy: “Just write down a story (one or two sides) about the functional problems or physical therapy of Mrs. A”. The PT was a 45-year-old woman with more than 15 years of professional experience who had trained to provide intense functional exercise training for elderly people at home. The

daughter lived in a town nearby with her husband and four children. She and her adolescent children may be informal caregivers. The participant were informed about the study details and given assurance about ethical principles, such as confidentiality. The stories of Mrs. A, her daughter and PT can be found as supplementary material.

A native speaker translated all stories. The stories were analyzed by two researchers (and authors of this manuscript) using the a narrative method[9–11] in order to identify guiding forces (motivation, termed destinator in the original method, see supplementary material), human actions, reality changed by these actions, and values realized. The method has been developed in the context of Franciscan spirituality, and is used there to transform daily experiences into the formulation of a prayer. The stories were first read several times and then interpreted and analyzed according to the so-called narrative scheme, which consists of four phases: 1 Motivation, 2 Competences, 3 Performance, and 4 Judgment or evaluation (Table 5.2). The analysis was discussed several times between the two researchers.

Table 5.2 The narrative scheme (used in the spiritual analysis).

Motivation	What or who motivates the action or program? What or who wants it to be carried out? Or in a negative scenario, who or what (anti-motivator) prevents the program from being carried out? The first phase describes the motivator who motivates an actor or subject of doing, and is often recognized by the values of 'wanting to' and 'having to'. The motivator often provides the actor with the competences of 'being able to' or 'knowing how to'.
Competence	The actor or subject of doing searches for competences to perform the action she or he is motivated to perform.
Performance	The performance describes the (main) action as the transformation from one situation into another. This transformation is described as the connection of a subject with an object of value. Motivated by a motivator, a competent actor connects a subject with an object in which a value has been invested. When a subject is connected with an object of value, this value is (said to be) realized. Values are notated between dashes "/…/".
Evaluation	The motivator evaluates whether the performance is successful.

Results

The patient's story

Motivation

The leitmotiv of Mrs. A's story is that she wanted to live an "easy" life, a life in which she can undertake pleasant and sociable activities without too much effort. *"I hope that after the operation, it'll be a question of – we're going out, put on your coat and go, but then without a walker or walking frame or whatever."* She wanted to keep active, but her body prevented her from doing so *"I did the shopping for my birthday … But I was completely exhausted the next day, I can tell you - and I had a lot of pain."* Pain and fear served as anti-motivators.

Mrs A could motivate herself to do things and was pleased with herself when she accomplished them. She did not want to be or feel old: *"I don't want to have to rehabilitate…..you have to go to an old people's home or a nursing home, everything is shoddy and old. Well, I'm old too. I'm 76 but I don't really feel old."*

Mrs. A's desire to lead an "easy life" (a first motivator) and her fear of falling, pain, and physical limitations (an anti-motivator) prompted her to go to the orthopedic surgeon and PT, who function as the third and fourth motivators.

Competences

Mrs A was "still doing her best" and sought resources (competences) to make her life easier; for example, her 89-year-old neighbor did her shopping, and she used a walking stick or rollator. She preferred not to use resources that made her feel old, such as a mobility scooter or going to an inpatient rehabilitation facility. Surgery was a resource that would make her life easier and the PT was a resource that would help her regain functionality, to enable discharge home and perform activities: *"Well, the physical therapist said that she'd get me back on my bike."*

Performance

Mrs. A could perform when she was motivated to do so. An example: After a phone call during our interview, she said enthusiastically that her diary was full for that day: *"it's full today! Lots of nice things, physical therapy – I'll pour the coffee in a minute – and I'm going to play games this evening. It's that type of thing. Sometimes I'm really tired, like Thursday when I did the shopping, and then I go out to play dice in the evening. Then you can forget it, because you're distracted, but if you stay at home then you feel everything. "*

Mrs. A. was the actor who wanted to lead a "normal active life" (an object of value) with the values 'nice', 'easy', and 'keeping busy'. She tried to achieve these values by disregarding her painful body and by rewarding herself by doing nice, agreeable things, which necessitated her using her competences.

Evaluation

Mrs. A was partly successful in achieving her goal of an 'easy' life. She did pleasant things and was proud of herself, but this success was at the cost of greater pain and exhaustion thereafter.

The physical therapist's story

Motivation

The PT seemed to be motivated by the treatment demands of Mrs. A (first motivator) but also by the guidelines (second motivator). According to the PT, Mrs. A wanted to have preoperative physical therapy, so that she could recuperate at home rather than in a nursing home or other setting. *"Mrs. A is very motivated to practice and train – she doesn't want to go to a nursing home."* The PT considered the main long-term motivator to be the ability to cycle again.

Competences

The PT monitored Mrs. A's competences, following the guideline for tailored exercises in the patient's home and environment: "Mrs. A walks 150 meters 2–3 times a day at a good pace (BORG score 13)…. Next week, Mrs. A will walk 150 meters daily, using a crutch, do the sit-and-rise test 10 times, three times a day, and go up and down stairs once a day."

The PT set up the exercise program. On the one hand, she followed the guideline to monitor progress, but on the other she used her own clinical expertise and insight: "I think that the BORG score is too low, because Mrs. A was breathless – it should be 17." and "I feel that she wants to do well." The PT was not only aware of objective treatment goals but also had insight into Mrs A as a person. "She is a clever, well-educated woman, a widow. She talks lovingly of her dead husband ... "

Performance

The performance of the PT was to help Mrs. A's acquire the competence to become a competent actor. By performing the exercises, Mrs. A was joining herself, as a subject, with the object of fitness, which had the value of 'being able to'. Surgery could be seen as an additional competence needed to attain the value of 'being able'.

Evaluation

The PT told Mrs. A that her physical abilities had improved, as evidenced by a decrease in the TUG score and she noted that Mrs. A had faith that doing the preoperative exercises would facilitate her post-discharge recovery of function: *"I think I will recover much better at home".*

The daughter's story

Motivation

The daughter mainly described her family with four children and her relationship with her mother. Her main concern seemed to create a pleasant, calm atmosphere in the home and to ensure that family relationships were good. These relationships, with the possibility to do pleasant activities together with her mother and family, were her motivators.

Competences

It seemed that the mother and daughter sometimes struggled to achieve a relationship on an equal footing. The daughter preferred to visit her mother without her children because she, the daughter, seemed to need calm and space (a competence). Her big family at home (anti-competence) might have prevented her from visiting her mother more often. In their relationship, Mrs. A helped her daughter rather than vice versa. *"She likes to help me with the washing; otherwise she doesn't feel she's useful. It's nice and practical!"* The daughter also saw surgery as a competence, she finished her story with: *"But if she recovers as well after this operation ..then she might feel like doing more with the grandchildren and we can go shopping together, something that she really wants to do and that I really hope she'll be able to do."*

Performance

One performance aspect would be that . A would be able to join in family life and do nice things after surgery. The leitmotiv in the daughter's story is the creation of an environment in which her mother could participate in the family life and relationships, in which the values 'good' and 'connectivity' can be recognized.

Evaluation

An evaluation of good family relations was when both Mrs. A and her daughter were proud when two grandchildren stayed some days successfully at Mrs. A's home.

Evaluation of all three stories

Additional to our regular preoperative assessment, the narrative analysis gave us information about motivations, competences and goals (Table 5.3). Mrs. A was mainly motivated by her will to do enjoyable social activities and stay independent. Her pain and physical limitations were anti-competences that motivate her to attend health care. Mrs. A used physical therapy as a way to get fit, so that she could go home directly after surgery. Surgery (as a competence) would be a means to alleviate pain and limitations. Although the PT seemed to be aware of some personal participation

goals, her main motivation was to improve and evaluate functions and activities according to formal professional guidelines. The daughter had almost the same motivation as her mother and did not see herself as an informal caregiver. We found some traces of evaluation, but the stories after surgery will show whether PT and surgery were the means to help Mrs. A achieve her goals of doing nice things and live an 'easy' life.

Table 5.3 Summary of the motivation, competences, performance and evaluation found in the stories of Mrs. A, her daughter and her physical therapist.

	Mrs. A.	Daughter of Mrs. A.	Physical therapist
Motivation	The desire to lead an "easy life" and her fear of falling, pain, and physical limitations (an anti-motivator) .	Good relationships, with the possibility to do pleasant activities together with her mother and family.	The treatment demands of Mrs. A. (she wants to be able to go home after surgery) and the treatment guidelines.
Competences	Mrs. A. is "doing her best" and is searching for resources like the use of a walking aid or the physical therapist to help her functioning.	Her own busy life seems to be an anti-competence to visit her mother more often. She hopes surgery will provide her mother the ability to do nice sociable things with her again.	The PT is providing an exercise program that should make Mrs. A fit for surgery.
Performance	Mrs. A. tried to achieve her values (nice, easy, keeping busy) and to lead a "normal active life" by disregarding her painful body and by rewarding herself by doing nice, agreeable things, which necessitated her using her competences.	The daughter tries to create an environment in which her mother could participate in the family life and relationships, in which the values 'good' and 'connectivity' can be recognized.	By performing the exercises, Mrs. A was joining herself, as a subject, with the object of fitness, which had the value of 'being able to'.
Evaluation	Mrs. A. was proud after doing nice sociable activities, but also had more pain.	Mrs. A and her daughter were proud when two grandchildren stayed some days successfully at Mrs. A's home.	Mrs. has faith in doing the exercises and the PT is measuring a decrease in TUG score, which implies better physical fitness.

Discussion

This case report with narrative analyses provides insight into functioning in relation to personal meaning of a 76-year-old woman with end-stage osteoarthritis. Although the preoperative assessment was comprehensive and we collected useful information about activities, participation, environmental, and personal factors (Table 5.1), the motivations and competences within the process of personal meaning became clearer after including the narrative of the patient. By including the stories of the PT, that provided her a preoperative training program before THA, and the patient's daughter,

we gained insight into the environment and the family relationships. Furthermore we were able to identify differences in the perspectives of the patient, PT, and family.

Personal meaning for the patient was to live her life as she wanted to (on a participation level). She wanted to do nice sociable activities and stay autonomous and useful. This is comparable with outcomes of other qualitative studies. From the perspective of older patients, physical activity or mobility is just for enjoying living and feeling 'whole' [26–28] and returning home is important because it relates to a normal life . The stories of people could help us with patient-centered goal-setting. We saw a difference in motivation and goals between patient and PT; the patient was motivated by personal participation goals but the PT focused on general functions and activities. This is recognizable from practice and research; Leach et al. found that goals aimed at the ICF levels of impairment and activity limitations were predominant in a subacute care setting.[29] Although the PT seemed to be aware of some personal goals, she was more motivated to follow her treatment guideline and to evaluate progression and success by measuring physical functions. The guideline, physical training, and even surgery could be of great value to achieve goals on a function level such as reducing pain or improving physical capacity, and they mainly served to give the patient competences. Likewise, the physical condition needed to return home after surgery instead of going to a nursing home or other facility is a means or competence to enable the patient realize her values. This example illustrates, that although there is a focus on activities rather than the disease, there is still a gap between the goal-setting of the therapists and the unique participation needs and preferences of older people.[2,30]

By including the story of the daughter, we gained insight in the role of the family. Mrs. A did not seem to want help from her daughter, which could help her achieve her goal of convalescing at home (instead of going to a nursing home). In the Netherlands, relatives are often approached on the role of informal caregiver. Neither Mrs. A nor her daughter wanted their relationship to be one whereby Mrs. A is disabled and needy and her daughter is the caregiver. Their motivations and values were consistent. Mrs. A wanted to remain independent and help her daughter rather than vice versa. As described in literature, the role of spouses or family members are important[20,21] but can differ between people and can be conflicting.[31] In our case study, the PT did not involve the daughter in therapy as a caregiver and which may be appropriate in this case. The PT knew Mrs. A. wanted to be autonomous and preferred to regulate her own daily life and help.

Although from a medical perspective Mrs. A was considered to be a frail and high-risk patient, this was not the perspective of the three stories, which tended to focus on Mrs. A's abilities rather than her limitations. Mrs. A did not accept that she was getting old and frail – she tried to adapt and self-manage her situation. This finding is in line with the new health concept of Huber et al.[5,7] where the focus is on a person's strengths rather than their limitations. Furthermore our approach provided us a broader and more holistic view on health and functioning from the perspective of the patient within her context. This is essential for health professionals to encourage and

empower patients to maintain a positive perspective and to keep or regain independence and functioning in daily life.[21,22]

Evaluation of the method

The spiritual method of Speelman is a valuable and feasible method to gain insight into personal meaning. Although it does not supply empirical evidence, the narrative analysis is nevertheless reliable and valid to the extent that its results can be found back in the stories (Supplementary material) and that two independent researchers followed the described narrative scheme[10] and discussed the analysis.[32] We did not perform a member check; i.e., ask the participants whether the results are credible or believable from the perspective of the participants, to check credibility, which is a limitation of this study. On the other hand, compared to the usual PROMS the narrative approach may have a better face and content validity as the results reflect issues that are important for individual patients. Any patient who is capable of telling his/her own story is suitable for this method, because all people will have personal meaning in relation to their functioning and most will be capable and willing to be explicit with these. Other narrative methods have already proved useful to understanding the patient perspective in health-care.[13] The added value of this method is that we also used the stories of the people involved: the daughter and PT, to gain a better understanding of relationships and context.

Although this case study was based on extensive and time-consuming research, the concept is usable in daily practice if the focus of the patient history is changed, so as to obtain a better understanding of patients' wishes and goals. This would lead to a better approach to, and treatment of, patients and could be useful when it comes to shared decision-making, patient-centered treatment, and goal setting at a participation level.[26,30,33] The method could also be used in research to develop more patient-specific measures that capture the true impact of disease or surgery on a person's life.[34]

Conclusion

The narrative method was a valuable tool to get insight into personal meaning related to functioning of a 76-year-old woman before THA. Although the usual preoperative assessment was comprehensive, personal meaning became clearer after narrative analysis. By including the stories of the daughter and PT in the analysis, we gained a better understanding of the patient context and the role of the daughter and PT in the process of personal meaning. By focusing on the identification of values and meaning in a person's life, we may learn to see the patients in their totality, not just their physical selves. This approach may help in patient centered goal-setting at the level of activities and participation.

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Supplementary material 5.1

Description of the tests (Table 5.1.)

General Patient reported outcome measures (PROMs)

EQ-5D

The EuroQol five dimensions questionnaire (EQ-5D) is a standardized measure of health status developed by the EuroQol Group in order to provide a simple, generic measure of health for clinical and economic appraisal.[1] The EQ-5D descriptive system comprises the following 5 dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each dimension has 3 levels: no problems, some problems, extreme problems. The descriptive system can be represented as a health state, e.g. health state 11212 represents a patient who indicates some problems on the usual activities and anxiety/depression dimensions. The EQ VAS records the respondent's self-rated health on a 20 cm vertical, visual analogue scale with endpoints labelled 'the best health you can imagine' (score 10) and 'the worst health you can imagine' (score 0). This information can be used as a quantitative measure of health as judged by the individual respondents.

NPRS pain

The numeric rating scale (NPRS) is an 11-point scale from 0-10 with "0" is no pain and "10" is the most intense pain imaginable and has good psychometric properties.[2,3] The patient has to choose a number between 0 (no pain) and 10 (extreme pain or other label) to rate current pain intensity at rest or with activity.

Disease specific PROMs

HOOS-PS

The HOOS-PS (Hip disability and Osteoarthritis Outcome Score – Physical Function Shortform) is a 5-item measure of physical functional derived from the items of the Function/ daily living (for example descending stairs) and Function/ sports and recreational activity (for example running) subscales of the HOOS. The interval score ranges from 0 to 100 with zero representing no difficulty.[4,5]

Oxford hip score

The Oxford hip score is a 12 item questionnaire which assesses pain and function of the hip. The range of Scores is from 12 to 60 with higher scores denoting worse pain and function. It has been shown to be reliable and valid.[6]

Performance based measurements

The Timed Up and Go test (TUG)

The TUG is a test of basic functional mobility for frail elderly persons. This test has been found reliable and valid for quantifying functional mobility in frail older people.[7,8] The time needed to rise from an armchair, walk 3 m, turn, walk back and sit down on the chair again is measured. A lower score (in seconds) reflects better functional mobility.

Two minutes' walk test (2MW)

The 2MW is a valid measure of exercise capacity and a responsive outcome measures in older persons receiving rehabilitation.[8] For the 2MW test we asked participants to walk as far as they could in 2 minutes using their customary walking aid. A higher score (in meters) reflects better exercise capacity.

Ten meters walk test (10mW)

The 10mW test is a reliable and valid instrument to measure walking speed.[9] Patients were asked to walk 10 meters at their usual walking speed using their customary walking aid. Time was measured with a stopwatch in seconds. A higher score (in seconds) means a slower walking speed.

Patient specific complaints

The Patient Specific Complaints questionnaire was used to evaluate her limited in physical activities that were relevant for her functioning.[10] The PSC is a feasible tool to support patient participation in the physiotherapy goal setting and it's use is recommended in several Dutch guidelines.[11] The information about validity and reliability is limited but the PSC is comparable with the Patient-Specific Functional Scale, which has good psychometric properties.[12] The patient has to choose 3 activities that are difficult to perform and important to improve and indicate on a visual analog scale (VAS) (0=no difficulty, 100=impossible) how difficult it was to perform each activity in the previous week. Lower scores indicate better performance (range=0–100).

Risk screening

The American Society of Anesthesiologists (ASA) score:
The ASA score measures the fitness of patients for surgery. It discriminates 6 classes, but for elective THR surgery only classes 1-3 are relevant: (1) healthy; (2) mild systemic disease; and (3) severe systemic disease.[13]

The Charnley-score

Indicating the function of the hip with regard to physical activity or the ability to walk and categorizes patients into three groups: (A) unilateral hip involvement with no other condition that interferes with walking; (B) bilateral hip involvement with no other condition that interferes with walking; (C) uni- or bilateral hip involvement with other conditions interfering normal locomotion, such as hemiplegia, or respiratory disability.[14].

Identification of senior at risk (ISAR)

ISAR is a self-report screening tool composed of six simple "yes/no" items, related to functional dependence, recent hospitalization, impaired memory and vision, polypharmacy to assess the risk of functional decline in older hospitalized patients.[15,16] The total scale range is from 0 to 6, as each item is scored 1 if the patient reports having the problem and 0 if not.

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Supplementary material 2, 3 and 4: http://www.tandfonline.com

Supplementary material 5. The formula of the narrative method.

$Dr \Rightarrow Sd \Rightarrow [(S \vee O_v) \rightarrow (S \wedge O_v)]$
Dr= motivation (destinator)
Sd=subject of doing
S=subject of state
Ov=object of value
The disjunction is formulated by a '$\vee$', the conjunction by a '$\wedge$'

6

Preoperative home-based physical therapy versus usual care to improve functional health of frail older adults scheduled for elective total hip arthroplasty: a pilot randomized controlled trial

Oosting E
Jans MP
Dronkers JJ
Naber RH
Dronkers-Landman CM
Appelman-de Vries SM
van Meeteren NLU

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Abstract

Objective
To investigate the feasibility and preliminary effectiveness of a home-based intensive exercise program to improve physical health of frail elderly patients scheduled for elective total hip arthroplasty (THA).

Design
Single-blind pilot randomized controlled trial.

Setting
Patients' homes and a general hospital in the Netherlands.

Participants
Frail patients (n=30) older than 65 years.

Intervention
A preoperative, home-based program supervised by an experienced physical therapist to train functional activities and walking capacity. The control group received usual care consisting of one session of instructions.

Main outcome measures
Feasibility was determined on the basis of adherence to treatment, patient satisfaction, adverse events, walking distance (measured with a pedometer), and intensity of exercise (evaluated with the BORG score). Preliminary pre- and postoperative effectiveness was determined by the Timed Up & Go test (TUG), 6-minute walk test (6MWT), Chair Rise Time (CRT) and self reported measures of functions, activities and participation.

Results
Patient satisfaction and adherence to the training were good (median 5 on a 5 point Likertscale) and no serious adverse events occurred. The BORG score during training was 14 (range 13-16). Preoperative clinical relevant differences on the TUG test (2.9s; 95% confidence interval [CI] -0.9 to 6.6) and significant differences on the 6MWT (41m; 95%CI 8 to 74) were found between groups.

Conclusions
Intensive preoperative training at home is feasible for frail elderly waiting for THA and produces relevant changes in functional health. A larger multicenter randomized controlled trial is in progress to investigate the (cost-)effectiveness of preoperative training..

Introduction

Total hip arthroplasty (THA) reduces pain and improves function and health-related quality of life in patients with end-stage osteoarthritis (OA).[1] Given the aging population, the number of THAs is expected to increase substantially to about 50,000 procedures in the Netherlands by 2030.[2-3] However, not all patients benefit to the same extent from THA,[1] and the preoperative functional status appears to be an important predictor of the postoperative course and outcome.[4-8] Patients with end-stage OA have a wide spectrum of limitations that are summarized in an *International Classification of Functioning, Disability and Health* (ICF) core set for OA.[9,10] Clinical evidence indicates that rehabilitation is faster in patients who are in better physical condition before surgery than in their less fit counterparts.[4,11,12]

The effects of preoperative physical training on functional status and postoperative recovery after THA have been studied before,[13-20] but results are inconsistent, possibly due to methodological limitations,[13,15] the lack of overload induced during training,[13,16] and the inclusion of relatively healthy patients.[15,16,19] According to the Dutch guidelines and other studies, exercise for patients with OA should focus on stimulating functions, activities and participation and promoting adequate coping strategies and it should be targeted to those who are particularly disabled.[21-23]

A former pilot study involving frail elderly patients scheduled for THA yielded encouraging results with respect to preoperative functional outcomes, but also revealed that more than 60% of the participants, especially the most frail patients, had problems participating because of the distance they had to travel to the outpatient department where the training was given and because they did not have enough energy to perform the exercises.[24] As evident from literature, existing guidelines, and our earlier pilot study, preoperative exercise should focus on the frail elderly patients and should be functional, targeting their limitations in activities and participation and taking into account environmental and personal factors. This prompted the development of a home training scheme to facilitate the participation of frail elderly individuals, with the added benefit that home-based training may be more ecologically valid.[25-28]

Before planning a proper randomized controlled trial (RCT), we performed the current pilot study to test the feasibility and to help clarify decisions about outcome measures and procedures.[25] The main aim of this pilot study was to investigate the feasibility of a home-based, short-term intensive therapeutic exercise program for frail elderly patients scheduled for elective THA. A second aim was to investigate the preliminary effectiveness of this program on pre- and postoperative functional health.

Methods

The study design was a single-blind pilot RCT.

Patients

Patients were recruited from the orthopedic department of the Gelderse Vallei Hospital in Ede, a general hospital in the Netherlands. Inclusion criteria were: (1) elective THA (minimum waiting period of 3 weeks), (2) OA as underlying diagnosis for THA, (3) age older than 65 years, and (4) a score of 2 or higher on the frailty index Identification of Seniors At Risk (ISAR).[29]

Because clinical prediction rules to assess which patients might have delayed functional recovery after total hip replacement were not available at the time of the study, the ISAR score was used to select patients.[29]

Exclusion criteria were: (1) unable to understand Dutch, (2) inadequate cognitive functioning (i.e., not able to understand instructions), (3) revision of THA, and (4) diagnosed with dementia or severe heart disease.[30]

The protocol was approved by the Medical Ethics Committees of the University Medical Centre Utrecht and the Gelderse Vallei Hospital Ede.

After patients were informed about the study and checked for inclusion criteria by a clinical nurse specialist, they were sent to the physical therapy outpatient department. Here inclusion and exclusion criteria were checked again, and patients were asked to sign informed consent. After baseline measurements were taken (t0), participants were randomly assigned to the intervention or control group by a research assistant not associated with the study. Randomization took place after stratification by age (65-70 y and age>70 y), using prepared envelopes per stratum. Within each stratum a permuted block randomization with a block size of 10 was used. The two physical therapists who performed the training (RHN and CMD) and patients were not blinded to treatment allocation, whereas outcome assessors (EO and SMA) were.

Intervention group

During supervised sessions (30 minutes/session), patients trained functional activities and walking capacity[30] twice a week for 3–6 weeks. Training was tailored to both the patient and his/her home environment, essentially according to the principles of functional task exercise developed by de Vreede et al..[31-32] The intensity and number of repetitions of the exercises were progressively increased over time, and functional activities were made more challenging by combining physical tasks or asking patients to perform physical and mental tasks. The patients were instructed to additionally train 4 times a week on their own or with the help of friends or relatives. They received a home-based exercise program with patient-tailored functional activities and walking. They were given a pedometer with a 7-day memory (NL1000, New Life Styles, Inc.) to monitor their walking activity, with an aim that they walk a minimum of 30 minutes per day in a graded activity manner.[33] Patients kept a diary of their daily exercise and possible adverse events and symptoms. If patients reported experiencing symptoms or pain after training, physical therapy and relaxation exercises were given as recommended in the Dutch guideline for OA,[23] to decrease patient discomfort.

The subjects trained at a moderate intensity of exercise, corresponding to 55-75% of their maximal heart rate or to perceived exertion between 11 and 13 on the Borg scale (30). Because the training was personalized, functional capacity was monitored with a standardized tailor-made functional circuit, where patients had to perform functional activities like walking, climbing stairs and sit and rise from a chair. We measured the time needed to finish the circuit, and/or perceived exertion.

Control group

Patients in the control group received care as usual in the Gelderse Vallei Hospital, which consisted of a single group session supervised by a physical therapist 3 weeks before surgery. In this session they received information about the operation, walking with crutches, and exercises that would be performed in the postoperative phase. These components were also part of the individual training in the intervention group.

Measurements

Measurements were taken at baseline (t0), 2–4 days before admission (t1), at discharge (t2), and 6 weeks after discharge (t3). At the time of the baseline measurements, demographic data (Table 6.1) were verified and the physical therapists rated the frailty of patients.

Table 6.1 Characteristics of patients in the intervention and control groups at baseline

	Intervention (n=15)	Control (n=15)	*p*
Age (y)	76.9±6.3	75.0±6.3	.41
Sex (n/% female)	14/93	10/67	.17
Living situation			
Living alone (n/%)	8/53	5/33	.26
Living with partner or relative (n/%)	7/40	10/67	
Living in institution (n/ %)	1/7	0/0	
Expected discharge to home (n/%)	9/60	10/67	.71
Body mass index (kg/m^2)	28.6±5.6	27.8±4.2	.68
Preoperative waiting period (d)	34.2±5.8	36.2±12.6	.58
Surgery technique			
Anterior minimal invasive (n/%)	5/33	5/33	1.00
Posterolateral (n/%)	10/67	10/67	
Bilateral symptoms (n/%)	4/27	4/27	1.00
First THA (n/%)	12/80	12/80	1.00
Use of walking assistance (n/%)	9/60	8/53	.71
6MWT (m)	272±74	297±99	.44
TUG test (s)	15.2±7.0	14.3±12.9	.81
CRT test (s)	47.5±26.9	32.7±10.0	.07

Note: Data are means ±SD or as otherwise indicated.

The feasibility of the preoperative home-based exercise program was determined on the basis of (1) adherence to treatment; (2) patient satisfaction (assessed with a questionnaire at t1 (Table 6.2, 9 questions recorded on a 5-point scale from totally disagree to totally agree); (3) adverse events and symptoms and their frequency, and number of patients that needed physical therapy and relaxation techniques as recommended in the Dutch guideline for osteoarthritis[23]; (4) walking distance (measured with the pedometer)[34]; and (5) intensity of exercises (measured with a Borg scale).

Preliminary effectiveness was determined by self-reported and performance-based outcome measures of functions, activities and participation at t0, t1, and t3 illustrated in Table 6.2.[35-43]

Postoperative (t2), the number, severity, and type of postoperative complications; length of hospital stay (LOS); and functional mobility were recorded. Functional mobility was measured with the Iowa Level of Assistance Scale (ILAS).[44] A total ILAS score of 1 or 0 means that the patient is able to function in daily life without physical assistance (theoretical day of discharge); if climbing stairs was not necessary, the theoretical discharge score was set at 6.

Table 6.2 Self-reported and performance based measures of effectiveness of functions, activities and participation (ICF).

ICF category	Measurement	Unit of measurement
Performance based measurements		
Body functions: power of the lower limb muscles	CRT	Seconds
Activities: functional mobility	TUG	Seconds
Activities: walking capacity	6MWT	Meters
Self-reported measurements		
Body functions: daily pain	numeric VAS	0 =no pain and 10= extreme pain
Body functions/ activities and participation: Degree of hip disability	HOOS (5 subscales: pain, other symptoms including stiffness, functioning in daily living, functioning in sports and recreation, and hip-related quality of life)	A normalized score (0 = no symptoms and 100 = extreme symptoms) was calculated for each subscale.
Activities and participation: patient-relevant outcomes	PSC questionnaire (the patient was asked to select 3 problematic activities and to score the severity of each complaint on a VAS)	The mean PSC score of 3 activities (0 = no problems and 10 = impossible).
Activities and participation/ personal factors: amount of physical activity	LAPAQ	Activities in the past 14 days (min/d)

ICF= International Calissification of Functioning, Disability and Health, VAS=Visual Analog Scale

Data analysis

Data were analyzed with SPSS Statistics 17.0. Summary descriptive statistics were computed for the variables measured at baseline. Differences between the groups at baseline were estimated with the independent sample *t* test for normally distributed data and the Wilcoxon signed-rank test and Mann-Whitney *U* test for non-normally distributed data. With regard to patient satisfaction with treatment, the median and range were calculated per question. Intention-to-treat analyses were used. Differences (and 95% confidence interval) between the two groups at t1 and t3 were calculated, using linear regression analyses adjusted for baseline differences. The proportion of patients with postoperative complications in the two groups was compared by means of a chi-square test. The LOS and the day of theoretical discharge in the two groups were compared by means of a *t* test.

Results

Of 204 patients, 148 had an ISAR score of 0 or 1 and 13 patients did not meet other inclusion and exclusion criteria. The intervention and control groups each consisted of 15 patients (Figure 6.1). At t1, 1 patient in the control group was lost to follow-up (lost interest) and assessment of 1 patient was cancelled because of advanced surgery. At t3, 1 patient in the intervention group (reason: no surgery) and 2 patients in the control group were lost to follow-up (1 patients lost interest, for 1 patient it was too great a burden because of a problematic recovery and comorbidities).

The characteristics of the patients are summarized in table 1. At baseline there were no statistically significant differences ($P>0.05$) between the intervention and control groups (Table 6.2). Of the patients identified as being frail with the ISAR, 62% were considered to be frail by physical therapists. Days between t0 and t1 were 32 (SD, 6) for the intervention group and 37 (SD, 9) for the control group, and days between operation and t3 were respectively 45 (SD, 3) and 50 (SD, 7).

Feasibility of preoperative training

Patients were visited at home a median of 7 (range 5-8) times; 1 of 104 visits was cancelled because of illness of the physical therapist. Per patient the median costs for the treatments were 283,50 euro (7x40,50 euro). The diary was completed by six patients and partially completed by five patients. All patients showed good adherence to the homework exercises. Patients thought that preoperative exercise in their home situation was useful, they were motivated to do them, they liked the exercises, and they thought they were better prepared for the operation (Table 6.3). No severe adverse events occurred. Pain in the hip, back, or legs (reported by 10 patients) was treated with traction of the hip (n=1), massage (n=4), relaxation techniques (n=3), (stretching) exercises (n=2), and medication (n=4), or a combination of these

interventions. Four patients decreased their activity level (temporarily, maximally 1-2 days after an exercise session) because of post exercise pain. Other complaints were dyspnea (n=1) and fatigue (n=1). The pedometer showed good adherence (patients used the pedometer every day), and physical activity (number of steps) was consistent with the distance walked recorded in the diary in 9 patients. These patients walked a mean of 2599 steps a day (range 1261-4703). Some patients were limited in their ability to exercise outdoors because of heavy snowfall. The median Borg score during outpatient training was 14 (range 13-16).

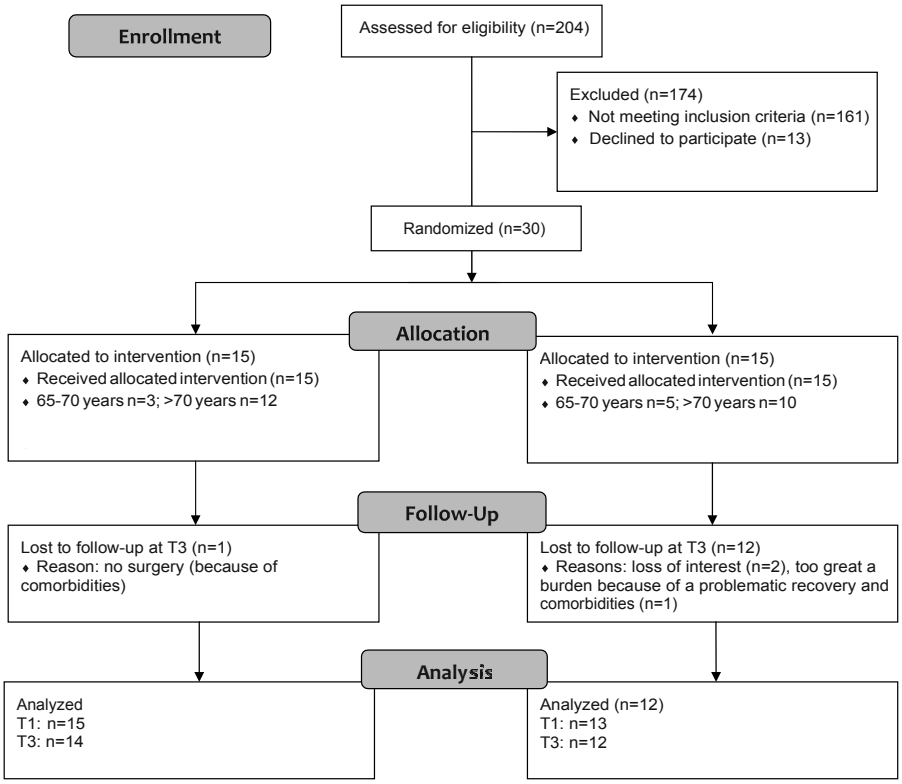

Figure 6.1 Flow diagram of enrollment, randomization, and loss to follow-up.

Table 6.3 Appreciation of the preoperative training in the intervention group, recorded on a 5-point scale (range 1 to 5; 5=totally agree) at the end of the preoperative period (n=14).

	Median (range)	Percentage agreed
The aim of the training was clear to me	5 (5-5)	100
I was motivated to exercise	5 (4-5)	100
I found it useful to exercise with a physical therapist twice a week	5 (4-5)	100
I found it useful to exercise in my home environment	5 (3-5)	93
The exercises supervised by the physical therapist were hard	4 (1-5)	53
The recommended exercises took a lot of time	3 (1-5)	20
I exercised with pleasure	5 (3-5)	87
My hip problems prevented me from performing the exercises	3 (1-5)	47
I think the training prepared me well for the operation	5 (2-5)	93

Preoperative effectiveness at t1

Within group analyses showed that the mean Patient Specific Complaints (PSC) questionnaire score and the Chair Rise Time (CRT) improved significantly in the intervention group, whereas the pain score increased in the control group (Table 6.4). The 6-minute walk test (6MWT) improved statistically significantly more in the intervention group than in the control group; other outcomes were not significantly different ($P>0.05$) between the 2 groups, but Timed Up & Go (TUG) test showed a trend of deterioration in the control group.

Postoperative effectiveness at t2

In both groups 5 patients were discharged to a nursing home as preoperatively planned. No significant differences were seen in complication rate, LOS or functional recovery (Table 6.5). Two patients in the control group did not achieve an ILAS score of 6 or less before discharge. One patient suffered from Parkinson's disease and postoperative delirium and was discharged to a nursing home on day 4 with an ILAS score of 18; the other patient had postoperative complications (delirium, decubitus ulcers, and bowel obstruction) and was discharged to a nursing home on day 11 with an ILAS score of 20.

Postoperative effectiveness at t3

Within group analyses showed a statistically significant improvement from baseline in pain score, mean PSC score, and all Hip disability and Osteoarthritis Outcome Scores (HOOS) in both groups and in the CRT in the intervention group 6 weeks after surgery (Table 6.6). Between-group analyses showed that only the CRT improved significantly more in the intervention group than in the control group, but both groups show equal scores at t3.

It should be noticed that some data, like data on t0 for 6MWT and TUG (Table 6.4 and 6.6) changed by using other numbers of participants because of drop outs and thus conclusions based on these results should be careful interpreted.

Table 6.4 Changes in outcomes in the preoperative phase (t1).

	Intervention group (n=15)			Control group (n=13)			Difference between groups at t1 adjusted for t0 (95% CI)
	t0	t1	Change	t0	t1	Change	
TUG (s)	15.2±7.0	14.9±7.6	-0.3±3.0	14.6±13.9	17.2±13.8	2.6±6.3	2.9 (-0.9;6.6)
CRT[1] (sec)	47.5±(26.9)	33.5±11.2	-14.0*±24.2	34.4±10.5	34.5±14.8	0.1±14.5	3.9 (-6.7;14.4)
6 MWT[2] (m)	280±68	288±88	7±(38	321±85	296±113	-25±45	-41*(-74;-8)
Pain score (0-10)	5.1±1.3	5.9±2.1	0.7±1.6	5.2±1.5	6.0±1.6	0.8*±1.1	0.0 (-1.1;1.2
PSC mean of 3 activities (0-10)	6.5±1.4	5.5±1.9	-1.0*±1.4	7.0±1.4	6.9±2.0	-0.1±2.0	1.1 (-0.3;2.4)
HOOS[3]							
Pain	69.6±14.7	66.8±9.2	-2.8±12.9	64.0±11.4	67.8±12.2	3.8±7.8	3.8 (-3.1;10.7)
Other symptoms	64.0±16.6	62.9±12.2	-1.1±9.7	60.0±17.3	64.0±18.3	4.0±6.9	4.2 (-2.0;10.4)
Function in daily living	65.4±16.5	65.2±10.6	-0.3±16.0	65.2±15.6	68.7±14.9	3.4±6.2	3.6 (-4.9;12.1)
Function in sport and recreation	89.5±13.3	86.8±16.6	-2.7±16.0	85.9±13.1	83.2±13.5	-2.7±15.7	-2.1 (-15.0;10.9)
Hip-related quality of life	76.0±11.4	77.0±10.1	1.0±10.2	83.1±9.9	80.4±11.1	-2.7±8.6	-0.8 (-7.9;6.3)
LAPAQ (min/d)	572±253	552±199	-20±217	560±339	476±379	-83±305	-68 (-254;119)

Note: data are mean ±SD or as otherwise indicated. [1]Control group, n=11. [2]Control group, n=12, Intervention group n=14. [3]Function in daily living: control group n=11, intervention group n=13 / Function in sport and recreation: control group n=11, intervention group n=11. *P<0.05. Description of Supervised Exercise Intervention for patients awaiting Total Knee Replacement.

Table 6.5 Complications and length of hospital stay after surgery.

	Intervention group	Control group
Complications, n (%)	7 (58) (n=12)	10 (71) (n=14)
Cardiac (n)	1	2
Wound (n)	4	3
Orthopedic (n)	1	1
Loss of sensation (n)	1	0
Shingles (n)	1	0
Cognitive deficit/ delirium (n)	0	2
Renal (n)	0	1
Decubitus ulcers (n)	0	1
Bowel obstruction (n)	0	1
Length of stay, mean days ±SD	5.1±1.0 (n=14)	5.4±2.1 (n=15)
ILAS* score <6 on day 4, n(%)	10 (83) (n=12)	11 (92) (n=13)
Nursing home after discharge, n(%)	5 (36) (n=14)	5 (33) (n=15)

* ILAS= Iowa Level of Assistance Scale

Discussion

This pilot study showed that home-based preoperative training for frail elderly patients scheduled for THA is feasible: patients were very satisfied (median=5 on a 5-point Likert scale),no serious long-lasting adverse effects occurred and Borg scores of 13-16 were achieved. Compared to our former pilot study[24] adherence (99%) and recruitment rate (70%) were better owing to the home visits instead of patients having to come to the outpatient physiotherapy department.

The decline in the control group and differences between the control and intervention group with regard to functional mobility (TUG) after preoperative training (2.9s, 95% confidence interval, -0.9 to 6.6) can be considered clinically important.[45] Although this study was underpowered to evaluate the effectiveness of the intervention on the pre- and postoperative indices and drop outs influenced the data, between group results show significant changes (P<0.05) in preoperative walking capacity (6MWT) and postoperative muscle power (CRT). Changes in 6 MWT are too small to conclude on their clinical relevance.[46] In the immediate postoperative period no statistically significant changes were seen between the groups, although patients in the control group had slightly more complications and two of them were not able to perform daily life activities without physical assistance at discharge. Although these finding were not statistically significant they may be clinically important.

Table 6.6 Changes in outcomes in the postoperative phase (t3). Data are means (SD).

	Intervention group (n=14)			Control group (n=12)			Difference between groups at t3 adjusted for t0 (95% CI)
	t0	t3	Change	t0	t3	Change	
TUG[1] (s)	13.8±6.2	13.4±5.5	-0.4±4.0	14.8±(14.4	13.8±11.1	-1.0±3.8	-0.3 (-2.7;2.0)
CRT[2] (s)	45.7±29.4	35.4±23.7	-10.3*±10.3	32.5±10.7	31.4±6.9	-1.1±6.0	5.8* (-0.0;11.6)
6 MWT[3] (m)	281±71	282±84	1±64	340±78	339±69	-1±27	9 (-39;58)
Pain score (0-10)	5.1±1.3	1.9±1.4	-3.1*±1.8	5.1±1.4	2.1±2.0	-3.0*±2.0	0.2 (-1.2;1.5)
PSC[4] questionnaire mean of 3 activities (0-10)	7.3±0.8	3.8±2.6	-3.5*±2.6	7.0±1.5	3.4±1.9	-3.6*±1.5	-0.2 (-2.1;1.8)
HOOS[5]							
Pain	68.9±14.4	34.5±8.6	-34.5*±16.5	63.7±11.4	37.3±16.8	-26.3*±18.0	3.6 (-7.7;15.0)
Other symptoms	63.1±16.8	44.9±15.4	-18.3*±17.8	59.0±17.5	42.7±10.8	-16.3*±(14.1	-0.7 (-10.7;9.3)
Function in daily living	67.2±17.0	36.5±10.8	-30.7*±15.0	64.7±16.2	40.0±13.3	-24.7*±15.4	4.4 (-7.2;16.0)
Function in sport and recreation	88.8±13.8	52.5±18.7	-36.3*±24.9	90.5±10.7	48.0±21.0	-42.5*±23.8	-4.2 (-25.1;16.6)
Hip-related quality of life	75.0±11.1	53.2± 16.4	-21.8*±18.7	81.7±9.8	49.2±16.1	-32.5*±13.9	-9.4 (-25.3;6.6)
LAPAQ[6] (min/d)	589±(252	425±288	-164±328	678±271	507±429	-171±464	55 (-266;376)

Note: data are mean ±SD or as otherwise indicated. * $P<0.05$. [1] Intervention group, n=13. [2] Control group, n=11, Intervention group n=12. [3]Control group, n=10, Intervention group n=13. [4]Control group, n=11, Intervention group n=10. [5]Function in daily living: control group n=11, intervention group n=13 / Function in sport and recreation: control group n=10, intervention group n=8. [6]Control group, n=11, Intervention group n=12.

One of the main benefits of a pilot trial is that practical problems and methodological issues (including measurements and training intensity) can be identified and resolved. The experimental intervention consisted of an individually tailored, preoperative program for exercising at home, so that training was adapted to the specific context of the individual patient (personalization). In addition to existing guidelines[21,23] we visited all patients in their own environment and tried to reach high exercise intensities for all patients. The target training intensity was a Borg score of at least 11-13. Although Borg scores of 13-16 were achieved, the question remains whether the intensity and duration were sufficient, because only half of the patients found the exercises difficult or tiring. However, pain was a major factor limiting exercise. Although we advised patients to take their pain medications, most patient did not. Monitoring patients and finding the right intensity level was a matter of trial and error.[47] We found the best way to monitor functional capacity of each individual patient was using tailor made functional circuit standardized for each individual. Furthermore, not all questionnaires are suitable for this population. We found that the cognitive function of some patients was deteriorating and that patients' self-report answers were influenced by their relatives. For example, the HOOS has many items, such as running and stair climbing, which were not applicable for all patients. We thus recommend the focus on performance-based measures.

The self-reported amount of physical activity (LAPAQ) did not increase preoperatively in the intervention group, despite encouragement by the physical therapists. It might be that patients did not report their activities on the LAPAQ because of strict blinding instructions at the start of the study, or they might have decreased their physical activity because of increased pain. This may thus also point out the relevance of personal and environmental factors like habit strength,[48] coping and the attitude of caregivers and family.[21-23] We took into account some of these factors like exercising at home, involving family and encouraging active coping. Our strategy substantially improved recruitment (70% vs. 34%) and adherence (99% vs. 91%), compared with our former pilot study[24] and during the here presented study we only had one patient in the intervention group who dropped out.

Study limitations

This pilot study identified some limitations that should be addressed in a full RCT. For instance, the ISAR proved to be very sensitive for selecting frail elderly individuals at risk of a delayed functional recovery after THA, which was supported by the experience of the two physical therapists who performed the training and the rapid functional recovery and mean LOS of only 5 days. Nevertheless, TUG and 6MWT scores were appropriate for the frail elderly population.[49]

Sources of risk of bias were the co-interventions we added for pain relief in the intervention group. Although we meant to blind the assessors, this was not successful

in all cases, mainly because patients spontaneously gave information about their intervention.

Conclusions

This pilot study demonstrated that preoperative training at home is feasible for frail elderly individuals waiting for THA and showed clinical relevant results on functional performance based measures. In future studies, overload, physical activity improvement, pain complaints and personal and environmental factors should be addressed by physical therapists working in close collaboration with general practitioners, orthopedic surgeons, and/or anaesthesiologists. The findings of this pilot study need to be verified in a well-powered multicenter RCT with longer follow-up, in order to establish the cost-effectiveness and external validity of this approach.

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7

General discussion

General discussion

The number of people who opt for total hip arthroplasty (THA) because of end stage osteoarthritis (OA) is growing.[1,2] This procedure has a (large) impact on the individual's life as well as on society in general due to its high incidence and substantial costs.[1,3–6] Many initiatives are aimed at improving quality and coordination of care and reducing costs for THA,[6,7] but there is a need to develop interventions to asses and improve pre- and postoperative functioning.[8] In order to improve outcome after THA, health professionals need to provide personalized and contextualized tools and interventions to aid the person's recovery of functioning and participation in daily life in a meaningful way.[9–11] For the woman who participated in our case study (Chapter 5), meaningful functioning meant doing pleasant social activities with family and friends and living independently in her own home. Unfortunately many physiotherapy (PT) interventions to guide recovery of functioning are usually one-size-fits-all[12] and not all people experience the same improvements of pain and functioning after THA.[13] Especially older people face many barriers in their recovery[3–5,13] and therefore PT interventions should mainly focus on those people at risk for a delayed recovery of functioning. A preoperative assessment followed by a tailored personalized therapeutic exercise program for those at risk, has already proved to be effective in patients scheduled for cardiac and abdominal surgery.[14–17] There is increasing appreciation of the relevance of this approach within the continuum of care for all major surgical procedures,[18–20] as recently described by Hulzebos and Van Meeteren in the *British Journal of Surgery*. A scheme is presented in Figure 7.1. The debate about its benefit and cost-effectiveness continues to stimulate further therapeutic research, development, and innovation.

In this thesis, we investigated the functioning of people before and after THA, with a view to stratifying risk and developing tailored physical therapy interventions. In this way, we aimed to improve the functional recovery and outcomes of people at high risk of postoperative complications after elective THA for end-stage osteoarthritis (OA) of the hip. The findings of this thesis are helpful for developing a tailored care pathway for individual patients who opt for THA in which not only preoperative physical fitness is optimized but also the context (professionals, infrastructure, and culture), as shown in Figure 7.1.[17]

There have been numerous studies investigating the optimization of care pathways, preoperative interventions and the physical functioning of people undergoing THA. Our systematic review of the available literature and the development of the CONTENT (Consensus on Therapeutic Exercise Training) scale to measure therapeutic validity provided insight into the shortcomings of current therapeutic exercise programs (section 1). We discuss these findings in relation to our data on preoperative assessment and patient selection (section 1.1) and personalized interventions (section 1.2) for people who elected to undergo THA. In section 2.1 we describe the feasibility and (preliminary) effectiveness of screening and training preoperative and postoperative physical functioning. In section 2.2, we discuss the

cost-effectiveness of this intervention. Thereafter we discuss methodological issues (section 3), and the implications of findings for practice (section 4) and for future research (section 5.). We finish with our overall conclusion (section 6).

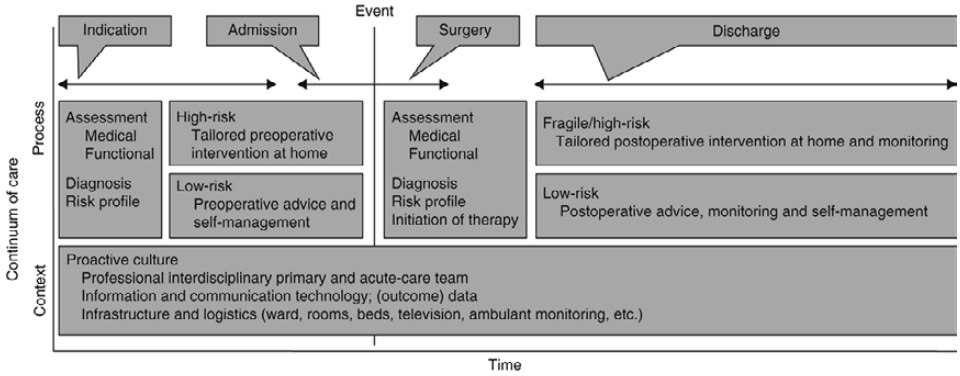

Figure 7.1 The continuum of care: process AND contextual components as described by Hulzebos and van Meeteren.[17] The process starts with medical and functional assessments to identify high- and low-risk patients, so that the most appropriate interventions can be started. The context should provide a proactive culture throughout the entire perioperative period.

1.1 Preoperative assessment and patient selection

In Chapter 2 we evaluated the available literature on preoperative therapeutic exercise programs in a systematic review. One of the shortcomings of included studies was patient selection. Therapeutic interventions are, as all other interventions, preferably preceded by and based on one and the same question: "*Which person will benefit the most from an intended intervention and when*".[21] To date, age and obesity are often seen as major risk factors for adverse outcomes after THA.[22] However, we demonstrated in this thesis that the variation in recovery after THA is only explained marginally by these, usually medically related, factors. We performed an observational cohort study to establsh which patients are at risk of delayed inpatient recovery of activities after THA, a first milestone after surgery (Chapter 3). Functional screening with performance-based tests in addition to medical variables improved the detection of people at risk of delayed recovery of activities after THA. This is consistent with the advice of Hulzebos and Van Meeteren[17] and other authors that functional screening batteries are better suited to the current elderly population than the more conventional screening instruments that focus solely on medical variables or individual diseases.[9,23–25] Recent studies of Elings et al. and Van der Sluis et al. confirmed the additional value of performance-based measures of functioning in a preoperative assessment for total joint arthroplasty (TJA).[26,27] Moreover, we found that muscle function modifies the association between, and probably also the prediction of,

postoperative recovery and obesity in patients after THA (Chapter 4). This is important because obesity is a rapidly growing problem that is associated with numerous negative health outcomes. Our findings are consistent with the current discussion in the literature that not all obese individuals, such as those who are metabolically healthy or highly fit, are at increased risk of health problems.[28] Recent studies have shown that, in patients who opted for THA, the presence of metabolic syndrome or a high percentage body fat showed a stronger correlation with negative outcomes after TJA than did obesity as such.[29,30] This is an interesting finding because there is still no clear insight into the impact of obesity on recovery after surgery and preventive interventions. For example, losing weight or even bariatric surgery have not been proven to be effective to increase the risk for negative health outcomes.[20,21] The findings of Chapter 4 suggest that we need to focus on body composition instead of only BMI and on interventions combining diet/nutritional supplementation and exercise interventions to prevent adverse outcomes in the group of obese elderly.

In our pilot intervention study (Chapter 6), we aimed to select frail older people at risk of delayed recovery after THA. Although, at the time there was no specific risk model to select high-risk people, we included frail elderly patients on the basis of the ISAR (Identification of Seniors At Risk) score.[33] Compared with the population included in the first pilot randomized controlled trial (RCT) in our hospital,[34] in which we evaluated a preoperative, therapist-supervised training program for frail elderly outpatients, we included people with a worse functional status in our home-based intervention study (Chapter 6).[35] Table 7.1 shows the differences in patient selection between the two studies.[36,37] We included patients with a mean age of 76 years, much older than the populations included in other studies, in which the mean participant age ranged between 51 and 70 years.[38] Baseline scores on the Timed Up and Go (TUG) test and the Six-Minute Walk Test were comparable with those of frail elderly populations described in the literature.[39] We did use our own risk model for the inclusion of a frail older patient in our case study (Chapter 5). Her age (76 years old), physical functioning (a TUG score of 16,75 seconds) and her comorbidities made her a patient at risk for delayed recovery of functioning. These measures may be useful for selecting those patients at risk of functional decline, who comprise 15-25% of the general population.[26,40,41] The identification of patients at greatest risk will make it possible to investigate the (cost-) effectiveness of preoperative interventions for these individuals.

Table 7.1 Participants and feasibility in hospital (A)- and home (B)-based studies of the effect of a preoperative exercise training program.

	Study A (hospital)	Study B (home)
Inclusion criteria	≥70 years ≥2 on the Clinical Frailty Scale	≥65 years ≥2 on the ISAR (Identification of Seniors At Risk)
Age (mean, SD)	77 (3)	77 (6)
Baseline TUG, seconds (mean, SD)	11.3 (4.7)	15.2 (7.0)
Baseline 6 minutes walk test, meters (mean, SD)	360 (117)	272 (74)
Recruitment rate	34%	70%
Compliance	91%	99%
Satisfaction	Mean 8.9 (on a scale from 1-10)	Median 5 (on a scale from 1-5)

Study A: Hoogeboom et al.[42], Study B: Oosting et al.[37], TUG= Timed up and go test

1.2 A tailored preoperative intervention

After selecting appropriate patients for a specific intervention, we need to determine which components of an intervention are effective for these individuals, so as to avoid the use of one-size-fits-all interventions. The selection of people at low and high risk is the starting point for the development patient-tailored interventions.[43] One of the items of the CONTENT scale, namely, an appropriate setting for the exercise program matched to the goals and content of the training, is a prerequisite for patient-tailored interventions, but in our case it also seemed to improve patient selection and participation. We assume that the training location (people's own home and surroundings) was the main reason for the successful recruitment of frail elderly individuals in our pilot intervention study, because a study of hospital-based, therapist-supervised therapeutic training reported that most people were not willing and/or able to participate because traveling to the hospital was too tiring and transport was a problem.[42] Furthermore, the setting (people's own home and living context) matches the goals of the preoperative intervention, namely, to improve daily functioning and to support recovery and discharge to home after THA. Home-based exercises may be more ecologically valid as they capture environmental factors and interactions related to the real-world physical performance of older people and their relatives.[44,45]

As described in the CONTENT scale, the goals and content of therapeutic exercise programs should not only match the patients' bodily functions and structures, activities, and participation levels, but also their personal and environmental factors. The case report (Chapter 5) with the in-depth narrative analysis provided a way to explore these personal and environmental factors and to gain insight into *meaning* and *preferences* about functioning in the period before THA. Furthermore, this specific case demonstrated that, although the intervention may have been appropriate to improve functional capacity and adaptability, the health professional and patient were not

entirely on the same 'page' when it came to the *meaning of functioning* and consequently differed in their perceptions about intervention goals. This gap between the perspectives of health professionals and patients has been reported earlier[9,46,47] and needs attention, both in terms of research, and professional education, guidelines, and everyday therapeutic practice. Although we could set personal goals for individual patients in our pilot RCT by using the Patient Specific Complaint questionnaire,[48] the insights gained from the narrative analysis could help refine these goals and encourage the involvement of partners, close family, or informal caregivers of individual patients. Such incentives may further improve the effectiveness of therapeutic interventions, such as exercise programs.[49]

The exercise program we developed (Chapter 6) largely met criteria for therapeutic validity. As described above, we could adequately select patients and tailor the exercise program training to individual patients. Exercises were supervised by competent and experienced physical therapists and the rationale, which was based on relevant and recent evidence, of the exercises was explained. The intensity of the exercises was monitored with the BORG score (and additional heart frequency and saturation) and was high enough to achieve the anticipated therapy effects. Regular monitoring of function, pain, and adverse events made it possible to optimize the exercise intensity for each individual. Even so, further improvement of the intensity, monitoring, and adjustment of therapy is possible. Although we achieved an adherence rate of 99% in the supervised training sessions and we evaluated physical activity by use of a pedometer, we could not monitor participants' adherence to daily training activities at home.

Taken together, these finding can be used to develop a personalized functional therapeutic exercise program for high-risk people, to be carried out in their own home and living context, with a content tailored to their personal abilities and goals and with sufficient content to achieve the necessary therapeutic effect. Such as program is feasible for even the frailest elderly and has the potential to optimize physical performance during the perioperative period, before and after THA.

2.1 Feasibility and effectiveness of preoperative assessment and therapeutic exercises

The preoperative therapeutic exercise program we developed was feasible, as concluded in Chapter 6. Patient satisfaction (median=5 on a 5-point Likert scale), participation rate, and adherence to training were good (Table 7.1), and no serious adverse events occurred.[50] The inclusion of frail elderly individuals was successful, as described above, but could be improved by using the risk factors identified in our cohort study (Chapters 3+4). The functional measures used in these studies are simple and cheap, and can to a large extent be successfully implemented in daily practice, as described in Chapter 8. Although it is not possible to perform a narrative analysis for all

patients, as it is a complex and time-consuming method, just listening carefully to a person's stories combined with observations in that person's home could give us relevant information about personal meaning, preferences, and performance.

2.1.1 Effectiveness on preoperative physical functioning

Because the feasibility study was a pilot study, we were not able to draw hard conclusions about the preoperative, and especially the postoperative, effectiveness of the preoperative therapeutic exercise program. That said, the preliminary results suggest that further loss of preoperative functioning can be – at the least partly – prevented in high-risk patients. In the preoperative phase, we demonstrated a significant change in walking capacity and a clinically relevant change in functional mobility in favor of the intervention. Walking capacity and mobility are relevant performance-based measures of physical functioning. Whether these findings can be extrapolated to all high-risk patients remains to be determined. Our systematic review did not focus on preoperative outcomes, but the results of the systematic review of Gill et al., which had preoperative physical functioning as main outcome of interest, indicated a medium-sized effect on pain and self-reported function in favor of the intervention.[51] However, these results should be interpreted with caution because therapeutic validity was not taken into account and most studies solely focused on self-reported function instead of, or in combination with, performance-based outcomes in relatively low-risk populations.

Although in general exercise programs are effective for improving the physical functioning of frail older people,[52,53] most programs studied in this population lasted longer than 3 months, which is longer than the average THA waiting time. Exercise programs are also effective in improving the physical functioning of people with OA,[54] but these programs often do not focus specifically on older people with comorbidities or a poor physical performance, whereas it is these individuals who may show a faster deterioration of functioning.[55] We can conclude that, beside the selection of appropriate high-risk patients at the right time, there is still ample room for improving the therapeutic approach and its components.

2.1.2 Effectiveness on inpatient postoperative physical functioning

Once exercises programs before surgery demonstrated its ability to improve physical function, it is important that also postoperative outcomes will be improved both on short a long term recovery of physical functioning. Our pilot RCT was not powered to show relevant postoperative changes in inpatient recovery of function, the outcome of interest in this thesis, in favor of the intervention. In our systematic review, only two studies used postoperative inpatient recovery of activities as an outcome[56]; however, neither study met criteria for methodological and therapeutic validity.[42,57] The more recent review of Wang et al. reported two studies that measured short-term inpatient recovery of activities of daily living (ADL), and results suggested that there was a

significantly earlier resumption of activities in favor of the intervention. However, one of the studies had a score of zero for therapeutic validity in our review,[58] and the other study focused on people younger than 70 years old and only had one session of physical therapy and education in the preoperative phase.[59]

Interventions with multiple components are successful in improving the inpatient recovery of physical function after THA. Pathways that combined intensive and rapid inpatient mobilization with optimization of medical, organizational, and logistic aspects were also able to optimize inpatient recovery.[7,8] Van der Sluis et al. concluded that a pathway for patients who had total knee replacement that included a preoperative assessment, patient empowerment, and focused on patient activation ensures a faster recovery of postoperative inpatient functioning.[60] Hansen et al. found that preoperative screening and physical optimization of high-risk patients combined with a motivational conversation was effective in improving postoperative inpatient recovery in patients scheduled for fast-track hip and knee arthroplasty.[61] One of the features of the fast-track pathway is optimization of the individual components of perioperative care.[7] All in all, the optimization of a combination of personalization, pathway, and context might improve outcomes in high-risk patients.

Our pilot RCT was included in a systematic review of the effect of psychological preparation (for example, behavioral instructions) before surgery.[62] Behavioral instruction aims to directly influence behaviors that are important for enabling the surgical procedure to go well and to enhance recovery; for example, instructing people how to manage their own analgesia, or instructing them about when and how to return to usual activities for optimal recovery. It was concluded that psychological preparation, in particular behavioral instruction (our therapeutic exercise program was classified in this category), has the potential to improve recovery. However, as the study included all adult patients, not only high-risk patients, we do not know the effect of psychological preparation in frail older people, but these findings suggest that patient empowerment is an important part of preoperative training programs.

In conclusion, therapeutic exercise programs for high-risk patients are possible and a promising way to improve physical functioning after THA. However, there is a need to develop and evaluate better patient-tailored, high-quality therapeutic training programs to improve the physical functioning of frail older people with end-stage OA. An RCT of high methodological quality and therapeutic validity is needed to evaluate the effectiveness of such a program on preoperative and postoperative physical functioning.[50,51]

2.2 Cost-effectiveness of preoperative assessment and therapeutic exercises

Given the increasing prevalence of primary TJA procedures, there is a need to improve outcomes and cut costs. In the United States, TJA is a popular target for fixed-cost, pay-

for-performance programs, such as bundled payments.[6] In these programs, emphasis is on minimizing unnecessary postoperative care and shortening the length of stay (LOS) in hospital. Optimizing physical functioning and a faster recovery of inpatient activities will subsequently reduce LOS and inpatient rehabilitation rates. However, in our cohort study (Chapter 3) we found a difference between the moment of recovery of activities (85% of the patients were independent in walking within 3 days) and the actual LOS (mean 4.1 days), which suggests that not all people are discharged home when they attain the most important discharge milestones. This may be because patients experience pain, dizziness, general weakness, or delayed wound healing,[65] but more likely it is because of suboptimal organization and logistics[66] and the poor social context and support system of patients in their home environment.[3] Our pilot RCT was not powered to evaluate the effectiveness of the exercise program on these outcomes, but preoperative assessment and training in optimized pathways have already proven effective in reducing LOS,[60,61] probably as a result of the instructive power of the preoperative assessment and the anticipatory approach of the therapist and team members in the hospital trajectory, with a focus on functional recovery and going home, as in the study of Van der Sluis et al..[60]

In addition to improving the recovery of physical functioning and reducing the LOS, it is a challenge to discharge people to home rather than to a long-term, and for them unfamiliar, rehabilitation setting. Beside reducing costs, rehabilitation at home is more effective and safe for people after TJA.[67,68] Our studies provide tools for risk assessment and discharge planning. Although the recent literature recommends the use of the Risk Assessment and Prediction Tool (RAPT) together with medical factors and body mass index,[68,69] we concluded that simple performance-based measures are of additional value to these more conventional measures and tools for predicting recovery (Chapter 3) and hence optimal discharge timing and destination. Shorter LOS and less use of inpatient rehabilitation will reduce costs; total hospital costs for THA are about 10,000 euro in the Netherlands[70] and 1 day of inpatient rehabilitation costs about 250 euro and a 14-day stay about 3000 euro.[71] In contrast, preoperative and postoperative physical therapy is relatively cheap (about 45 euro for a single home-based session, consequently about 360 euro for a preoperative episode, based on 8 individual home-based therapeutic exercise sessions) and has the potential to a reduce care utilization[72] and inpatient rehabilitation.[73] Furthermore, a study of Fernandes et al. found preoperative supervised neuromuscular exercise for 8 weeks to be cost-effective in patients scheduled for THR and TKR surgery, based on one-year clinical effects. Those clinical effects, in favor of the intervention group, were small to moderate and only statistically significant for quality of life measures.[74] Thus, the use of performance-based measures when planning discharge and the guidance of physical therapists for optimizing physical functioning seem a promising and cheap investment to reduce the health-care costs associated with poor physical functioning and a lack of independence.

3. Practical and methodological issues

One of the strengths of the studies described in this thesis is that research was embedded in daily practice. As the preservation of physical functioning in frail elderly before and after THA is a complex problem, we used an action research approach in which we developed knowledge and evidence in our local (individual) practice and within a dedicated interdisciplinary "community of practice".[63,75] Our approach, integrating research in daily practice, provided continuous input from patients and their close relatives, even in their homes, and from an interdisciplinary team of colleagues. In our pilot RCT (Chapter 6), we asked patients about their experiences and opinions. The case study (Chapter 5) with narrative analysis provided valuable information from the perspective of the patient, her daughter, and her physical therapist. All studies gave us direct input about the feasibility of preoperative screening and about barriers to and facilitators of implementation in daily practice. Furthermore, it raised awareness about personal and contextual factors, preferences, and goals that will help us to improve our patient-tailored interventions in daily practice, to improve our pathways, and to set new research questions. This 'patient-included' approach[76] might help us to identify innovative therapeutic components of perioperative pathways for people opting for TJA or other major surgery.

We focused our research on frail older people, a group that is often excluded from research but which would probably benefit the most from preventive care procedures focused on optimizing functioning before and after THA. As we did not use preoperative exclusion criteria, we successfully recruited frail elderly patients. This enabled us to investigate the association between preoperative characteristics and postoperative outcomes for the entire population. We developed and implemented a preoperative screening program and included functional measures that are feasible for both patient and professional and which can easily be incorporated in clinical practice. For several reasons (mainly a skewed distribution of data), we used dichotomized data in our regression models, which has the advantage that data (in the form of cut-off points) are easy to use in daily practice, but it has the disadvantage that there is less information about variability at an individual level.

Using data from a local practice has the disadvantage that generalizability is limited and results could be influenced by the local standard of care or by people. For example, at the time of the cohort study, surgery was performed by a posterolateral or anterior approach. As the anterior approach is associated with faster short-term recovery,[77] this may have influenced the results and may limit the comparison with other hospitals. In addition, the influence of the local health-care providers with whom we jointly conducted this research with great enthusiasm could also affect the results as they can be seen as "early adopters". Early adopters are very important for successful innovation and implementation of research in practice.[78] Although knowledge is shared with several hospitals, we did not perform multicenter research, which could improve the

power and thereby scientific and societal value of our research. Thus, this thesis should serve as an impetus for multicenter studies to further improve surgical interventions.

We used different research methods to explore functioning before and after THA. The development of the CONTENT scale, the pilot RCT study and the case report made it possible to investigate and improve the quality and content of preoperative therapeutic training programs. However, the pilot RCT was not powered to study improvement of preoperative or postoperative physical functioning and therefore could not give us information about cost-effectiveness. The case study with narrative analysis was very useful to gain insight into personal values and life impact, aspects that commonly used patient-reported outcome measures do not capture.[47,79,80] The new narrative qualitative method has some limitations and methodological issues, such as external validity and generalizability. As it is a time-consuming method, it is less suitable for daily practice, but it can be very useful in research or education.

Taken together, the approach we used had many advantages for investigating, developing, and implementing interventions suitable for individuals at risk of functional decline. The next step is to implement and evaluate these interventions in a larger context, to establish their value.

4. Improve care pathways for THA & implications for practice

The findings of this thesis can be used to improve care pathways for THA, with a focus on more personalized and anticipatory and preventive care, especially for those at high risk of negative functional outcomes. As described in Figure 7.1, both process and context need attention and should be optimized when and where possible.

After THA is indicated, we recommend that the person should have a medical and functional assessment. Walking speed, the TUG test, and Hand Grip Strength are simple, cheap, and appropriate tests that can be used alongside self-reported patient outcomes to chart the functional status of patients. The use of these tests is supported by international literature and recommendations.[24,27,81,82]

Despite the lack of conclusive and consistent evidence, older people with comorbidities and poor physical fitness should be explicitly considered for referral to a trained and specialized physical therapist, who could provide an exercise program to be carried out at home. Exercise sessions should be short and be tailored to each individual, taking into account the personal and contextual factors related to that person's functions, activities, and participation, as described in the International Classification of Functioning (ICF)[83] and in the CONTENT scale. For obese people with muscle weakness, both therapeutic exercise and a nutritional intervention could be considered.[84,85] These interventions may be appropriate to improve outcome after THA but may also postpone surgery as non-surgical interventions may result in greater functional improvement and less adverse events then surgical treatment, as studied by Skou et al..[86]

Intervention goals include participation and the relevance given to functioning by the patient. Observing functioning in the natural context and carefully listening to the stories of patients (and their relatives) can help the physical therapist recognize personal functioning patterns, motivations, competences, anti-competences, and values related to functioning. Given the short time before surgery in which to improve the functional performance of these high-risk patients, tools that monitor progress and adverse events are also necessary. Simple and cheap functional tests such as the TUG test can be used to evaluate functional mobility, together with conventional measures of pain and exertion (heart rate, BORG score), but more advanced measures, such as heart rate variance,[87,88] may also be useful for monitoring exercise progress.

Beside this process of assessment and therapy within the continuum of care, the context should change (Figure 7.1). A proactive culture, interdisciplinary care, transmural collaboration, and involvement of family are essential components to improve primary outcomes and also the quality of care.[17] Physical therapists should be trained to develop and perform personalized therapeutic exercise programs and should be able to adapt to the emerging health-care needs of patients.[89] Informal caregivers/ family should be involved in therapy. All people involved, but also the entire environment, should promote patient empowerment, independence, and meaningful physical activity. Monitoring self-reported and performance-based functioning should be continued throughout the whole pathway, to evaluate progress, to adjust and titrate therapy,[90] and to evaluate and optimize the care pathway.

The development, implementation, and evaluation of a new care pathway require a thorough approach. It is important to create patient, management, and professional support and to make a plan in several phases, as described in the national "Better in, Better out" procedure.[91] Creating a network of regional physical therapists and other caregivers in combination with a solid and unambiguous transfer of information to the patient and/or his/her representatives, including information about his/her physical functioning, is essential for ensuring that the recovery of functioning is sustained by the patient him-/herself and his/her (informal) caregivers throughout the entire continuum of care.

In summary, optimizing the care pathway for and especially preferentially ***with*** people before and after THA requires some changes to both the process (preoperative screening and training) and the context, so that a patient's personal preferences, barriers, and environment are considered and ensure that the patient, the professional team, and the hospital environment focus on promoting meaningful physical activity.

5. Future research

A challenge for future research is to take into account the variation in preferences and meaning people give to physical functioning and to develop individualized interventions that focus on what is relevant and meaningful to people in their own living context. The

use of an alternative ICF-scheme as proposed by Heerkens et al, focusing on functioning, participation and personal factors, should be incorporated in research.[92]

The patient-related factors and functional measures we studied in this thesis can be used to develop a more personalized risk model that considers this individual variability. Beside age, comorbidity, and physical performance, other possible risk factors, such as nutritional status, body composition, psychosocial and contextual factors, should be investigated. A great opportunity to evaluate a person's current problems and prognosis is provided by the development of growth curves, as shown by Van Buuren et al..[93] These make it possible to compare a patient's outcomes with a reference chart for expected therapy and projected progress. This would make it possible to detect the effectiveness or failure of an intervention based on a more personalized dataset and evidence. The development of a dynamic database with clinically important data collected during daily practice would make it possible to adapt and adjust these risk models and growth curves continuously.

When developing, evaluating, and reporting on an effective preoperative exercise program, researchers should use the CONTENT statement, or the comparable Consensus on Exercise Reporting Template (CERT),[94] to optimize therapeutic validity. The CONTENT statement is currently being evaluated and will be adapted by means of an international Delphi study. Even though there are general recommendations for exercise programs for elderly people, there is no consensus about the optimal intensity and content of these programs.[52,95,96] High-intensity exercise seems to be somewhat more effective than low-intensity exercise in improving physical functioning in the short term.[52] Furthermore, the combination of exercise programs and nutritional interventions and the addition of patient empowerment strategies should be investigated in the prehabilitation phase.[18] A great opportunity to personalize training and to observe, quantify, and define physical activity in the real-world setting is provided by the use of accelerometers and other wearable technology,[97] technology that with the right interface might be adopted and used by patients to monitor their physical activity. This would help improve self-management during the relatively short period before surgery.

We propose using a combination of self-reported and performance-based measures to evaluate the effectiveness and value of these interventions. Additionally, a tool should be developed to evaluate the different dimensions of personal factors[47] and personal meaning, not only in the short term, as in this thesis, but also in the long term. Extensive qualitative research could provide us more insight into the personal meaning and the barriers and facilitators of physical performance and context of patient, caregiver and family. We should use and assess methodological approaches to evaluate individualized interventions and to interpret scientific results at an individual level.[63] Although a well-powered RCT is still considered the gold standard in research, other research methods, such as step-wedge designs or multiple-baseline single case studies, will probably better fit with this complex intervention.[63,98]

The development of large databases containing data from daily practice is a prerequisite to evaluate health care and physical functioning. In the Netherlands, the Dutch Orthopedic Society (NOV) is already collecting medical data and patient-reported outcomes. This should be supplemented with relevant measures of performance-based physical functioning. To accomplish this, all stakeholders, such as patients, orthopedic surgeons, anaesthesiologists, geriatricians, nurses, dieticians, and physical therapists, should work together to collect relevant medical and functional data. This will make it possible to evaluate and optimize the physical functioning of all people and to minimize negative outcomes, such as complications and re-admission, especially for those individuals at high risk.

6. Conclusion

Although THA surgery is usually successful in improving functioning for people with end-stage osteoarthritis, a significant amount of people face difficulties in their recovery. Preoperative interventions have not proven their effectiveness in improving recovery of functioning so far perhaps because the therapeutic validity of these interventions is insufficient. Patient selection could be improved by adding measurements of performance based physical functioning to the preoperative assessment and by appreciating the complexity of the human body; rather than only looking at BMI, age or a single comorbidity. After selection of the patients at risk for a delayed recovery of functioning, preoperative therapeutic exercises can improve physical functioning of these patients and may even partly prevent or decrease the temporary functional decline seen before and after surgery. Frail, physically unfit, elderly people are willing and able to perform intensive exercises in their home environment. This patient-tailored, home-based intervention we studied in this thesis is consistent with the needs of most elderly people we have seen during the time these studies were performed. These needs and the way people function in relation to personal and spiritual factors and their context can be clarified from daily life stories. Being able to function in their own environment gives meaning to a person's daily life and increases the likelihood of continued participation in society. With the findings of this thesis we created tools and knowledge to change the one-size-fits-all pathways and physiotherapy-interventions into tailored personalized care with a focus on optimization of functioning of each individual before and after THA.

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8

Valorisatie

Valorization / English summary

Physical functioning is provisional for people to participate in the community, to undertake sociable activities and to stay autonomous. In this thesis, we developed and evaluated diagnostic and therapeutic interventions to assist to improve physical functioning of patients before and after total hip arthroplasty (THA). In this valorization chapter, we describe how we combined practice and research to optimize the pathway for people undergoing/opting for THA.

Our approach

To improve the clinical pathway for patients that have chosen to have a THA, we initially started the (scientific) evaluation of daily practice in 2008 in Ziekenhuis Gelderse Vallei (ZGV). The author of the thesis (Ellen Oosting) is working in this regional hospital as a physiotherapist and embedded scientist (a practice-based researcher). Questions, problems and relevant data from daily practice were used to formulate and answer research questions in an iterative manner. In this way, the results of the research could be directly integrated into daily practice and vice versa. In our approach, we focused on physical functioning of patients as a priority in the pathway, and measured performance-based physical functioning with functional tests in addition to the usual medical and demographic information and Patient Reported Outcome Measures (PROMs). Unlike many scientific studies, we focused most of our research on those patients who are at risk for a delayed and/or impaired recovery of activities after THA (Chapter 3) and we adapted the physical therapy interventions to the specific possibilities and problems of those individual patients. The case study in Chapter 5 is an example expressing individual possibilities and problems and the personal meaning of physical functioning of a patient at risk. Our pilot RCT (Chapter 6) was also adapted to these at-risk patients by offering the supervised exercise training at the home, in the own environment of the vulnerable people. This approach increased participation in the training, was feasible and was well appreciated by the participating patients themselves.

Practical innovations

To evaluate daily practice and to study important practical issues, we developed and implemented a preoperative screening and training and set up a regional collaboration with physiotherapists. This transmural collaboration, but also the intensified inpatient interdisciplinary collaboration, made it possible to improve the logistics, content and culture of the THA-pathway, to create support from all stakeholders and to ensure long-term sustainable improvements. Furthermore, we are part of the national Better in Better Out-Community of Practice (BiBo-CoP) to share knowledge and experiences with other embedded scientists of eight hospitals in the Netherlands.

Preoperative screening

Data from the preoperative screening that we implemented in 2012 in ZGV, were used for our cohort studies (chapter 3 and 4) and taught us that people with older age, comorbidity and worse physical functioning are the ones that are at risk for a delayed recovery of activities after THA. This knowledge is used nowadays as part of usual care to: 1) predict postoperative recovery, 2) inform patients regarding the optimal discharge destination, and 3) inform patients regarding the usefulness of preoperative therapeutic exercise. In addition, by listening closely to the story of the patient (chapter 5), the underlying motivations, goals, expectations and barriers become clear. Such an approach should be considered in clinical practice as well, probably somewhat less sophisticated, to work well within the possibilities of daily practice. Finally, by continuously monitoring the screening and outcome data and through discussions with colleagues, we gather insight on what factors are contributing to better physical functioning and recovery after THA.

Based on another of our clinical views we inferred that not all obese people experience difficulties in their recovery. We thus studied the interaction of muscle function with body mass index (BMI) and their association with postoperative recovery. The conclusion was that not obesity, but the combination of obesity and muscle weakness was associated with a prolonged recovery after THA. An important finding for practice, because only weight loss, as recommended often, will probably not help to promote postoperative recovery. It may even work just the opposite way, because people with muscle weakness may lose even more muscle mass when losing weight without muscle training.

Preoperative training

During the preoperative session, the patient gets an advice on how he or she can stay physically active and prepare for surgery. A patient with an increased risk for delayed functional recovery, as determined by the preoperative screening, is given the opportunity to participate in a home based preoperative training program. Functional intensive training in the home situation as developed in Chapter 6, is included in the transmural guideline and associated training for physiotherapist, which we have developed in our network with the regional physiotherapists. It remains to be seen what the cost-effectiveness of such an approach in the real life daily practice is.

Postoperative recovery of functioning

To improve postoperative recovery of activities, the more anesthetic and surgical "fast track" principles including early mobilization, have been implemented in ZGV. In a daily multidisciplinary consultation, readiness for discharge is being discussed with the patient, based on the recovery of their functional milestones. This will prevent patients from being in the hospital for longer than necessary (Chapter 7) and gives the opportunity to discuss timely what care (physical therapy, home care, rehabilitation) is

necessary after discharge. For a proper transition of care, a written transfer has been made, which also includes the pre- and postoperative function and the personal and environmental factors of interest.

These innovations and research findings were part of the optimization of the THA-pathway in ZGV. We managed to decrease the number of people with a delayed functional recovery or LOS (in 2012 50% of the patients stayed >4 days in hospital, in 2016 only 10% stayed >3 days in hospital), the outpatient rehabilitation rate (from 19% in 2012 to 10% in 2016) and the mean length of hospital stay (from 4.1 days (SD 1.6) in 2012 to 2.0 days (SD 1.0) in 2016).

Future

The research in this thesis provides many suggestions on how to improve the care for people before and after THA. It fits well with the transition in healthcare towards a focus on functioning and individual preferences and possibilities of the patient. Within the participatory research practice, which we developed both regionally (in and around ZGV) and nationally (BiBo-CoP), preoperative screening and training will need to be further improved to optimize the physical functioning of patients before and after THA. More research on the best content and intensity of preventive or preoperative training, as well as the combination of exercises with optimization of nutrition and sleep is needed. Optimization of these interventions may delay or even adjust the need for surgery. When surgery is the best option after intensive preoperative training, we also need to explore which interventions are needed to improve long term postoperative physical functioning. Furthermore, we need to explore and implement digital developments such as the use of wearables and big databases. Data of these wearables and databases can help us to personalize interventions more and more. The Dutch Arthroplasty Register (LROI) of PROMs should be completed with performance based data to optimize timing of surgery and risk-screening. We need to evaluate these datasets continuously and make the data available and usable for patients on an individual level to improve daily practice and personalized care.

In future, length of hospital stay will further decrease and most people will recover at home after THA, even the frailest elderly. It's important to monitor their recovery of functioning, but also their complications and re-admissions. By optimizing and (scientifically) evaluating the pre- and postoperative screening and interventions, future value and cost-effectiveness for the patient and society should be clarified.

Fysiek functioneren van patiënten voor en na een heupoperatie

Introductie en relevantie

Fysiek functioneren, oftewel in beweging zijn, is een voorwaarde om mee te kunnen blijven doen in de maatschappij, om leuke activiteiten te kunnen ondernemen en om zelfstandig te blijven. Bij heupartrose krijgen mensen vaak te maken met toenemende pijn en functioneringsproblemen. Het plaatsen van een totale heupprothese (THP) is over het algemeen een succesvolle operatie om pijn en functioneringsproblemen te verminderen in het eindstadium van artrose. Helaas zijn lang niet alle mensen in staat om in de preoperatieve periode voldoende actief te blijven. Hierdoor neemt bij de (tijdelijk) sedentaire mensen de functionaliteit en conditie af en dat kan hun postoperatief functioneel herstel stagneren. De fysiotherapeut kan een belangrijke rol spelen om met deze mensen hun fysieke fitheid te behouden en/of verbeteren. In dit proefschrift (en in de praktijk) hebben we kennis, producten en diensten ontwikkeld om de fysiotherapeutische interventies beter te laten aansluiten op de behoeften van individuele patiënt en hun eigen mogelijkheden en beperkingen. In dit valorisatiehoofdstuk wordt beschreven hoe de praktijk heeft geleid tot het onderzoek en hoe de resultaten uit dit proefschrift de afgelopen vijf jaar hebben bijgedragen aan een verbeterde zorg, verbeterde uitkomsten en welke verbeterpunten en plannen er nog zijn voor de toekomst.

Setting en doelgroep

Ziekenhuis Gelderse Vallei

De auteur van dit proefschrift (Ellen Oosting) is sinds 2007 in Ziekenhuis Gelderse Vallei (ZGV) te Ede werkzaam als fysiotherapeut en embedded scientist (een professional met een wetenschappelijke achtergrond die in de praktijk werkt en daar praktijk en onderzoek verbindt).[1,2] ZGV is een regionaal ziekenhuis, met onder andere een afdeling orthopedie met 24 bedden en acht orthopedisch chirurgen. Speerpunten van het ziekenhuis zijn voeding, beweging en sport. In 2016 werd in de ZGV bij ruim 600 patiënten (gemiddelde leeftijd 70 jaar, range 29-97 jaar) een THP geplaatst.

Hoewel zorgpaden rond een orthopedische operatie vaak al goed georganiseerd waren in Nederland, bleek al voor de start van het onderzoek van dit proefschrift dat de kwaliteit van de fysiotherapie in die zorgpaden onvoldoende was. Uit een eigen onderzoek van 10 ziekenhuisprotocollen uit 2008[3] bleek dat de inhoud en kwaliteit van de fysiotherapie binnen de zorgpaden voor gewrichtsvervanging aanmerkelijk verbeterd kon worden. De 5 belangrijkste gebieden waarop de toenmalige

ziekenhuisprotocollen tekortschoten waren: 1) geen preoperatieve prognostische risicobeoordeling van patiënten; 2) achterhaalde preoperatieve interventies (groepsvoorlichting); 3) late postoperatieve mobilisatie; 4) geen gebruik van gevalideerde meetinstrumenten en objectieve ontslagcriteria en 5) onvoldoende overdracht van het fysiek functioneren van patiënten tussen ziekenhuis en vervolgzorg. In ZGV was er destijds een zorgpad met een “one-size-fits-all” benadering, met wel een preoperatieve groepsvoorlichting, maar geen preoperatieve training. Het postoperatief mobiliseren was gebaseerd op een vast protocol met een streefontslag na vijf dagen. De noodzaak voor revalidatie in een verpleeghuis was vooral gebaseerd op de sociale status waarbij het actuele fysiek functioneren van patiënten niet of nauwelijks gemeten werd, laat staan dat deze indicator gebruikt werd bij de besluitvorming met de patiënt over ontslagplanning en -richting. Zaken die destijds toch al wel aanbevolen werden in de literatuur.[4] In die periode zijn we gestart met onderzoek en innovaties binnen dit orthopedische zorgpad, aansluitend op het onderzoek dat al plaatsvond om de perioperatieve zorg en uitkomsten van patiënten die abdominale chirurgie ondergaan te verbeteren.[5,6] Hierbij is samengewerkt met onder andere TNO en de Universiteit Maastricht (Nico van Meeteren), Ziekenhuis Nij Smellinghe (Geert van der Sluis, Drachten) en het Diakonessenhuis (Jordi Elings, Utrecht). Het onderzoek is altijd uitgevoerd en geëvalueerd vanuit de bestaande praktijk, met fysiotherapeuten en patiënten. Metingen en data, die de klinische beslissingen van patiënt en therapeut helpen nemen, zijn gebruikt om de zorg systematisch te evalueren en analyseren. Vragen, problemen en hierbij relevante data uit de praktijk zijn op deze manier gebruikt om klinische- en onderzoeksvragen op te stellen en te beantwoorden. De resultaten van het onderzoek konden op deze manier direct en gecontroleerd in de praktijk geïntegreerd worden. Door deze participatieve onderzoekspraktijk is zodoende gepoogd de valorisatie van de onderzoeksresultaten van begin tot eind te waarborgen.

Doelgroep

Het behoud en verbeteren van het fysiek functioneren en het optimaliseren van het perioperatieve zorgpad voor een THP is van belang voor de mensen die de operatie verkiezen te ondergaan en hiervan optimaal willen profiteren. De resultaten uit dit proefschrift zijn met name van belang voor de kwetsbare ouderen die risico lopen op complicaties en vertraagd en/of suboptimaal herstel. Deze kwetsbare ouderen hebben relatief het meeste baat bij een persoonlijke aanpak op basis van een preoperatieve risico inschatting, aanvullende preoperatieve diagnostiek en prognostiek en aansluitende therapeutische training om hun conditionele en functionele capaciteiten te verbeteren. Hiermee is de kans groter dat ze na de operatie weer sneller naar huis kunnen en zelfstandig kunnen functioneren.

Het uitvoeren van de preoperatieve screening en training verbetert de rol van fysiotherapeuten bij de begeleiding van het fysiek functioneren van mensen in hun eigen omgeving in samenwerking met verpleegkundigen, orthopeden en andere zorgverleners. In ZGV heeft de fysiotherapeut nu een initiërende rol in de transmurale

zorgketen en heeft een grote invloed bij belangrijke beslismomenten met de patiënt zoals de ontslagplanning.

De transitie in de zorg met het fysiek functioneren en de wensen van de patiënt als uitgangspunt

In onze aanpak hebben we het fysiek functioneren van patiënten tot prioriteit verheven en de fysieke vaardigheden met functionele *performance* testen gemeten naast de gebruikelijke medische, demografische en door de patiënten zelf gerapporteerde informatie (*Patient Reported Outcome Measures*; PROMs). Hierbij hebben we vooral bekeken welke mensen problemen hadden met hun (herstel van) fysiek functioneren en de interventies aangepast op individuele mogelijkheden en problematiek. Preoperatieve screening, functionele performance testen en de continue evaluatie van de dagelijkse praktijk en zorginnovaties uit dit proefschrift geven steeds meer zicht op wat van belang is voor de patiënt. De case study van hoofdstuk 5 is een voorbeeld uit de praktijk waarbij de persoonlijke betekenis van het fysiek functioneren expliciet gemaakt wordt.[7] Door verdiept naar het verhaal van de patiënt te luisteren, worden de motivaties, doelen, verwachtingen en belemmeringen vaak al duidelijk. Elke zorgverlener zou vragen over persoonlijke betekenis moeten verwerken in de anamnese. Zeker bij (kwetsbare) ouderen, waarbij veel factoren een rol spelen in de gezondheidssituatie, zou het verdiept uitvragen en analyseren van wensen, verwachtingen en doelen een vast onderdeel van het assessment moeten zijn om als patiënt en behandelaar tot betekenisvolle behandeldoelen te komen. Waar nodig kan een 'derde' – van geestelijk verzorger tot maatschappelijk werker – helpen om deze doelen en hun diepe betekenis voor de individuele patiënt te verhelderen.

Uit ons cohortonderzoek (hoofdstuk 3) bleek dat kwetsbare ouderen met comorbiditeit en een slechte preoperatieve fysieke fitheid[8] risico lopen op vertraagd herstel van fysiek functioneren na de operatie. In tegenstelling tot de meeste onderzoeken hebben we juist deze groep geïncludeerd in ons interventieonderzoek. Uit de recent verschenen 'Leidraad voor medisch-wetenschappelijk onderzoek bij ouderen' van de Nederlandse Vereniging voor Klinische Geriatrie blijkt ook dat deelname van ouderen binnen wetenschappelijk onderzoek een heel relevant topic is.[9] Uit de eerste pilot-interventiestudie in ZGV[10] bleek dat kwetsbare ouderen niet graag participeerden bij onderzoek waarbij ze in het ziekenhuis moesten trainen. Het volgende onderzoek (hoofdstuk 6) heeft hier direct op ingespeeld door de training thuis aan te bieden.[11] In vergelijking met de eerste pilot waren ruim twee keer zoveel ouderen bereid te participeren in de thuistraining. Door al preoperatief te starten wordt verdere achteruitgang van fysiek functioneren in aanloop naar de operatie voorkomen (hoofdstuk 6). Door de trainingsinterventie aan te bieden in de eigen omgeving van deze kwetsbare ouderen lukt het dus beter om deze doelgroep te bereiken. Het is nu zaak om deze interventie nu ook te evalueren op het postoperatief rendement voor de patiënt en de doelmatigheid.

Een belangrijke voorwaarde voor gepersonaliseerde zorg is een goede samenwerking tussen alle betrokken disciplines. Bij het opstarten van het interventieonderzoek en het implementeren van de preoperatieve screening, waarvan we de data in dit proefschrift hebben gebruikt, is samengewerkt met alle betrokken zorgverleners zoals de orthopeden, anesthesisten en verpleegkundigen. In ZGV is die samenwerking verder geïntensiveerd in 2014 bij de implementatie van het huidige Actief Herstelzorgpad. Hierin zijn alle "fast track" principes uit de literatuur verwerkt[12] en is gekeken hoe de vertegenwoordigers van voornoemde disciplines gezamenlijk de inhoud van de zorg, de logistiek en de cultuur kunnen verbeteren. Alle zorgverleners zorgen hierbij voor een actieve intramurale omgeving en stimuleren de patiënt gedurende zijn/haar ziekenhuisverblijf zelf actief te blijven en zodoende aan het functioneel herstel te werken. Tweemaal per jaar vindt interdisciplinair overleg plaats om met relevante data te evalueren hoe het zorgpad verder verbeterd is, en nog kan worden.

Innovaties

Voor een meer persoonlijke benadering, waarbij het optimaliseren van fysieke fitheid voorop staat, is het van belang de zorg zo in te richten dat mensen bij de start van het zorgpad nauwgezet gescreend worden. Vervolgens kunnen interventies worden ingezet die passen bij de individuele wensen en mogelijkheden van de patiënt. Vanuit ZGV hebben we de preoperatieve screening en training geïmplementeerd en ontwikkeld en samen met regionale fysiotherapeuten een netwerk gevormd waar patiënten naar doorverwezen worden voor deze specifieke training. Daarnaast is de postoperatieve mobilisatie en ontslagplanning, -richting en -informatie geoptimaliseerd door de betere screening, functionele metingen, vroege mobilisatie en intensievere interdisciplinaire samenwerking. Deze innovaties maakten onderdeel uit van het doorlopende onderzoek en zijn inmiddels verworden tot de standaard *usual care* van de ZGV.

Preoperatieve screening en therapie initiatie

In 2012 is de preoperatieve functionele screening geïmplementeerd binnen een multidisciplinaire zorginnovatie van de ZGV, geïnitieerd door de onderzoeker en collega ziekenhuisfysiotherapeuten. De resultaten van deze innovatie, die met name waren gericht op een beter postoperatief advies over ontslagbestemming, staan beschreven in bijlage 8.1. Deze resultaten zijn gepresenteerd op het landelijke geriatriecongres in 2013. Met deze presentatie hebben we de prijs voor de beste voordracht van de Nederlandse Vereniging voor Fysiotherapie in de Geriatrie (NVFG) gewonnen. De data van de preoperatieve screening zijn gebruikt voor de cohortstudie (hoofdstuk 3 en 4). Op basis van deze data-analyse bleken de leeftijd, de aanwezigheid van comorbiditeit (Charnley score C) en fysieke fitheid (gemeten met de 10 meter wandeltest of Timed up and go test, TUG) de beste voorspellers van herstel van postoperatieve functioneren.[8] De TUG is gekozen als basis voor de preoperatieve screening, aangezien deze test ook bij de onderzoeken van Van der Sluis et al.[13] en Elings et al.[14] een belangrijke

voorspeller bleek bij respectievelijk patiënten die opgingen voor een totale knieprothese (TKP) en een THP. Binnen het regionale netwerk is besloten ook de twee (of zes) minuten wandeltest en de Chair Rise Test (CRT) toe te voegen om de fysieke fitheid van patiënten te kunnen monitoren en evalueren gedurende het hele pre- en postoperatieve traject. Dergelijks maakt het mogelijk om bij suboptimaal beloop van het herstel van het fysiek functioneren direct samen met de individuele patiënt te besluiten tot wijzigingen in de behandeling.

Door continu ook de individuele herstelbeloopgegevens te analyseren en te evalueren welke (preoperatieve) factoren daaraan in positieve of negatieve zin in bijdragen, blijven we het screeningsinstrumentarium verder optimaliseren. Bij twijfel over de invloed van bijvoorbeeld psychosociale factoren bij de individuele patiënt, wordt gevraagd of de fysiotherapeut in de eerste lijn ook nog in de thuissituatie inventariseert – bijvoorbeeld aan de hand van de individuele coping strategie, motivatie of (fysieke en mentale) belastbaarheid van de patiënt bij fysieke training - in welke mate deze factoren het fysiek functioneren van de patiënt beïnvloeden. Zo kunnen we van elke patiënt een goed beeld krijgen van de mogelijkheden en beperkingen in het dagelijks functioneren.

In de praktijk zagen we ook dat mensen met overgewicht lang niet altijd trager herstellen, zoals vaak wordt gedacht. Waarbij veel zorgverleners en wetenschappers alleen body mass index (BMI) meten en interventies gericht op afvallen adviseren, hebben wij BMI-metingen gecombineerd met een functionele maat, namelijk spierfunctie (met behulp van de hand knijpkracht), aangezien juist ook lichaams-samenstelling in verband wordt gebracht met gezondheidsproblemen. De *peer-reviewer* van Journal of Arthroplasty die ons artikel hieromtrent van commentaar had voorzien, gaf aan direct spierfunctie te gaan meten in zijn eigen praktijk, aanvullend op de BMI, naar aanleiding van de resultaten van de studie uit hoofdstuk 4.[15] De bevindingen suggereren dat mensen met een te hoge BMI (>30 kg/m^2) en een beperkte spierfunctie (<20 kg voor vrouwen en <30 kg voor mannen), gedurende het perioperatieve traject zouden kunnen profiteren van de combinatie van voeding en training. Een optie die o.a. ook door Van Loon et al (Universiteit Maastricht) wordt onderzocht en aanbevolen.[16] Het goedbedoelde advies aan patiënten met een hoge BMI om te gaan afvallen, kan in voorkomende gevallen vermoedelijk juist averechts werken aangezien mensen dan nog meer spiermassa (en – functie) kunnen verliezen en zelfs ondervoed kunnen raken.

Aan de hand van de preoperatieve gegevens wordt een prognose opgemaakt over het herstel en de verwachte opnameduur. Deze gegevens worden met de patiënt besproken. Naar aanleiding van de preoperatieve screening kan besproken worden of postoperatieve hulp of aanvullende revalidatie (Geriatrische Revalidatie Zorg; GRZ) nodig is. Als hoog-risicopatiënten wel graag thuis willen revalideren, wordt in samenwerking met de eerste lijn en de patiënt en zijn/haar mantel(zorg) beoordeeld of dit met intensieve pre- en postoperatieve fysiotherapie (en andere hulp) haalbaar is. De pre- en postoperatieve screening en metingen geven daarnaast informatie over

mensen die een goed herstel van fysiek functioneren hebben. Deze groep heeft slechts minimale fysiotherapeutische begeleiding nodig. In ZGV wordt een groot deel van de patiënten na een THP niet standaard doorverwezen voor een intensief traject in de eerste lijn, zoals vaak wel wordt gedaan,[17] maar bestaat de interventie bij ongeveer 50% van de patiënten uit adviseren, monitoren en het bevorderen van zelfmanagement.

Preoperatieve fysiotherapie & netwerk

Tijdens de preoperatieve sessie krijgt de patiënt een advies hoe hij/zij zich conditioneel en functioneel kan voorbereiden op de operatie. Een hoog-risicopatiënt krijgt een verwijzing en advies voor het volgen van een preoperatief trainingsprogramma in de thuissituatie. Om de preoperatieve training te implementeren, maar ook om de postoperatieve fysiotherapie te verbeteren, is vanaf 2013 een regionaal netwerk van 25 eerstelijns fysiotherapiepraktijken en 3 revalidatie instellingen gevormd in samenwerking met de Regionale Organisatie Fysiotherapeuten Gelderse Vallei (www.ROFGV.nl). Het verbeteren van de vakinhoudelijke kwaliteit is bij het netwerk altijd het belangrijkste doel geweest. Binnen het netwerk is een transmurale werkwijze ontwikkeld, waarin afspraken staan over interventies, meetinstrumenten en informatieverstrekking naar de patiënt en naar elkaar. De bevindingen uit het proefschrift hebben bijgedragen aan de inhoud van transmurale werkwijze THA. Functionele intensieve training in de thuissituatie, waarbij rekening wordt gehouden met persoonlijke doelen omstandigheden, zoals ontwikkeld in hoofdstuk 6, is het uitgangspunt voor de preoperatieve periode.

Alle deelnemers hebben een, door het KNGF geaccrediteerde, scholing van 3 avonden (van 2 uur) gevolgd waarin het functioneel testen en trainen centraal stond. Jaarlijks zijn er twee bijeenkomsten voor intervisie en uitwisseling van ervaringen waarin ook de hoog-risicopatiënten, hun functionele thuistrainingen en het meten en evalueren wordt besproken. Ook wordt in deze bijenkomsten relevante recente literatuur besproken. Naast onze eigen onderzoeksresultaten, zijn onder andere de studies over de nieuwe definitie van gezondheid van Huber et al.,[18,19] de uitdagingen in het postoperatief herstel na het invoeren van de "*fast track*" principes[20] en de huidige literatuur en visie over de effectiviteit van fysiotherapie voor en na een THA[21–23] de afgelopen 3 jaar besproken. Hiermee hebben we een participerende leeromgeving gecreëerd en kunnen nieuwe praktische vragen en problemen gesignaleerd worden en weer worden meegenomen voor verdere evaluatie en onderzoek.

Postoperatief herstel van fysiek functioneren

Op basis van het herstel van het postoperatief fysiek functioneren en, meer specifiek, de behaalde mijlpalen van het mobiliseren (veilig zelfstandig transfers kunnen maken, lopen en eventueel traplopen), gecombineerd met medische ontslagcriteria, wordt met de patiënt besproken wanneer hij/zij met ontslag kan. De opbouw van het mobiliseren

gebeurt op basis van de individuele progressie en aan de hand van individuele doelstelling met betrekking tot de thuissituatie na ontslag. In de onderzoeken gepresenteerd in dit proefschrift is steeds de MILAS (Modified Iowa Level of Assistance Scale) gebruikt om het functioneel herstel te kwantificeren, maar uiteindelijk is in het vakinhoudelijk overleg van de afdeling fysiotherapie in 2016 gekozen om de FAC (Functional Ambulation Categories) voortaan te gaan gebruiken in de ZGV-praktijk om mijlpalen in het functioneel herstel van patiënten na een THA te objectiveren omdat deze eenvoudig is in gebruik en al op andere ZGV-afdelingen werd gebruikt. Nadeel is wel dat deze niet specifiek transfers meet, maar alleen gericht is op de loopfunctie van patiënten. Voor kwetsbare patiënten die meer beperkingen ervaren en demonstreren gedurende het functioneel herstel van deze mijlpalen is de MILAS geschikter, of beter zelfs de DEMMI (De Morton Mobility Index) die nog specifieker de problemen in mobiliteit en dagelijks functioneren objectiveert.[13]

Om te voorkomen dat een patiënt langer in het ziekenhuis verblijft dan nodig (hoofdstuk 7) is de voortgang in het fysiek functioneren een vast onderdeel van de dagelijkse visite. Met de patiënt, orthopeed, verpleegkundige en fysiotherapeut wordt de progressie in het mobiliseren en de verwachting van het ontslagmoment besproken. Aan de hand van het herstel van functioneren en de risicofactoren wordt ook geïndiceerd, óf en zo ja, welke vorm van fysiotherapeutische begeleiding iemand nodig heeft na ontslag. Hierbij is een goede overdracht, met informatie over het pre- en postoperatief fysiek functioneren, essentieel[24] (een voorbeeld staat in bijlage 8.2).

Uitwisseling van kennis, inzichten en ervaringen

De resultaten en inzichten van de onderzoeken opgetekend in deze thesis, gecombineerd met de innovaties in de ZGV-praktijk, zijn vaak gedeeld binnen internationale, nationale en lokale publicaties, scholingen en congressen (bijlage 8.3). Voorbeelden zijn de landelijke BiBo-Community of Practice (BiBo-CoP) en het landelijk “Better in, better out”-advies voor fysiotherapeuten.

In de BiBo-CoP nemen ongeveer 20 embedded scientists[1,2] deel, werkzaam in 8 verschillende ziekenhuizen uit heel Nederland.[22] In de BiBo-CoP worden kennis, inzichten en praktijkervaringen uit de verschillende onderzoeksprojecten van de deelnemende ziekenhuizen gedeeld en kritisch besproken. Deze samenwerking in de BiBo-CoP is meer dan 10 jaar geleden gestart op initiatief van Nico van Meeteren, met als doel gezamenlijk de (perioperatieve) ziekenhuiszorg te verbeteren. Acht keer per jaar komen de leden samen. Er worden geregeld deelnemers van andere ziekenhuizen, praktijken, bedrijven of universiteiten uitgenodigd om ook andere perspectieven of inzichten op de perioperatieve zorg te belichten. Binnen de BiBo-CoP, maar ook door andere afdelingen Fysiotherapie in andere ziekenhuizen wordt de ZGV als een van de voorlopers gezien in Nederland als het gaat om innovatieve *state of the art* perioperatieve fysiotherapeutische zorg. Tal van bezoeken door fysiotherapeutcollegae

van Nederlandse ziekenhuizen en ook buitenlandse ziekenhuizen mogen dit onderbouwen.

De bevindingen en ervaringen uit de pilotstudie naar de haalbaarheid van preoperatief trainen in de thuissituatie (hoofdstuk 6) en van de systematische review (hoofdstuk 2) zijn verwerkt in het landelijke "*Advies aan fysiotherapeuten: 'Better in, Better out' bij totale heup- en knieoperaties".*[23] Dit advies stammend uit 2012 geeft aanbevelingen aan de hand van *best evidence* en *best practice* om "Better in, Better out" voor patiënten die kiezen voor een gewrichtsvervanging een *state of the art* fysiotherapeutische benadering te geven. Dit advies zal aan de hand van recente literatuur, waaronder de studies uit deze thesis, geactualiseerd moeten worden.

Toekomst

Het fysiek functioneren en de individuele wensen en mogelijkheden van de patiënt zullen steeds meer centraal komen te staan in de Nederlandse gezondheidszorg.[25] Binnen de participatieve onderzoekspraktijk zal de preoperatieve screening en training nog verder verbeterd en onderzocht moeten worden om de meerwaarde voor het fysiek functioneren van elke patiënt voor en na een THP te evalueren.

Preoperatieve screening en conservatieve zorg

Door continue data-evaluatie en toevoeging van bijvoorbeeld relevante psychosociale factoren zal het risicomodel steeds verbeterd kunnen worden. Inzicht in welke factoren invloed hebben op de fysieke activiteit en het herstel van fysiek functioneren na de operatie helpt om gedeelde besluitvorming (Shared decision making) beter in de praktijk te brengen. Door continue evaluatie van factoren die bijdragen aan goede of slechte uitkomsten na de operatie, zal de patiënt in de toekomst steeds beter kunnen beslissen of de operatie wel de beste keuze is op dat moment. Samenwerking met de anesthesioloog en geriater is, zeker voor kwetsbare ouderen, onmisbaar. Tijdens onze preoperatieve screening hebben we gemerkt dat sommige mensen nog geen fysiotherapie of pijnmedicatie hebben gehad in het conservatieve traject of nog heel goed functioneren ondanks de coxartrose. In ZGV hebben we daarom een artroseconsult ontwikkeld en is het een actiepunt voor 2017 om de artrosezorg in ons netwerk te verbeteren.[24,25] Optimale preventieve en conservatieve zorg en een betere timing van de operatie-indicatie kan mogelijk operaties uitstellen en misschien ook afstellen.

Pre- en postoperatieve training

Als de operatie wel de juiste keuze lijkt te zijn om het fysiek functioneren te verbeteren en de pijn en beperkingen te verminderen, is het van belang dat mensen zo fit mogelijk in het ziekenhuis verschijnen. De preoperatieve training die wij ontwikkeld hebben

moet verder geoptimaliseerd worden door te onderzoeken welke vorm, intensiteit en inhoud de beste pre- en postoperatieve uitkomsten op fysieke fitheid en herstel van functioneren geven. Het gebruik van wearables kan hieraan bijdragen door continu fysieke activiteit en fysiologische parameters te meten.

In de toekomst moet het mogelijk zijn de interventie verder te optimaliseren door bijvoorbeeld de combinatie van training en voeding te exploreren, met name voor de mensen met onder- of overgewicht of een slechte spierfunctie (of weinig spiermassa) (zoals beschreven in hoofdstuk 4). Naast voeding en beweging, de speerpunten van ZGV, is rust en slaap ook van belang voor een goed herstel van trainingsinspanningen voor de operatie en van de chirurgische en anesthesiologische interventies na de operatie. Om het perioperatief fysiek functioneren te verbeteren moeten onderzoeken en interventies niet alleen focussen op training, maar op een combinatie van deze metabole thema's. In ZGV wordt momenteel onderzoek gedaan naar de meerwaarde van het gebruik van extra eiwitten en de combinatie van voeding en training in de perioperatieve zorg. Van deze onderzoeken waarbij de ZGV samenwerkt met WUR mogen medio 2018 de eerste resultaten verwacht worden. Daarnaast wordt eind 2017 vanuit de ZGV met verschillende partnerinstituten als WUR en UM een symposium georganiseerd waarbij de resultaten van dit proefschrift, aangevuld met de nieuwste inzichten rondom het optimaliseren van slaap en voeding perioperatief, centraal zullen staan.

De trend is dat steeds meer ouderen zo lang mogelijk thuis willen blijven wonen en functioneren. Revalidatie, ook voor kwetsbare ouderen, zal steeds meer in de eigen thuis- en leefomgeving plaatsvinden. De training in de thuissituatie zoals uitgevoerd in hoofdstuk 6 laat zien hoe collegae deze revalidatie thuis kunnen uitvoeren en ook hoe deze te personaliseren. Ook de zorg voor laag-risicopatiënten zal meer verplaatst worden naar de thuissituatie door de steeds kortere opnameduur. Enkele ziekenhuizen in Nederland bieden al de mogelijkheid voor een THP in dagbehandeling aan voor fitte patiënten met voldoende mantelzorg. Bij de transitie naar zorg dichtbij huis, zal zowel voor de fittere patiënt die in dagbehandeling geholpen wordt als de kwetsbare oudere die intensieve zorg nodig heeft, de directe omgeving en de mantelzorgers steeds belangrijker worden om de patiënt te begeleiden in het herstel van fysiek functioneren.

Technologie en dataverzameling

De patiënt zal steeds meer een partner worden van de zorgverlener. Om de patiënt meer inzicht in eigen zorg te geven is digitale toegang tot informatie en eigen data van belang. Een landelijk voorbeeld hiervan is het VIPP-programma, ontwikkeld door de NVZ, in samenwerking met het ministerie van Volksgezondheid, Welzijn en Sport (VWS)(26). Binnen ZGV hebben we regionaal een start gemaakt met Ezorg en een platform voor dataverzameling en samenwerking met de eerste lijn.

Het verzamelen van informatie over fysiek functioneren gebeurt al binnen de landelijke Registratie Orthopedische Implantaten (Lroi)[27] door de Nederlandse Orthopaedische Vereniging (NOV). Hoewel dit een goed initiatief is om op grote schaal

PROMs te meten en de orthopedische zorg te evalueren, kan door het toevoegen van functionele maten, oftewel “Patient Performance Measures” (bijvoorbeeld de TUG), de preventieve en gepersonaliseerde zorg verder geoptimaliseerd worden. Ook metingen waarbij de ervaring van de patiënt wordt gevraagd (Patient Reported Experience Measures; PREMs), zijn een goede toevoeging omdat patiëntervaringen over bijvoorbeeld informatieverstrekking, patiëntparticipatie of nazorg een belangrijke informatie opleveren waarmee de zorg verder verbeterd kan worden. Het is belangrijk de patiënt (waar mogelijk) zelf te betrekken in het verzamelen, begrijpen en interpreteren en ook eventueel in delen van zijn/haar eigen data zodat hij/zij de regie houdt en shared-decision mogelijk is.

Economische waarde

Optimale preventieve en conservatieve zorg kan mogelijk operaties uitstellen en kosten besparen. Heupartrose komt in Nederland voor bij 359.000 personen[28] en de verwachting is dat dit aantal gaat toenemen door de vergrijzing en het groeiende aantal mensen met overgewicht en de toenemende inactiviteit. Als een operatie de beste optie is, is het van belang het (herstel van) fysiek functioneren te optimaliseren. Mensen die fysiek beter functioneren zullen beter participeren in de maatschappij, minder (betaalde) hulp nodig hebben en sneller weer productief zijn (in ZGV is 35% van de patiënt jonger dan de pensioenleeftijd van 67 jaar). In 2014 werden in Nederland 28.026 totale heupprotheses geplaatst en dit aantal zal waarschijnlijk verder groeien tot meer dan 50.000 in 2030 (29). Ook in ZGV zien we jaarlijks een toename.

Het optimaliseren van de pre- en perioperatieve fysiotherapie hebben in ZGV bijgedragen aan een kortere opnameduur en een hoger percentage mensen dat direct naar huis ontslagen wordt. In 2012 had bijna 40% van de mensen na een THP in ZGV een verlengde opnameduur uitgaande van de toenmalige streefopnameduur van 4 dagen. Bij de implementatie van het nieuwe Actief Herstel zorgpad in 2014, waarbij de nadruk nog meer kwam te liggen op het actief mobiliseren, werd uitgegaan van een streefopnameduur van 3 dagen. Bij de start van het nieuwe zorgpad in 2014 verbleef ongeveer 50% langer dan 3 dagen in het ziekenhuis. In 2016 was dit nog maar 10%. De gemiddelde opnameduur voor THP is momenteel afgenomen tot gemiddeld 2.0 dagen (SD 1.0) in vergelijking met 4.1 (SD 1.60) in 2012.

Door een geoptimaliseerde preoperatieve screening, en mede door de strengere indicatiestelling en landelijke regelgeving, is het percentage mensen dat gaat revalideren en ook de duur van die revalidatie de laatste jaren afgenomen (zie ook bijlage 8.1). Momenteel is de GRZ na een THP in ZGV standaard kortdurend en heeft slechts een enkele kwetsbare ouderen met een zeer lage belastbaarheid langer dan 4 weken revalidatie nodig om weer thuis te kunnen functioneren. Landelijk was de duur voor GRZ na een THP of TKP in 2015 28 dagen.[30] In ZGV gaat tegenwoordig ongeveer 10% van de patiënten revalideren in een GRZ-instelling. De verwachting is dat steeds

meer ouderen thuis gaan revalideren en de GRZ ook in de thuissituatie wordt aangeboden.

Zoals beschreven in de discussie (hoofdstuk 7) is er literatuur die ondersteunt dat preoperatief trainen kosteneffectief is en gerelateerd is aan een afname in zorgkosten postoperatief.[31,32] De kosten voor ziekenhuisopname en revalidatie vormen een groot deel van de totale kosten. De zorgkosten voor artrose worden voor 54% besteed aan ziekenhuiszorg. Een heupoperatie kost bijna 10.000 euro[33] en twee weken opvang in een revalidatie instelling kost ongeveer 3000 euro.[34] Daarentegen kost een periode van preoperatieve fysiotherapie ongeveer 360 euro uitgaande van 8 sessies van 45 euro voor fysiotherapeutische begeleiding aan huis. Omdat deze kosten momenteel niet vergoed worden uit de basisverzekering, is er voor veel mensen nog een financiële drempel om deze training te volgen. Uit de evaluaties van ons zorgpad blijkt dat het nog steeds de ouderen met een slechte fysieke fitheid en comorbiditeit zijn die een verlengde opnameduur hebben. Aangezien minder dan de helft van deze mensen ook daadwerkelijk de preoperatieve training volgt, is hier nog winst te behalen.

Risico's

Om te waarborgen dat de kortere opnameduur niet ten koste gaat van het herstel, is het van belang het fysiek functioneren, complicaties en heropnames goed te monitoren. Bij zowel laag- als hoog risicogroepen, kan de fysiotherapeut in de thuissituatie het herstel van activiteiten begeleiden en monitoren samen met de patiënt. Uit onze preoperatieve metingen en interventiestudie is gebleken dat intensieve functionele testen en training bij kwetsbare mensen geen risico's met zich meebrengen; behalve tijdelijke pijntoename, traden in de interventiestudie geen serieuze complicaties of bijwerkingen op. Ook in ons netwerk, waarin sinds 2014 de preoperatieve training wordt uitgerold, zijn geen zorgwekkende bijwerkingen gerapporteerd. Wel blijft van belang deze kwetsbare groep te laten trainen door specifiek opgeleide en ervaren fysiotherapeuten. Het netwerk met de regionale fysiotherapeuten heeft een belangrijke bijdrage geleverd aan een verbeterde communicatie tussen 1^{e} lijn en ziekenhuis bij problemen of complicaties postoperatief.

Conclusie

Het onderzoek in dit proefschrift geeft veel suggesties hoe de zorg voor mensen die een THP krijgen verbeterd kan worden. Door het implementeren van functionele testen en deze te combineren met andere persoonsgebonden factoren zoals leeftijd, BMI en comorbiditeit en door goed te luisteren naar het verhaal en de ervaringen van de patiënt, kan de zorgverlener inzicht krijgen in welke behandeling voor elk individu meerwaarde heeft om het fysiek functioneren te verbeteren. Door de continue

evaluatie binnen een zorgpad, komen steeds verbeterpunten naar voren. Door het optimaliseren en (wetenschappelijk) evalueren van de interventies zal in de toekomst de meerwaarde en ook de kosteneffectiviteit voor de patiënt en samenleving verder duidelijk moeten worden.

Bijlage 1 Ketenoptimalisatie voor heup- en knie arthroplastiek

Abstract van de presentatie op het landelijke Geriatriecongres, 2013 (Ellen Oosting, Suzan Appelman, Adam Swets, Paul Kapitein, Nico van Meeteren)

Inleiding

Optimale ketenzorg rondom totale heup- of kniearthroplastiek (THA, TKA) zorgt voor betere kwaliteit en meetbare (kosten-)effectieve zorg. Geriatrische revalidatie gericht op een spoedig herstel van laag belastbare ouderen, waarbij gestreefd wordt naar terugkeer in de oude woonsituatie, is hierbij een belangrijk onderdeel. Deze studie beschrijft de tussenevaluatie van een ketenzorgoptimalisatie-project.

Methode

Fase 1. in deze implementatiestudie: analyse van de huidige en gewenste situatie, knelpunten en risico's in het ketenzorgproces en het bepalen van doelen en indicatoren. Fase 2: implementatie van: a) een preoperatieve functionele screening waarbij kwetsbare ouderen die risico lopen op complicaties of een vertraagd herstel worden gedetecteerd, b) postoperatieve monitoring van functioneel herstel, c) een patiënt specifieke voorlichting over het functioneel herstel met een advies voor ontslagrichting en -datum, d) strategieën om zelfmanagement en zelfredzaamheid bij de patiënt te bevorderen, e) intensievere intra- en extramurale samenwerking en f) een lokaal fysiotherapienetwerk en -ketenrichtlijn. Fase 3: eindevaluatie, vindt plaats in 2013.

Resultaten

De nulmeting toonde dat patiënten en zorgverleners tevreden waren over de preoperatieve screening/voorlichting en ontslagrichting. 23% van de patiënten ging voor revalidatie (standaard 6 weken) naar een verpleeghuis en gemiddelde ziekenhuisopname was 5,1 dagen (THA) en 5,4 dagen (TKA) (2e kwartaal 2011, n=128). De tussenevaluatie (april 2012) toonde een gelijke tevredenheid van patiënten en zorgverleners. Patiënten (n=45) waren ADL-zelfstandig bij ontslag en achteraf tevreden over ontslagrichting en revalidatieduur (steekproef n=13). Een meet- en behandelrichtlijn met meer aandacht voor functionele doelstellingen, evaluatie van postoperatief herstel en intensievere functionele training was in ontwikkeling. 19% ging revalideren (-4%), 52% kwam in aanmerking voor een korter revalidatietraject (3-4 weken). Opnameduur was 4,7 dagen voor THA en TKA (2e kwartaal 2012, n=111).

Conclusie

De tussenevaluatie van de ketenoptimalisatie laat naast kwalitatieve resultaten ook een afname in opnameduur en verpleeghuisopname zien.

Bijlage 2. Inhoud overdracht fysiotherapie ZGV voor fysiotherapie en/of GRZ indicatie.

Patiëntgegevens:

Geachte collega,

Bovengenoemde patiënt is van dd-mm-jj tot dd-mm-jj opgenomen in Ziekenhuis Gelderse Vallei in verband met coxartrose rechts.

Operatie
Datum: dd-mm-jj door …..
Verrichting: THP anterieur re.
Nabehandeling:

Mevrouw ….. kwam op dd-mm-jj voor een fysiotherapeutische preoperatieve screening in ziekenhuis Gelderse Vallei in verband met een geplande THP operatie. (Hieruit volgde een advies voor preoperatieve fysiotherapie/ Geriatrische Revalidatie Zorg (GRZ).)

Relevante medische voorgeschiedenis: …..

Preopratieve gegevens
Sociaal
Gezinssituatie: …..
Woonsituatie: …..
Opmerkingen: …..

Functioneren voor opname
Gebruik hulpmiddel:….. Loopafstand:….. Traplopen:…..
Gebruik pijnmedicatie:…..
Benodigde of aanwezige hulp/mantelzorg: …..

Klinimetrie

	Preoperatief
Timed up and go (sec)	
Hulpmiddel	
Chair rise time (5x, sec)	
Borg (6-20)	
NRS pijn (0-10)	
2 minuten wandeltest (m)	
Hulpmiddel	
Borg (6-20)	
NRS pijn (0-10)	
Hartfrequentie rust	
Hartfrequentie inspanning	
Saturatie rust	
Saturatie inspanning	

Conclusie screening
Motorisch functioneren:
Belastbaarheid:
Leer- en trainbaarheid:
Motivatie:

Huidige situatie (van het postoperatieve herstel van activiteiten, eventuele complicaties of bijzonderheden)

Plan: Graag voortzetting van de fysiotherapeutische behandeling gericht op….

Met vriendelijke groet,

….. , fysiotherapeut

Bijlage 3

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Internationale congres- en scholingsbijdragen

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"Personal preferences and motivations of a person and two relatives before total hip arthroplasty: a case report with a narrative analysis." (Poster presentation)
The interaction between preoperative muscle weakness and obesity and recovery after total hip arthroplasty (oral presentation)

2015 WCPT (World Confederation for Physical Therapy Congress)
Therapeutic validity of exercise therapy in rcts (presentatie)
Prediction of inpatient recovery of physical function for patients after total hip arthroplasty using performance based tests: a prospective cohort study (oral presentation)
Feasibility of an intensive therapeutic exercise program for frail elderly prior to total hip arthroplasty: two randomized pilot studies (poster)

2015 Better in, better out: Clinical Expertise in acut stationary, Physiotherapie ZHAW, Zurich University of Applied Sciences (onderwijs).

2014 EULAR, Paris
Prediction of inpatient functional recovery for patients after total hip arthroplasty: the added value of performance based tests to self-reported information, a prospective cohort study (oral presentation)

2014 EUGMS congress Rotterdam
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2011 International WCPT Congress, Amsterdam
A research methodology to identify relevant factors of quality of care in physiotherapy interventions for abdominal and thoracic surgery (oral presentation)

Nationale congres- en scholingsbijdragen

2016 NOV najaarsvergadering: De combinatie van obesitas en spierzwakte geeft risico op trager herstel na een totale heupprothese (mondelinge presentatie)

2013 Informatiebijeenkomst over het innovatieproject Better-in -Better-out KNGF/ CBO/ TNO: Praktijkervaringen "Better in, better out".

2013 Geriatriedagen: 'Ketenoptimalisatie voor heup- en kniearthroplastiek'.
Prijs "Beste voordracht NVFG"

2013 Slotconferentie RGF Zuidwest Nederland: Workshop Functioneel trainen bij een totale heup arthroplastiek (Better in, Better out).

2012 NOV jaarcongres: 'Intensive training programs of fragile elderly before total hip arthroplasty: two randomized pilot studies'.

2011 BSL Congres Fysieke fitheid voor en na een operatie: ‘Fysieke fitheid bij totale knie/heup’.

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2015 Wetenschapsavond ZGV: Voorspellen van klinisch functioneel herstel na een heupprothese: een prospectieve cohort studie. (presentatie)
2014 Regionaal symposium ZGV: orthopedie & sport (presentatie).
2014 Onderwijsdag ZGV voor aios anesthesiologie UMCU: Bewegen voor de operatie (onderwijs).
2013 Regionaal symposium Ziekenhuis Gelderse Vallei: ‘Transmurale ketenrichtlijn Totale Heup’.
2012 Regionaal symposium Ziekenhuis Gelderse Vallei: ‘Orthopedie in beweging’.
jaarlijks Regionale scholing fysiotherapeuten ZGV/ ROFGV: transmurale ketenzorg heup/knie
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Summary

Summary

Nowadays, health is regarded as the ability to self-manage and adapt to physical, social and emotional challenges in life. Undergoing a total hip arthroplasty (THA) can present such a challenge. Where the majority of people show a quick and satisfactorily postoperative recovery, a substantial group of people do face barriers in their recovery after the procedure. Unfortunately, interventions with the aim to improve functioning before and after THA have typically been employed in the general or "healthier" population. However, in order to improve functioning of each individual in his/her own environment before and after THA, professionals should change towards providing opportunities, tools and interventions that take into account individual variation between people and permit functioning in daily life and participation in society in a way that is important for each individual. From this perspective, the studies described in this thesis investigate ways to preserve or optimize the physical functioning of people after a major life event, namely, total hip arthroplasty (THA). The aim of the studies was to evaluate which patient-related factors and personal preferences affect functioning before and after surgery. Another objective was to evaluate the content, feasibility, and preliminary effectiveness of a preoperative intervention to improve functioning before THA in high-risk individuals with a poor functional status and health.

Current evidence based practice

To assess the current content and effectiveness of preoperative exercises, we performed a systematic review of the available literature (**Chapter 2**). Besides a usual methodological quality assessment, we determined the therapeutic validity with a rating scale we developed using a Delphi study. Therapeutic validity can be defined as the potential effectiveness of a specific intervention given to the potential target group of patients. Experts determined five critical areas as being important for the therapeutic validity of preoperative exercise interventions: patient selection, therapist and setting selection, rationale, content and adherence. The conclusion was that none (!) of the 12 included studies met our criteria for therapeutic validity mainly because information about adequate patient selection, adequate dosing and monitoring were missing. After pooling the low quality studies the effect of preoperative exercise on postoperative recovery could not be demonstrated.

Preoperative assessment

To be able to select the people who are at risk for delayed recovery of activities after THA a functional screening was implemented additional to the medical screening that was already part of usual care in our hospital the Gelderse Vallei. Data from this functional screening and medical charts were collected, resulting in a cohort of 315 people. Regression analysis was used to determine what person-related factors were associated with recovery of activities after THA. Furthermore, we studied if the

use of performance based measures was of additional value to the use of more conventional factors as age, comorbidities, body mass index (BMI) or sex and self-reported information as the Risk Assessment and Predictor Tool (RAPT).

In **Chapter 3** it was found that a combination of conventional factors and performance based tests predict recovery of function after THA best. Regression analysis with all variables identified older age (>70 years), comorbidity (Charnley score C), slow walking speed (Ten-meter Walk Test >10.0 seconds), and poor functional mobility (Timed Up and Go test (TUG) >10.5 seconds) as the best predictors of delayed recovery of function. This model performed better (AUC 0.85, 95% CI 0.79-0.91) than a model with conventional factors and RAPT scores, and significantly (p=0.04) better (AUC 0.81, 95%CI 0.74-0.87) than a model with only conventional factors. In conclusion, a functional assessment with performance based tests, additional to usual patient related factors as age, BMI and comorbidity, suits best to predict recovery after THA and to select people who could benefit from preoperative exercise.

In **Chapter 4** we were interested in the interaction between obesity and muscle strength and the association with postoperative inpatient recovery after THA. As hypothesized, we found an interaction between muscle strength and BMI. The combination of weakness and obesity, which could be linked to sarcopenic obesity, is associated with delayed inpatient recovery after THA. People with both muscle weakness and obesity had a higher risk for having a delayed recovery of inpatient activities (OR 6.21, 95%CI 1.64-23.65) or a LOS over 4 days (OR 3.59, 95%CI 1.09-11.89) after THA than people without obesity and muscle weakness or people with only muscle weakness or only obesity. This is an interesting finding because there is still no clear insight into the impact of obesity on recovery after surgery. Interventions such as losing weight or even bariatric surgery for obese people have not been proven to be effective to improve postoperative outcomes. The findings of Chapter 4 suggest that we need to focus on body composition instead of only BMI and on interventions combining diet/nutritional supplementation and exercise interventions to prevent adverse outcomes in the group of obese elderly people.

Preoperative therapeutic exercises

In **Chapter 5**. we selected an at-risk person within our preoperative functional screening and explored personal meaning of this person before THA in a case report. In addition to a medical and functional preoperative assessment, we aimed to gather insight into personal preferences and motivations of a person involved in a physical therapy intervention by use of a narrative analysis of the stories of a person before THA (Mrs. A, a 76-year-old woman with severe comorbidity), her daughter and her physiotherapist. Mrs. A was mainly motivated by her will to do enjoyable social activities and stay independent. Although she had the competence to try her best to undertake those activities that make her proud, her pain and physical limitations were anti-competences that motivated her to attend health care. The physiotherapist seemed to be aware of these personal participation goals, but her focus was on

improving and evaluating functions and activities. The daughter also wanted her mother to be able to do enjoyable activities; however, in this process she did not see herself as an informal caregiver.

The narrative method was a valuable tool to clarify personal meaning, preferences and motivations of this person within her context before THA. This knowledge could help caregivers in applying shared decision-making and patient centered treatment and goal setting.

To develop our exercise program for our pilot RCT (**Chapter 6**) we used our practical experience combined with the current evidence to develop an intensive exercise program to improve preoperative functioning of frail elderly. In this training program, personal and environmental factors were taken into account. The training program took place at the own people's home and treatment goals were adapted to personal goals measured with the Patient Specific Complaints questionnaire. We managed to reach a high intensity in the training without adverse events and with good patient satisfaction. When compared to the first pilot RCT in our hospital, in which we evaluated a preoperative training program for frail elderly in the hospital, in our pilot RCT with exercises at home, we were able to reach a higher participation rate (70% vs 34%) and include people with worse functional status. TUG and Six Minutes' Walk Test (6MWT) scores were appropriate for the frail elderly population. We assume that the location (home) was the main reason for the successful inclusion of frail elderly because the former pilot RCT reported people were not willing to participate because traveling to the hospital to perform exercise was too tiring and often the availability of transport was a problem.

Because of the nature of the study (a pilot study) we were not able to draw conclusion about the effectiveness, but it was notable that we saw the most relevant changes on performance based measurements. Evaluation of preliminary effectiveness indicate preoperative clinical relevant differences on functional mobility (TUG, Δ 2.9 sec; 95% CI -0.9-6.6) and significant differences on walking ability (6MWT, Δ 41m; 95% CI 8-74) in favour of the intervention group. Taken together, these finding can be used to develop a personalized functional therapeutic exercise program for high-risk people, to be carried out in their own home and living context, with a content tailored to their personal abilities and goals and with sufficient content to achieve the necessary therapeutic effect. Such as program is feasible for even the frailest elderly and has the potential to optimize physical performance during the perioperative period, before and after THA.

Discussion and conclusion

In **Chapter 7**. we discuss the results and provide suggestions for practical implications and future research. The additional value of performances based measures in preoperative assessment is more and more supported by international literature and may help in future to indeed select those patients that are really at risk for functional

decline. Future research should focus on even more personalized risk models. Databases combining medical and functional data can help to develop and adapt personalized risk models and growth curves continuously.

Therapeutic exercise training for those high-risk patients is possible and promising to improve physical functioning after THA, but the findings from this thesis and current evidence also confirm the need to develop and evaluate better patient tailored high quality therapeutic training programs to improve physical functioning of frail older people with end-stage OA. Future research should focus on the optimal intensity to improve physical fitness of frail older people and on the influence of the context and family. Furthermore, tools to measure personal meaning in daily practice are needed.

Optimizing the pathway for people before and after THA require several changes in both the process (preoperative screening and training) and the context in which we should take into account these people's personal preferences, barriers and environment and make sure the patient's, professional team and hospital environment has a focus on promoting meaningful physical activity. With the findings of this thesis we can optimize our pathways and physiotherapy-interventions towards tailored personalized care with a focus on optimization of functioning of each individual before and after THA.

Samenvatting

Samenvatting

Hoofdstuk 1 is de introductie van dit proefschrift. In de huidige samenleving worden mensen steeds ouder en ouderen hebben vaak een of meerdere chronische ziektes. Ondanks hun beperkingen, willen deze mensen regie houden op hun eigen gezondheid, zelfstandig blijven wonen en blijven participeren in de samenleving. In dit opzicht gaat "gezondheid" over de mogelijkheid om zelf regie te houden en zich aan te kunnen passen aan de fysieke, sociale en emotionele uitdagingen in het leven. Een ziekenhuisopname en operatie, bijvoorbeeld het krijgen van een totale heupprothese (THA), is voor ouderen een dergelijke uitdaging. Voor kwetsbare ouderen kan dit een “major life event” zijn die ernstige gevolgen kan hebben voor hun dagelijks functioneren. Waar veel mensen vlot en naar tevredenheid herstellen na een operatie, komen sommige mensen veel moeilijkheden tegen in hun herstel. Helaas houden interventies om het fysiek functioneren te verbeteren voor en na THA niet altijd rekening met deze variatie in mensen en variatie in herstel. In dit proefschrift verkennen we het functioneren van mensen voor en na THA. Het doel is om te onderzoeken welke mensen risico lopen op vertraagd herstel van activiteiten (transfers en lopen) na de operatie, wat de rol is van de preoperatieve fysieke functie in deze risicoscreening en om een fysiotherapeutische interventie te verkennen die het pre- en postoperatief fysiek functioneren van hoog-risicopatiënten kan verbeteren.

De huidige evidence based practice

Om de huidige inhoud en effectiviteit van preoperatieve therapeutische trainings-programma’s te evalueren, is de beschikbare literatuur systematisch beoordeeld (**hoofdstuk 2**). Naast een gebruikelijke beoordeling van methodologische kwaliteit, is een beoordelingsschaal ontwikkeld voor therapeutische validiteit. De beoordelings-schaal werd ontwikkeld in een Delphi-onderzoek met vijf deskundigen. Therapeutische validiteit kan worden gedefinieerd als ‘de potentiële effectiviteit van een specifieke interventie in het licht van de potentiële patiënten doelgroep’. Experts bepaalden vijf gebieden als belangrijk voor de therapeutische validiteit van preoperatieve therapeutische training: patiënten selectie, therapeut en keuze van de behandel-omgeving, onderbouwing, inhoud en therapietrouw. De conclusie was dat geen van de 12 geïncludeerde studies voldeed aan onze criteria voor therapeutische validiteit. Vooral informatie over adequate selectie van patiënten, adequate dosering en monitoring ontbrak. Hierdoor is het onwaarschijnlijk is dat deze interventies relevante effecten konden sorteren.

Preoperatieve screening

Om de mensen die risico lopen op vertraagd herstel van activiteiten na een THA te detecteren werd een functionele screening toegevoegd aan de gebruikelijke (medische) screening in Ziekenhuis Gelderse Vallei. Gegevens uit deze functionele screening en de

medische status werden verzameld in een cohort van 315 mensen. Via regressieanalyse werd bepaald welke persoonsgebonden factoren geassocieerd waren met het herstel van de activiteiten na THA. Verder is onderzocht of het gebruik van 'performance based' testen een toegevoegde waarde heeft op het gebruik van meer conventionele factoren zoals leeftijd, comorbiditeit, body mass index (BMI) of geslacht en zelf-gerapporteerde informatie zoals de 'Risk Assesment and Predictor Tool' (RAPT).

In de analyses van de cohortstudie (**hoofdstuk 3**) is gebleken dat een combinatie van conventionele factoren en 'performance based' testen het best het herstel van activiteiten na THA kan voorspellen. Regressieanalyse met alle variabelen identificeerde oudere leeftijd (>70 jaar), comorbiditeit (Charnley score C), een trage loopsnelheid (een tien meter wandeltest in meer dan 10,0 seconden), en een slechte functionele mobiliteit (een Timed up and go (TUG) score van meer dan 10,5 seconden) als de beste voorspellers van vertraagd herstel van het postoperatief functioneren. Dit model met functionele maten (AUC 0.85, 95% CI 0.79-0.91) gaf een significant betere voorspelling (p=0.04) dan een model met alleen conventionele factoren (AUC 0.81, 95%CI 0.74-0.87). Geconcludeerd kan worden dat een screening van fysiek functioneren nodig is om mensen die risico lopen op vertraagd herstel te detecteren. Dit maakt het mogelijk tijdig preventieve interventies te starten voor deze kwetsbare groep.

In **hoofdstuk 4** is de interactie tussen obesitas en spierkracht, gemeten met een hand knijpkracht meting, en de associatie met postoperatief herstel na een THA onderzocht in hetzelfde cohort. Er bleek een interactie te zijn tussen spierkracht en BMI. De combinatie van spierzwakte en obesitas, passend bij sarcopene obesitas, bleek geassocieerd met vertraagd klinische herstel na een THA. Mensen met zowel spierzwakte en obesitas hebben een hoger risico na THA op een vertraagd herstel van activiteiten (OR 6.21, 95%CI 1.64-23.65) of een opnameduur langer dan 4 dagen (OR 3.59, 95%CI 1.09-11.89) vergeleken met mensen zonder overgewicht en spierzwakte. Dit is een interessante bevinding die inzicht kan geven in de rol van BMI in herstel na een THA en kan verklaren waarom huidige interventies zoals afvallen niet effectief blijken om negatieve uitkomsten na een operatie bij mensen met obesitas te voorkomen. Gewicht zegt niet alles; lichaamssamenstelling en spierfunctie geven een indicatie over gezondheid en voedingstoestand.

Preoperatieve training

In **hoofdstuk 5** is een hoog-risicopatiënt geselecteerd en een narratieve methode toegepast om inzicht te krijgen in 'persoonlijke betekenis' in relatie tot preoperatief fysiek functioneren van deze patiënt voor een THA. Binnen een case report hebben we als aanvulling op de functionele screening, deze narratieve analyse uitgevoerd aan de hand van de verhalen van drie personen betrokken bij een fysiotherapeutische interventie. De hoofdpersoon was Mevrouw A., een 76-jarige vrouw met ernstige artrose en comorbiditeit die op de wachtlijst staat voor een nieuwe heup. Daarnaast hebben zijn de verhalen van haar dochter en haar fysiotherapeut geanalyseerd. Met de

methode wordt gezocht naar motivaties, benodigde competenties en waarden. Uit de analyse bleek dat Mevrouw A. gemotiveerd was om leuke sociale activiteiten te ondernemen en onafhankelijk te blijven. Hoewel ze de competentie had om haar best te doen en activiteiten te ondernemen die haar trots maken, waren haar pijn en lichamelijke beperkingen anti-competenties die haar gemotiveerd hebben om de gezondheidszorg te benaderen (de orthopeed en later ook de fysiotherapeut). Hoewel de fysiotherapeut zich bewust leek van deze persoonlijke participatiedoelen, waren de behandeldoelen vooral gericht op het verbeteren en evalueren van lichaamsfuncties en activiteiten. De dochter wilde vooral een goede relatie met haar moeder en hoopte dat haar moeder in staat zou zijn om leuke activiteiten te doen. De dochter presenteerde zichzelf niet in de eerste plaats als een mantelzorger. De narratieve methode was een waardevolle toevoeging om persoonlijke drijfveren en waarden van mevrouw A., en verschillen tussen de betrokkenen, te verduidelijken binnen haar leefomgeving. Deze kennis kan zorgverleners helpen bij de toepassing van een patiëntgerichte behandeling en het stellen van participatiedoelen, passend bij de nieuwe definitie van gezondheid.

Hoofdstuk 6 beschrijft een preoperatief therapeutisch oefenprogramma gericht op het fysiek functioneren en de participatie van de hoog-risicopatiënten. In deze training werd rekening gehouden met persoonlijke- en omgevingsfactoren; de training vond thuis plaats en behandeldoelen werden aangepast aan persoonlijke voorkeuren en behoeften en geëvalueerd met de Patiënt Specifieke Klachtenlijst (PSK). We zijn erin geslaagd om een hoge trainingsintensiteit te behalen zonder bijwerkingen en met een goede tevredenheid van de patiënt.

Vergeleken met een pilot RCT waarin in het ziekenhuis werd getraind, was de participatie van kwetsbare ouderen bij deze training aan huis veel hoger (70% vs 34%). De scores op de testen voor functionele mobiliteit (TUG) en loopvaardigheid/conditie (Zes Minuten Wandeltest, 6MWT) bevestigden de inclusie van kwetsbare ouderen met een slechte fysieke fitheid.

Vanwege de aard van het onderzoek (een pilotstudie) waren we niet in staat om conclusies te trekken over de effectiviteit, maar de meest relevante veranderingen werden gezien op de ‘performance-based’ metingen. Er waren klinisch relevante verschillen op de functionele mobiliteit (TUG, Δ 2.9 sec; 95% CI -0.9-6.6) en significante verschillen op loopvaardigheid/ conditie (6MWT, Δ 41m; 95% CI 8-74) in het voordeel van de interventiegroep.

Discussie en conclusie

Hoofdstuk 7 bevat een algemene discussie van de resultaten en geeft suggesties voor praktische implicaties en toekomstig onderzoek.

De toegevoegde waarde van de performance based testen in de preoperatieve screening wordt steeds meer ondersteund door de internationale literatuur en kan in de toekomst helpen patiënten die risico lopen op functionele achteruitgang rondom een operatie te selecteren. Toekomstig onderzoek moet zich nog meer richten op

gepersonaliseerde risicomodellen. Het aanleggen van grote databases kan helpen om deze gepersonaliseerde risicomodellen, maar ook bijvoorbeeld groeicurves voor het functioneren, te ontwikkelen en continue aan te passen. Intensieve therapeutische oefentherapie voor hoog-risicopatiënten is goed haalbaar en veelbelovend om fysiek functioneren voor en na THA te verbeteren. De bevindingen uit dit proefschrift bevestigen tevens de noodzaak voor het ontwikkelen en evalueren van een therapeutische training van goede therapeutische validiteit om fysiek functioneren van kwetsbare ouderen met artrose te verbeteren. De informatie en kennis uit deze thesis kunnen worden gebruikt om een deze thuistraining te ontwikkelen, waarbij de inhoud afgestemd wordt op de persoonlijke mogelijkheden en doelstellingen van de patiënt. Toekomstig onderzoek moet zich richten op het bepalen van de optimale intensiteit van de oefentherapie en op de rol en invloed van familie en omgeving.

Optimaliseren van het zorgpad voor mensen vóór en na THA vereist een aantal veranderingen in zowel het proces (preoperatieve screening en training) en de context waarin we rekening moeten houden met persoonlijke voorkeuren, barrières en omgeving. Zowel de patiënt, het professioneel team en het ziekenhuis hebben een omgeving nodig waarin fysieke activiteit wordt gestimuleerd. Met de bevindingen van dit proefschrift kunnen we onze zorgpaden en (p)revalidatie optimaliseren waarbij het fysiek functioneren van elk individu in de eigen omgeving de leidraad is.

Dankwoord

Dankwoord

Net als voor patiënten die hun fysiek functioneren willen optimaliseren, zijn de persoonlijke omstandigheden en omgeving zeer belangrijk voor mij geweest bij het schrijven van dit proefschrift en het 'optimaliseren' van mijn wetenschappelijke vaardigheden. Vele mensen om mij heen waren en zijn een inspiratiebron, hebben mij geholpen of zijn een grote steun geweest. Die mensen wil ik graag bedanken.

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Over de auteur

Over de auteur

Ellen Oosting is op 1 september 1977 geboren in Oosterhesselen. Na het afronden van het VWO in Coevorden heeft ze Fysiotherapie gestudeerd in Groningen van 1995 tot 1999. Na het afstuderen heeft ze in enkele praktijken gewerkt in Groningen en omgeving. In 2006 startte ze met de opleiding Fysiotherapiewetenschappen aan de Universiteit van Utrecht en ze ronde deze Master of Science met succes af in 2010. Vanaf 2007 werkt ze Ziekenhuis Gelderse Vallei, vooral op de afdeling orthopedie. Naast haar werk als fysiotherapeut, was ze betrokken bij diverse interdisciplinaire en transmurale zorgvernieuwingsprojecten met als doel het zorgpad voor de mensen die een nieuwe heup of knie krijgen te verbeteren. Het verbeteren van het fysiek functioneren, van met name de kwetsbare ouderen, rondom een ziekenhuisopname en operatie, het zorgdragen voor goede samenwerking en continuïteit van zorg in de transmurale keten en de vertaling van onderzoek naar praktijk, hebben daarbij haar interesse. Vanaf 2008 is ze betrokken bij het wetenschappelijk onderzoek naar de meerwaarde van preoperatief trainen in Ziekenhuis Gelderse Vallei en heeft hieraan invulling geven voor de orthopedische operaties. Ook heeft ze een bijdrage geleverd aan de landelijke ontwikkelingen van “Better in, better out”. Al deze praktijkgerichte onderzoeksactiviteiten hebben geleid tot het schrijven van dit proefschrift. De resultaten van dit proefschrift zijn zowel lokaal, nationaal als internationaal gedeeld, onder andere op het congres van de European Union Geriatric Medicine Society (EUGMS), het European League Against Rheumatism congres (EULAR) en het World Confederation for Physical Therapy congres (WCPT).

De auteur woont samen met Vincent Verhoeven en hun vier kinderen, Sofie, Bram, Lotte en Matthijs.