Recovery after total hip or knee arthroplasty

physical and mental functioning

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CONTENTS

Chapter 1

General Introduction

Musculoskeletal complaints are extremely common and have important consequences for the individual and society. The most prevalent chronic musculoskeletal disease is osteoarthritis (OA). OA is a disease of the articular joint and can lead to severe disability. In Western adult populations it is one of the most frequent causes of pain and stiffness, loss of function and disability[1]. With regard to the major joints, OA is most prevalent in the knee and hip joint[2].

In the Netherlands, in 2007 about 312,000 persons had knee OA and 238,000 persons had hip OA[3]. Based on demographic development it is expected that the absolute number of persons with OA will increase by about 52% between 2007 and 2040. If the expected increase of patients with obesity is also taken into account, the prevalence of OA will become even greater[3].

The initial treatment of OA consists of pain medication, physical therapy, and lifestyle recommendations[4]. These treatments aim to suppress the symptoms and to improve or maintain functioning. When conservative treatment fails to alleviate pain and dysfunction caused by knee or hip OA, total knee arthroplasty (TKA) and total hip arthroplasty (THA) are cost-effective surgical options that can provide significant pain relief and improvement in physical functioning[4,5].

The number of TKA and THA procedures performed in the Netherlands has increased substantially in the last decades. Between 1996 and 2008 the annual number of TKAs placed in the Netherlands in patients with a primary diagnosis of OA increased from 4,046 to 11,881, an increase of almost 300%. During this same period, the number of THAs placed in the Netherlands increased from 16,803 to 17,401 procedures[6]. Because of the aging of the Western population, together with the increasing number of people with overweight and the improvements in surgical techniques, these numbers are expected to increase even further[7].

PHYSICAL FUNCTIONING

Relevance

Evaluation of the results of TKA and THA has traditionally focused on mortality rates, surgical and technical aspects, survival rates, and assessment by the treating surgeon. More recently, patient-reported health outcomes, such as pain relief, joint function and health-related quality of life after TKA and THA are increasingly reported[8].

Today's patients (who tend to be younger and more active) have high expectations regarding functional outcome after TKA and THA[9-11]. For many patients, an important goal of surgery is the ability to return to a relatively high level of physical functioning[9]. If such expectations are not met, they may still be dissatisfied with the outcome of a technically successful procedure. Therefore, patients need to be well (and realistically) informed about the potential recovery of physical functioning after TKA and THA. To achieve this goal, surgeons must have accurate knowledge on the recovery of physical functioning after TKA and THA. Therefore, current research focuses not only on pain relief, joint function and health-related quality of life, but also on the recovery of physical functioning after TKA and THA.

Aspects of physical functioning

Physical functioning is a multi-dimensional concept covering various aspects of health. Based on the International Classification of Functioning Disability and Health[12] and characteristics of currently used instruments, three aspects can be distinguished. A first aspect is self-reported or perceived (problems in) daily functioning. Perceived problems with, for example, walking, chair rising, and stair climbing are assessed with *questionnaires*. A second aspect is functional capacity to perform activities in a (semi-) laboratory setting. *Functional tests*, such as how many meters a patient can walk in six minutes (six-minute walk test) and how much time they need to perform five chair rising movements, are used. A third aspect is actual daily activity in the natural environment, measured with *pedometers or activity monitors*. This aspect describes how active patients are in their natural environment, and how they perform the different activities, e.g. how fast they walk or rise from a chair.

Because studies have shown a low correlation between these three aspects of physical functioning, it can be assumed that they cover different aspects of physical functioning. Thus, when examining the recovery of physical functioning after TKA and THA all three aspects need to be evaluated[13,14].

PSYCHOLOGICAL FACTORS RELATED TO THE RESULTS OF JOINT ARTHROPLASTY

In general the results after TKA and THA are good. However, a subset of patients has suboptimal postoperative improvement in pain, physical functioning, and quality of life. Furthermore, after THA dissatisfaction rates up to 16% are reported[15,16] and after TKA even more patients are dissatisfied, with reported dissatisfaction rates up to 27%[17-22]. In these studies the suboptimal results and patient dissatisfaction could not be completely explained by patient characteristics, adverse events, physical co-morbidities or the surgery itself, but seemed to be related to some other characteristics[23].

One of the characteristics that could be related to suboptimal outcome and dissatisfaction after TKA and THA are psychological characteristics. In the elderly, psychological disorders are also highly prevalent and closely related to pain and disability[24]. In patients with OA psychological disorders were found to be associated with increased pain sensitivity and less effective coping with the illness. Moreover, psychological disorders have an impact on motivation, energy, and the adherence of patients[25]. Therefore, the influence of psychological characteristics on the treatment results of OA and rehabilitation after TKA and THA should also be evaluated.

From the literature, it seems that physical and mental aspects have an influence on patient satisfaction after TKA and THA. Knowledge of which factors contribute to patient satisfaction is important, because that knowledge can be used to improve the care for patients undergoing TKA and THA.

BACKGROUND OF THIS THESIS

The rationale for some of the studies presented in this thesis is based on the work performed earlier by De Groot et al.[26,27]. These latter studies showed that patients on the waiting list for TKA and THA are significantly and clinically relevantly less active than healthy matched controls measured with an accelerometry-based Activity Monitor (AM). Six months post-surgery the patient's level of daily activity showed no clinically relevant improvement, despite improvements in perceived functioning and functional capacity. To date, it is still unclear why patients do not improve on the aspect of actual daily activity, whilst they perceive fewer problems with physical functioning and their functional capacity has improved.

Two possible explanations for this are examined in this thesis. Firstly, patients may perform activities in daily life faster and/or for a longer period of time, indicating a better level of functioning, although the total amount of physical activity has not changed. Secondly, six months might be too short a period for TKA and THA patients to change their actual physical activity level. Patients have suffered from OA for many years and might have adapted their lifestyle to the limitations caused by the disease. After surgery most of these limitations are no longer present, but it might take longer than six months to adapt to the new situation.

Apart from evaluating the recovery of physical functioning after TKA and THA, we also examined the influence of psychological characteristics on the treatment of OA and on rehabilitation after TKA and THA. Several studies reported that patients with psychological symptoms have a worse outcome after TKA and THA compared with those without such symptoms. However, so far, a structured overview is missing which addresses important questions such as: *Which psychological symptoms influence the outcome of TKA and THA?* and *How much influence do these psychological symptoms have on the outcome of TKA and THA*? Answers to these questions could help to inform patients and guide their decision as to whether this influence is strong enough to warrant surgical intervention. Furthermore, it remains unclear how many patients with end-stage OA of the knee and hip have psychological disorders, and whether this prevalence changes after TKA and THA. This thesis also addresses these questions.

Finally, because patient satisfaction is one of the ultimate goals of all orthopaedic procedures, optimization is of major importance. Compared to hip arthroplasty, patients undergoing knee arthroplasty are generally less satisfied[15-22]. Knowledge of which factors contribute to patient satisfaction can also help to improve the care for TKA patients. Therefore, the final question addressed in this thesis, is whether the different aspects of physical and mental functioning are related to patient satisfaction after TKA.

AIM OF THIS THESIS

The first aim of this thesis is to evaluate why the aspect 'actual daily activity' did not improve six months post-surgery, despite improvement of the two other aspects of physical functioning.

The second aim is to evaluate the relationship between psychological characteristics and the treatment of OA, and the recovery after both TKA and THA.

The final aim of this thesis is to examine whether the different aspects of physical and mental functioning are related to patient satisfaction six months after TKA.

OUTLINE OF THIS THESIS

The overall objective of the studies described in this thesis is to examine and determine the recovery of physical and mental functioning after TKA and THA.

DESCRIPTION OF CHAPTERS

Chapter 2 presents a systematic review of the state of knowledge regarding the recovery of physical functioning after THA. Furthermore, we examine whether the different aspects of physical functioning (perceived daily functioning, functional capacity, and actual daily activity) show the same pattern of recovery after THA.

Chapter 3 investigates whether the aspect 'actual daily activity' in the natural environment improves six months after THA in terms of how patients perform the individual activities. In addition, we examine how the performance of both end-stage hip OA patients and THA patients relates to that of healthy matched controls. In **Chapter 4** we investigate these same questions for the knee (TKA) population.

Chapter 5 examines the long-term (four years) recovery of physical functioning after TKA and THA as measured on the different aspects of physical functioning.

Chapter 6 presents a summary of the literature on the influence of preoperative psychological characteristics on the outcome of TKA and THA.

Chapter 7 examines the prevalence of two important psychological disorders, i.e., depressive and anxiety disorders, in patients on the waiting list for TKA and THA and also at three months after TKA and THA.

Chapter 8 evaluates whether the different aspects of physical and mental functioning are related to patient satisfaction six months after TKA.

Finally**,** in **Chapter 9**, we discuss the most important results of these studies, as well as their limitations and their implications for future research.

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Chapter 2

Recovery of physical functioning after total hip arthroplasty: systematic review and meta-analysis of the literature

Vissers M.M., Bussmann J.B.J, Verhaar, J.A.N., Arends L.R., Furlan A.D., Reijman M.

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ABSTRACT

Background. After total hip arthroplasty (THA), patients today (who tend to be younger and more active than those who previously underwent this surgical procedure) have high expectations regarding functional outcome. Therefore, patients need to be well informed about recovery of physical functioning after THA.

Purpose. The purpose of this study was to review publications on recovery of physical functioning after THA and examine the degree of recovery with regard to 3 aspects of functioning (i.e., perceived physical functioning, functional capacity to perform activities, and actual daily activity in the home situation).

Data sources. Data were obtained from the MEDLINE and EMBASE databases from inception to July 2009, and references in identified articles were tracked.

Study Selection. Prospective studies with a before-after design were included. Patients included in the analysis had to have primary THA for osteoarthritis.

Data extraction and Synthesis. Two reviewers independently checked the inclusion criteria, conducted the risk of bias assessment, and extracted the results. Data were pooled in a meta-analysis using a random-effects model.

Results. A total of 31 studies were included. For perceived physical functioning, patients recovered from less than 50% preoperatively to about 80% of that of controls (individuals who were healthy) 6 to 8 months postsurgery. On functional capacity, patients recovered from 70% preoperatively to about 80% of that of controls 6 to 8 months postsurgery. For actual daily activity, patients recovered from 80% preoperatively to 84% of that of controls at 6 months postsurgery.

Limitations. Only few studies were retrieved that investigated the recovery of physical functioning longer than 8 months after surgery.

Conclusions. Compared with the preoperative situation, the 3 aspects of physical functioning showed varying degrees of recovery after surgery. At 6 to 8 months postoperatively, physical functioning had generally recovered to about 80% of that of controls.

INTRODUCTION

When conservative treatment fails to alleviate pain and dysfunction of the hip caused by osteoarthritis (OA), total hip arthroplasty (THA) is a cost-effective surgical treatment that can provide significant pain relief and improvement in physical functioning[1]. Evaluation of the results of THA traditionally has focused on mortality rates, surgical and technical aspects, survival rates, and assessment by the treating surgeon[2,3]. More recently, patient-reported health outcomes, such as pain relief, joint function, health-related quality of life, and patient satisfaction after THA, are increasingly reported[4-6].

Besides these aspects, it is important to analyse physical functioning because limitations in physical functioning are directly related to OA and THA. These limitations also are associated with decreased quality of life, increased risk of disability or depression, and increased health care costs[7]. Furthermore, patients today (who tend to be younger and more active than those who previously underwent this surgical procedure) have high expectations regarding functional outcome after THA[8]. For many patients, an important goal of surgery is the ability to return to a higher level of physical functioning[8]. However, a discrepancy often exists between expectations of the patients and those of the surgeon[9]. Therefore, patients need to be well informed about potential recovery of physical functioning after THA.

Physical functioning is a multi-dimensional construct covering various aspects of health. Based on the *International Classification of Functioning, Disability and Health*[10] and characteristics of currently used instruments, the aspects examined in the present study were: 1) perceived problems in daily functioning, as measured with questionnaires, 2) functional capacity to perform activities in a laboratory setting or outpatient clinic, as measured with capacity tests, and 3) actual daily activity in the home situation, as measured with pedometers or activity monitors. Previous studies have shown that self-reported physical functioning and more quantitatively measured physical functioning not only differ, but also measure different aspects of physical functioning. Therefore, it is important to evaluate the recovery of physical functioning based on these different aspects[11-13].

The aim of the present study was to examine whether the 3 aspects of physical functioning showed different degrees of recovery after THA. Therefore, we identified and summarized studies with a prospective design and a minimum follow-up of 6 weeks that evaluated the recovery of physical functioning after primary THA for OA.

MATERIALS AND METHODS

Data sources and searches

A search for relevant studies was performed in MEDLINE and EMBASE from their inception to July 2009. The terms of the search strategy were combined with a part of the search strategy for nonrandomized studies based on the study of Furlan et al.[14]. The search strategy used in the current study is shown in Appendix 1.

Citation tracking was performed by manually screening the reference lists of eligible studies. In addition, personal communication with content experts took place.

Study selection

Two reviewers (MV, MR) assessed the studies to confirm that they met the following inclusion criteria:

1. Patients in the study had to have a primary THA for OA.
2. The study must be a prospective study with a before-after design, with measurementstaken at fixed time points (all patients were seen at the same follow-up time, with a small range in time), and with a minimum follow-up period of 6 weeks.
3. The study must have measured at least one of the following outcomes:

- o Perceived problems in daily functioning using validated questionnaires for patients with hip conditions. These validated questionnaires were the Western Ontario and McMaster University Osteoarthritis Index physical functioning subscale (WOMAC-PF), the Medical Outcomes Study Short-Form Health Survey physical functioning subscale (SF-36-PF), the Oxford Hip Score, and the Arthritis Impact Measurement Scales physical activity scale (AIMS-PA).

  OR
- o Functional capacity to perform activities in a laboratory setting or outpatient clinic with: (1) a capacity test of the activities of walking, rising from a chair, and climbing stairs or (2) gait analysis with temporal-spatial outcome variables such as speed, cadence, and stride length (kinematic outcome variables were not included).

  OR
- o Actual daily activity in the home situation using activity monitoring, with devices such as pedometers or accelerometry-based activity monitors.

4. Full text of the article had to be available.
5. The article had to be written in English, German, or Dutch.
6. The original preoperative and postoperative data had to be available.

Disagreements regarding inclusion were resolved by discussion; the final decision of a third reviewer (JV) was not necessary.

Risk of bias assessment

For the aims of this study, it was important that studies measured physical functioning before and after THA. Because not all before-after studies have a separate control group, the existing risk of bias assessment tools could not be used in this systematic review. Therefore, we developed our own risk of bias assessment tool based on published quality assessment tools and with the help of an expert (AF)[15-17]. The risk of bias of the studies was evaluated using a checklist consisting of 13 items divided among 3 subscales (Appendix 2). Two reviewers (MV, MR) assessed the risk of bias independently from each other. Disagreements on risk of bias were resolved by discussion; the final decision of a third reviewer (JV) was not necessary.

Data extraction

Two reviewers (MV, MR) independently extracted the study characteristics, follow-up times, and clinical outcome measures using a pretested standardized form**.** The data extraction form was pre-tested using 5 articles, followed by a consensus meeting. No adaptations to the data extraction form were found to be necessary. Agreement on data extraction was reached by consensus.

Data analysis

A trained statistician (LA) performed the meta-analysis of weighted means using Comprehensive Meta-analysis software version 2.2. Data were pooled in a meta-analysis using a random effects model. Sufficient data were available to pool the results for the WOMAC-PF, SF-36-PF, and walking speed measured with gait analysis. The results of the WOMAC-PF were first normalized to a score of 0 to 68, with 0 representing the best possible score. The results of studies that did not present standard deviations (SDs) or standard errors (SEs) were not included in the meta-analysis. Data were pooled for the following time periods: preoperative, 1 to 3 months postoperative, 6 to 8 months postoperative, and 12 months postoperative. A *t* test was used to examine statistical differences between the different time points. In cases where different articles covered results from the same study population, data from only one article were pooled. Only studies with a minimum follow-up of 6 weeks were included in this review. Of the included studies, the results of all follow-up assessments have been used. Studies that had a follow-up assessment at 1 month postsurgery also had a follow-up assessment at 6 weeks postsurgery at a minimum.

For the outcome measurements, results from patients were compared with reference values or with results from a control group of individuals who were healthy. For the WOMAC-PF, we used the reference value of 1.8 scored by participants with a mean age of 69 years (range = 58-96) and without prior joint arthroplasty surgery and no lower-extremity complaints[18]. For the SF-36-PF, we used the reference value of 76 obtained from age-matched controls in the Netherlands[19]. For the walking speed, we used the weighted mean of the walking speed measured in age-matched controls in 3 of the included studies[20-22]. The actual daily activity was measured in only one study, and that study also measured actual daily activity in age-matched controls.

RESULTS

Of the 1,398 abstracts identified using the search strategy, 31 met all of the inclusion criteria (Figure 1). The main reasons for excluding abstracts were: no prospective study with a before-after design, no follow-up period of minimally 6 weeks, no primary THA for OA, and no original data available after contact with author(s). Table 1 presents the characteristics of the 31 included studies. The number of patients in the studies ranged from 11 to 7,151. The total number of patients covered by this review was 9,890 (Table 1).

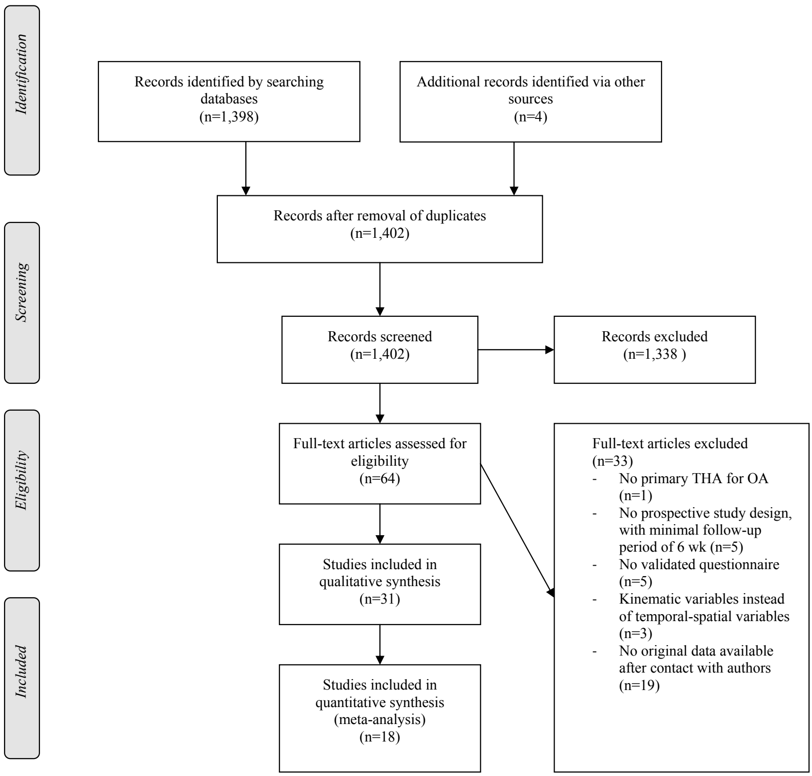

Figure 1. Flow chart of the selection of studies for the present meta-analysis. THA = total hip arthroplasty; OA = osteoarthritis

Table 1 Information on the included studies[a]

Study, Year of Publication, and Country	No. of Patients	Age, (y)	BMI, (kg/m^2)	Gender, % Women	Maximum Follow-up in Months (No. of Follow- up Assessments)	Measurement	Study Design	Risk of Bias Assessment Total score (13 items)
Ajemian et al,[45] 2004, Canada	11	62.6 (8.6)	NR	18	8 (1)	Gait analysis	Prospective cohort	6
Bachrach-Lindström et al,[30] 2008, Sweden	229	69.5 (10.0)	NR	49	12 (1)	WOMAC-PF	Prospective cohort	10
Bennett et al,[20] 2006, Ireland	17	60.4 (6.0)	NR	35	1.5 (1)	Gait analysis	Prospective cohort	8
Berge et al,[26] 2004, United Kingdom	40	71.3 (6.05)	NR	68	12 (2)	Capacity test (Four-Minute Walk Test)	RCT	9
Boardman et al,[31] 2000, United States	30	65 (range = 38-85)	NR	NR	12 (1)	WOMAC-PF Capacity test (Six-minute Walk Test) Gait analysis	Prospective cohort	8
Brown et al,[46] 1980, United States	29	56 (range = 21-73)	NR	66	36 (4)	Gait analysis	Prospective cohort	6
Busija et al,[32] 2008, Sweden	274	70.5 (8.9)	NR	53	60 (2)	SF-36-PF	Prospective cohort	7
Chiu et al,[33] 2000, Taiwan	46	52 (17)	NR	46	6 (1)	SF-36-PF	Prospective cohort	9
Chiu et al,[34] 2001, Taiwan	76	NR	NR	47	12 (2)	SF-36-PF	Prospective cohort	8
Dawson et al,[35] 1996, United Kingdom	186	69.4 (3.5)	NR	63	6 (1)	SF-36-PF Oxford Hip Score	Prospective cohort	7
Dawson et al,[36] 1996, United Kingdom	173	70.5 (range = 38-89)	NR	63	6 (1)	SF-36-PF Oxford Hip Score AIMS-PA	Prospective cohort	8
Dorr et al,[23] 2007, United States	60	67.0 (11.8)	28.9	48	3 (2)	Gait analysis	RCT	9
Fitzpatrick et al, [37] 2000,United Kingdom	7,151	67.8 (10.9)	NR	60	12 (2)	Oxford Hip Score	Prospective cohort	8

Fortin et al,[38] 1999, United States and Canada	220[b]	67.0 (9.0)	NR	49	6 (2)	WOMAC-PF SF-36-PF	Prospective cohort	8
Gilbey et al,[28] 2003, Australia	68	65.2 (11.0)	27.9 (4.1)	62	6 (2)	WOMAC-PF	RCT	6
de Groot et al,[39] 2008, The Netherlands	36	61.5 (12.8)	26.6 (4.2)	64	6 (2)	WOMAC-PF SF-36-PF Capacity test (Six-Minutes Walk Test, timed chair rising test, timed stair climbing test) Actual physical activity	Prospective cohort	10
Huber et al,[40] 2006, Switzerland	73	66.8 (9.9)	27.4 (4.5)	47	24 (2)	SF-36	Prospective cohort	9
Laupacis et al,[41] 1993, Canada	188	64 (range = 40-75)	NR	48	24 (4)	WOMAC-PF Capacity test (Six- Minute Walk Test)	Prospective cohort	8
Laupacis et al,[24] 2002, Canada	250	64	NR	48	12 (3)	Capacity test (Six-Minute Walk Test)	RCT	7
Leuchte et al,[21] 2007, Germany	32	61.2 (7.7)	27.7 (3.5)	NR	7 (4)	Gait analysis	Prospective cohort	8
Lindemann et al,[42] 2006, Germany	17	67.2 (5.25)	29.7 (3.55)	47	3 (1)	WOMAC-PF Gait analysis	Prospective cohort	10
McBeath et al,[47] 1980, United States	60	66.3 (6.7)	NR	NR	36 (4)	Gait analysis	Prospective cohort	6
Rooks et al,[27] 2006, United States	63	62.0 (9.0)	29.3 (7.2)	58	6.5 (2)	WOMAC-PF SF-36-PF Capacity test (Timed "Up &Go" Test)	RCT	9
Salmon et al,[43] 2001, United Kingdom	107	69 (11)	NR	65	6 (2)	WOMAC-PF SF-36-PF	Prospective cohort	6
Shrader,[48] 2009, United States	14	50.8 (7.5)	NR	36	3 (1)	Gait analysis	Prospective cohort	8

Stauffer et al,[49] 1974, United States	25	63	NR	NR	6 (1)	Gait analysis	Prospective cohort	6
Unver et al,[29] 2004, Turkey	51	49.4	NR	NR	3 (1)	Capacity test (Six-Minutes Walk Test)	RCT	9
Van den Akker-Scheek et al,[22] 2007, The Netherlands	63	62.0 (12.6)	26.4 (3.3)	68	6 (2)	Gait analysis	Prospective cohort	9
Van den Akker-Scheek et al,[44] 2008, The Netherlands	75	62.7 (11.7)	26.6 (3.4)	71	6.5 (2)	WOMAC-PF	Prospective cohort	10
Vendittoli et al,[25] 2006, Canada	210	49.8	28.4	35	12 (3)	WOMAC-PF	RCT	9
Wall et al,[50] 1980, United Kingdom	16	NR	NR	63	12 (2)	Gait analysis	Prospective cohort	5

[a] Results are presented as mean (SD) unless otherwise indicated. Abbreviations: BMI = Body Mass Index, NR = not reported, RCT = randomized controlled trial, WOMAC-PF = Western Ontario and McMaster Universities Osteoarthritis Index physical functioning subscale, SF-36-PF = Medical Outcomes Study 36-item Short-Form Health Survey questionnaire physical functioning subscale, AIMS-PA = Arthritis Impact Measurement Scales physical activity scale.
[b] The presented characteristics of this study also included patients with knee conditions

For this systematic review, we included studies with a before-after design. Prospective cohort studies (n = 24) and randomized controlled trials (RCTs) (n = 7) were included. Of the 7 RCTs, 3 studies evaluated the differences between 2 types of arthroplasty[23-25], 1 study evaluated a preoperative pain intervention[26], 1 study evaluated a preoperative exercise intervention[27], 1 study evaluated a preoperative and postoperative exercise intervention[28], and 1 study evaluated a postoperative rehabilitation intervention[29] (Table 1).

Perceived problems in daily functioning were measured in 18 studies[25, 27, 28, 30-44], functional capacity to perform activities in a laboratory setting or outpatient clinic was measured in 16 studies[20-24, 26, 29, 31, 39, 42, 45-50], and actual daily activity in the home situation was measured in 1 study [39] (Table 1). Tables 2, 3 and 4 present the results (mean and SEs) of the studies.

Risk of bias assessment

The mean score on the risk of bias assessment tool was 8 (range = 5-10). Of all studies, 77% (24 of 31) scored positive on 50% or more of the questions (Table 1).

In all studies, the main outcomes were clearly described in the "Introduction" or "Methods" section, the main outcomes measures were accurate, and the statistical analyses were preplanned. Only 3 studies described the characteristics and proportion of patients lost to follow-up. In only 6 studies were the individuals who gave consent to participate representative of the entire population from which they were recruited. Finally, in only 8 studies were the individuals who were invited to participate in the study representative of the entire population from which they were recruited (Appendix 3).

Perceived physical functioning

The perceived physical functioning of the patients was measured with the WOMAC-PF in 11 studies, with the SF-36-PF in 10 studies, with the Oxford Hip Score in 3 studies, and with the AIMS-PA in 1 study (Table 1).

Because scoring of the WOMAC was not uniform in all studies (e.g., 5-point Likert scale, visual analogue scale, or numeric scale with scores ranging from 0 to10), only results of studies using a 5-point Likert scale (range of scores = 0 - 4) were pooled (Table 2). The mean pooled WOMAC-PF score showed a significant decrease from 35.75 (SE = 1.54) preoperatively to 18.00 (SE = 3.36) at 1 to 3 months postsurgery ($P = 0.0003$) and to 12.76

Table 2. Data on self-reported physical functioning: Western Ontario and McMaster University Osteoarthritis Index physical functioning subscale (WOMAC-PF)[a] .

Study	preoperative		1-3 months postsurgery		6-8 months postsurgery		12 months postsurgery	
	mean	SE	mean	SE	mean	SE	mean	SE
Boardman et al[31]	35.60	2.14	-	-	-	-	9.30	1.88
Fortin et al[38]	37.30	0.53	-	-	13.70	0.69	-	-
Gilbey et al[28]	33.90	0.26	10.90	0.24	7.17	0.18	-	-
De Groot et al[39]	46.92	1.89	23.80	1.88	21.76	1.62	-	-
Rooks et al[27]	29.44	1.52	12.85	1.08	5.35	0.71	-	-
Salmon et al[43]	30.93	0.82	24.28	0.77	14.89	0.97	-	-
Van den Akker-Scheek et al[44]	36.11	1.30	18.50	1.35	14.69	1.17	-	-
Pooled results	**35.75**	**1.54**	**18.00**	**3.36**	**12.76**	**1.98**	-	-
Bachrach-Lindström et al[30, b]	45.20	-	-	-	-	-	5.10	-
Laupacis et al (10 cm VAS score; 0 best)[41,b]	6.00	0.12	1.70	-	1.20	-	0.80	-
Lindemann et al (range 0-100; 0 best)[42,b]	76.88	6.90	25.82	5.41	-	-	-	-
Vendittoli et al[25,b]	36.50	-	13.30	-	8.60	-	7.10	-

[a] WOMAC-PF range of scores = 0-68; lowest scores indicates best functioning. SE = standard error, VAS = visual analog scale.

[b] Results of these studies were not included in this meta-analysis because a different scoring method was used.

(SE = 1.98) (*P*=0.0001) at 6 to 8 months postsurgery. The difference in scores between 1 to 3 postsurgery and 6 to 8 months postsurgery was not significant. Forest plots of the pooled results are presented in Appendix 4.

The scoring method of the SF-36-PF subscale was similar in all studies. The score ranges from 0 to 100, with higher scores representing better functioning. The pooled SF-36-PF score increased from 30.92 (SE = 3.69) preoperatively to 49.93 (SE = 12.49) at 1 to 3 months postsurgery (*P*=0.085) and to 63.04 (SE = 4.17) at 6 to 8 months postsurgery (*P*=0.0001) (Table 3). Forest plots of the pooled results are presented in Appendix 4.

The Oxford Hip Score was scored in a similar way in all 3 studies. The score ranges from 12 to 60, with higher scores denoting worse pain and function. Preoperatively, the Oxford Hip Score ranged from 43.6 (SE = 6.6) to 44.5 (SE = 7.5); at 12 months postsurgery, the score had improved to 21.5 (SE = 9.0). The AIMS-PA was used in only 1 study; the score ranges from 0 to10, with a lower score representing better functioning. The mean preoperative score was 8.8 (SE = 1.4), and the mean score at 6 months postsurgery was 5.6 (SE = 2.8).

Table 3. Data on self-reported physical functioning: Medical Outcomes Study 36-Item Short-Form Health Survey Questionnaire physical functioning subscale (SF-36-PF)[a]

Study	preoperative		1-3 months postsurgery		6-8 months postsurgery		12 months postsurgery		24 months postsurgery		60 months postsurgery	
	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
Busija et al[32]	30.70	1.66	-	-	60.50	1.82	-	-	-	-	57.6	2.25
Chiu et al[34]	49.30	2.49	-	-	73.70	1.92	-	-	-	-	-	-
Dawson et al[36]	17.20	1.19	-	-	50.20	2.07	-	-	-	-	-	-
Fortin et al[38]	26.30	1.38	-	-	60.00	1.67	-	-	-	-	-	-
De Groot et al[39]	33.00	3.40	60.00	3.19	70.00	3.40	-	-	-	-	-	-
Huber et al[40]	30.70	2.13	63.80	2.72	-	-	-	-	70.2	2.72	-	-
Rooks et al[27]	42.70	2.28	56.40	2.80	79.20	2.31	-	-	-	-	-	-
Salmon et al[43]	18.58	1.92	19.78	1.65	47.84	2.74	-	-	-	-	-	-
Pooled results	**30.92**	**3.69**	**49.93**	**12.49**	**63.04**	**4.17**	-	-	-	-	-	-
Chiu et al[33, b]	43.80	3.36	-	-	73.80	2.57	76.9	2.17	-	-	-	-
Dawson et al[35, b]	17.80	-	-	-	19.50	-	-	-	-	-	-	-

[a] SF-36-PF range of scores = 0-100; highest score indicates best functioning. SE = standard error.
[b] Results of these studies were not included in this meta-analysis because we pooled only one study when different articles were published using the same study population.

Functional capacity to perform activities

The functional capacity to perform activities was measured with gait analysis in 12 studies and with other capacity tests in 6 studies (walking capacity test in 6 studies, rising from a chair capacity test in 2 studies, and stair climbing capacity test in 1 study).

Gait analysis was performed with different devices, including videos, a gait evaluation mat, a stride analyzer, forceplates, and systems based on body-fixed sensors such as accelerometers and gyroscopes.

Walking speed was measured in 11 studies. One study was not added to the pooled data because the data were normalized and results could not be compared with those of other studies[20], and another study did not present standard deviations or SEs[46].Thus, the results of 9 studies were pooled. Walking speed increased from 0.90 m/s (SE = 0.048) preoperatively to 1.026 m/s (SE = 0.043) at 1 to 3 months postsurgery (P=0.086) and to 1.082 m/s (SE = 0.048) at 6 to 8 months postsurgery (P=0.046) and decreased to 1.032 m/s (SE = 0.072) at 12 months postsurgery (P=0.198) (Table 4). Forest plots of the pooled results are presented in Appendix 4.

Stride length was measured in 5 studies; however, because only 2 studies had a follow-up period of 3 months or longer, the data were not pooled. Stride length ranged from 0.79 m (SE = 0.052) to 1.20 m (SE = 0.037) preoperatively and from 1.07 m (SE = 0.044) to 1.26 m (SE = 0.025) at 6 to 8 months postsurgery (Table 4).

Cadence was measured in only 3 studies. In 1 study, because data had been normalized, the results could not be compared with the results of the other 2 studies. Preoperatively, the cadence ranged from 61.2 steps/min to 103.14 steps/min (SE = 16.94) compared to 113.74 steps/min (SE = 10.55) at 1 to 3 months postsurgery and 80.4 steps/min at 6 to 8 months post-surgery (Table 4).

Different capacity tests were used in the various studies. Because of the different tests and instructions, the results of the capacity tests could not be pooled. Walking capacity was evaluated with the Four-Minute Walk Test in 1 study[26] and with the Six-Minute Walk Test in 5 studies. Patients were instructed to walk at a comfortable speed in 1 study[31], whereas they were instructed to walk as far as possible in 6 minutes in other studies[24,29,39]. The distance covered in 6 minutes ranged from 134 m (SE = 7.9) m to 339 m (SE = 18.9) preoperatively, whereas the distance ranged from 386 m to 409 m (SE = 12.7) at 12 months postsurgery. A study of Troosters et al.[51] showed that people aged 50 to 85 years and with no history of hospitalization or chronic diseases walked on average 631 m (range = 383-820) in 6 minutes. In addition, a review by Steffen et al.[52] showed that in people aged 60 to 89 years, men walked 356 to 623 m and women walked 345 to 579 m in 6 minutes. Therefore, even at 12 months after surgery, patients scored lower than matched controls.

Two studies measured the ability to rise from a chair. One study used the Timed "Up & Go" Test[27], and another study measured the time needed for 5 repetitive chair-rise

Table 4. Data on ability to perform activities: gait analysis.

Study	preoperative		1-3 months postsurgery		6-8 months postsurgery		12 months postsurgery	
	mean	SE[a]	mean	SE	mean	SE	mean	SE
Walking speed (m/s)								
Ajemian et al[45]	0.950	0.048	-	-	1.080	0.027	-	-
Boardman et al[31]	0.990	0.044	-	-	-	-	1.17	0.037
Brown et al[46]	0.680	0.047	0.730	0.037	-	-	0.920	0.063
Dorr et al[23]	0.970	0.023	1.100	0.029	-	-	-	-
Leuchte et al[21]	1.070	0.035	1.080	0.023	1.170	0.025	-	-
Lindemann et al[42]	1.060	0.049	1.160	0.032	-	-	-	-
McBeath et al[47]	0.600	0.034	-	-	0.930	0.032	0.990	0.028
Shrader et al[48]	0.880	0.024	1.050	0.019	-	-	-	-
Van den Akker-Scheek et al[22]	0.930	0.024	0.950	0.021	1.140	0.023	-	-
Pooled results	**0.903**	**0.048**	**1.026**	**0.043**	**1.082**	**0.048**	**1.032**	**0.072**
Bennett et al (unitless)[20, b]	0.250	-	0.320	-	-	-	-	-
Stauffer et al[49, b]	0.355	-	-	-	0.618	-	-	-
Stride length (m)								
Dorr et al[23]	1.13	0.020	1.18	0.030	-	-	-	-
Lindemann et al[42]	1.20	0.037	1.26	0.029	-	-	-	-
Shrader et al[48]	1.05	0.076	1.18	0.049				
Van den Akker-Scheek et al[22]	1.12	0.022	1.16	0.020	1.26	0.025	-	-
Wall et al1980 [50]	0.793	0.052	-	-	1.07	0.044	1.11	0.037
Cadence (steps/min)								
Bennet et al (unitless) [20]	29.05	-	31.06	-	-	-	-	-
Dorr et al[23]	103.14	16.94	113.74	10.55	-	-	-	-
Stauffer et al[49]	61.2	-	-	-	80.4	-	-	-

[a] SE = Standard error
[b] Results of these studies were not included in this meta-analysis because the standard errors were not presented.

movements[39]. Compared with the preoperative situation, the time needed to rise from a chair decreased by 6 months postoperatively. None of the studies exploring the rising from a chair test had a follow-up longer than 6 months.

Only 1 study measured stair climbing capacity[39]. The time needed to ascend 5 steps, turn around, and descend the steps decreased from 9.5 s (range = 4.7- 28.2) preoperatively to 7.8 s (range = 4.3 minimum - 17.2) at 6 months postsurgery. Measured with capacity tests, the recovery of physical functioning generally increased after surgery.

Actual daily activity in home situation

Only 1 study measured actual daily activity in the home situation of 36 patients by use of an activity monitor (48-hour measurement of the patient at home based on accelerometry)[39]. The actual daily activity increased from 8.7% (SE = 4.0%) of daily activity per 24 hours (125 minutes per 24 hours of movement-related activity) preoperatively to 9.2% (SE = 3.7%) of daily activity per 24 hours (132 minutes per 24 hour of movement-related activity) at 6 months postsurgery.

Degree of relative recovery from different measurement methods

Figure 2 shows the pooled results plotted as relative improvement normalized for the reference scores of controls. On the WOMAC-PF, patients recovered from 46% of the reference score preoperatively to 81% of the reference score at 6 to 8 months postsurgery. On the SF-36-PF, patients recovered from 41% of the reference score preoperatively to 83% of the reference score at 6 to 8 months postsurgery. Walking speed recovered from 69% of the reference score preoperatively to 82% of the reference score at 6 to 8 months postsurgery.

In the study measuring daily activity in the home situation, patients recovered from 80% of that of controls preoperatively to 84% of that of controls at 6 months postsurgery.

The 3 aspects of physical functioning (perceived physical functioning, functional capacity, and actual daily activity) showed different degrees of recovery after THA. Compared with the preoperative situation, physical functioning showed considerable recovery, functional capacity showed moderate recovery, and actual daily activity (based on 1 study only) showed a small recovery. All 3 aspects recovered to about 80% that of controls at 6 to 8 months after THA.

DISCUSSION

This systematic review aimed to summarize the state of knowledge regarding recovery of physical functioning after THA and to examine the degree of improvement in 3 aspects of functioning. To our knowledge, the present study is the first review on this topic. Almost all prospective studies included in this review evaluated the recovery of physical functioning in the first 8 months after THA. Little information is available about recovery of physical functioning at 8 months or longer after surgery compared with the preoperative situation.

The results of the pooled data showed that perceived daily functioning and functional capacity reflect different aspects of functioning. Preoperatively and compared with references values, patients scored relatively low on perceived daily functioning, but relatively high on functional capacity to perform activities (i.e., what patients can actu-

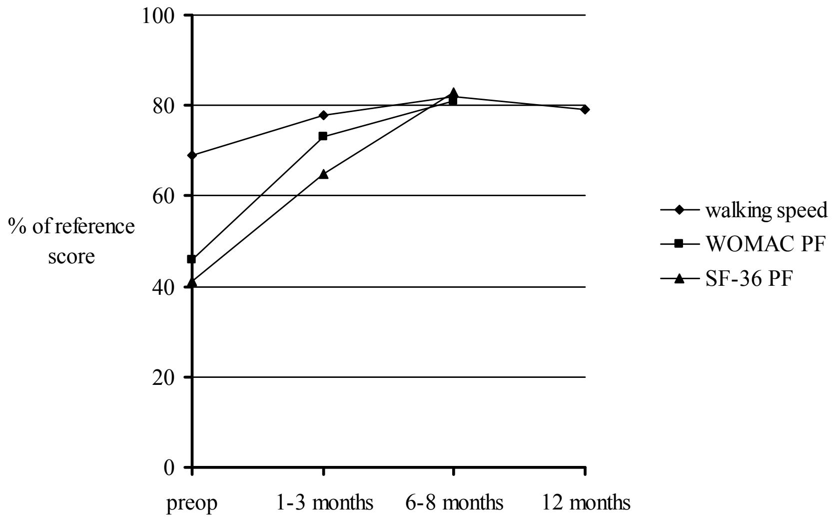

Figure 2. Data on relative improvement normalized for maximum scores for the pooled results. WOMAC PF = Western Ontario and McMaster Universities Osteoarthritis Index physical functioning subscale, SF-36-PF = Medical Outcomes Study 36-Item Short-Form Health Survey questionnaire physical functioning subscale.

ally do). That is, despite the perceived problems with daily functioning preoperatively, patients still had a relatively high functional capacity compared with controls. Perhaps patients try to keep their functional capacity as high as possible, despite the hindrance of pain and discomfort. The degree of recovery also differed between these 2 aspects. Compared with references values, a relatively large recovery was seen in perceived problems with daily functioning at 6 to 8 months postsurgery. For functional capacity to perform activities, the relative recovery was much smaller at 6 to 8 months postsurgery. In line with our results, previous studies have shown that self-reported physical functioning and more quantitatively measured physical functioning differ and measure different aspects of physical functioning[11,13].

Surprisingly, only 1 study measured the aspect of actual daily activity in the home situation. Six months postsurgery, only a small recovery was seen. Compared with controls, the patients scored relatively high preoperatively on this aspect, implying that there was little opportunity to make improvement.

Comparison of our systematic review with other reviews is difficult because no other systematic review on the recovery of the different aspects of physical functioning exists. A review by Ethgen et al.[6] summarized the literature on health-related quality of life after total hip and total knee arthroplasty. They also found that the majority of studies described the results at 6 to 12 months postoperatively. In their review, the aspect 'self-reported physical functioning' was described. Similar to our review, they found substantial improvements in self-reported physical functioning and that the greatest improvement was seen in the first 3 to 6 months after surgery. Self-reported physical functioning was also reported in a review by Montin et al., who also found that self-reported physical functioning was improved after surgery[5].

Randomized controlled trials are considered to provide the strongest evidence, and meta-analysis has frequently been applied to RCTs. However, RCTs are not always feasible, and sometimes only data from observational studies are available. The number of published meta-analyses concerning observational studies has increased substantially in the past 40 years. However, meta-analysis of observational studies presents particular challenges because of inherent biases and differences in study designs.

Our meta-analysis also may be subject to possible bias. The inclusion of only published data could have led to publication bias; however, it is difficult to reduce publication bias because it is almost impossible to be certain that all unpublished studies have been located. Only articles written in English, German or Dutch were included, which could have led to selection bias. Additionally, only for the WOMAC-PF, SF-36-PF, and walking speed measured with gait analysis were sufficient data available for pooling. The results of the other outcome measures could not be pooled, either because too few data were available or because the methods varied too much; therefore, no definite conclusions can be drawn from these data. Because the scoring methods for the WOMAC-PF differed among the studies, only data from studies using the 5-point Likert scale could be pooled, which might have influenced the results. Furthermore, studies that did not present standard deviations or SEs of their data could not be pooled. In this systematic review, we included both prospective cohort studies and RCTs. The results of 3 RCTs were used for pooling the results. Of the pooled RCTs, only one intervention (postoperative exercise intervention) had an effect on the physical functioning outcomes (WOMAC-PF) examined in our review. To compensate for this effect, we calculated weighted means of the results of the intervention and control groups of the RCTs and used these weighted means for pooling. Therefore, because the aim of our study was to examine the recovery of physical functioning after THA (irrespective of the interventions), we think that pooling the results of prospective cohort studies and RCTs for the physical functioning outcome measures was feasible. Furthermore, there is clinical heterogeneity between the pooled studies with respect to the types of THA prostheses used, the approaches used, and the different rehabilitation processes and pain management protocols used in the clinical phase after THA. Too few studies were available to allow a separate analysis of these differences. Moreover, too few data were available to examine the influence of patient characteristics (e.g., age, sex, body mass index) on the recovery of physical functioning after THA.

Walking speed was measured with different gait analysis devices, which could had led to some bias. Moreover, walking speed assessed with gait analysis was measured at a comfortable speed and not at maximum speed. The use of the term "capacity" for the walking speed measured with gait analysis, therefore, is somewhat misleading. Thus, we only know that after THA, patients walk slower at a comfortable speed compared with controls. Furthermore, 3 of the 9 pooled studies for the walking speed scored negative on 50% or more of the questions on the risk of bias assessment. Therefore, the results of these studies must be interpreted with caution.

Clinical implications

The 3 aspects of physical functioning showed different degrees of recovery in the first 8 months after THA compared to the preoperative situation. Despite the preoperative perceived problems with daily functioning, patients have a relatively high functional capacity and actual daily activity level. At 6 to 8 months postsurgery, a considerable relative recovery is seen in perceived problems with daily functioning. For functional capacity to perform activities, the recovery is moderate, and for the actual daily activity, the recovery is relatively small. Even at 8 months after THA, all 3 aspects have recovered to about 80% of the levels of controls. Based on the study selection criteria, few data are available on recovery of physical functioning 8 months or longer after surgery. Traditionally, orthopedic surgeons consider a minimum of 2 years as the threshold for assessing THA outcomes. This systematic review indicates that 8 months after surgery, patients have already recovered to about 80% of the levels of controls, but it remains unclear whether and when patients recover to more than 80% of the level of controls regarding physical functioning after THA.

Future research

First, future studies need to examine the recovery of physical functioning at 8 months or longer after THA with regard to the 3 aspects of physical functioning. Second, most studies measured self-reported physical functioning with questionnaires or the capacity to perform activities in a laboratory setting or outpatient clinic. Only 1 study examined physical functioning in the home situation of patients. Because the 3 aspects of physical functioning showed different degrees of recovery, the recovery of actual performance needs to be explored in the home situation. Third, many studies measured the capacity to perform the activity of walking. However, patients before and after THA also have problems with, for example, rising from a chair and climbing stairs. Therefore, these activities should be studied in more detail in a laboratory setting or outpatient clinic and in the home of the patients. Finally, the wide variability in outcome measures used to evaluate physical functioning makes it difficult to compare the results of different studies. Therefore, more standardization is needed when measuring the 3 aspects of physical functioning.

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Appendix 1. Search strategy

Search Strategy
"Arthroplasty, replacement, hip" OR (hip AND replacement) OR (hip AND arthroplasty)
AND
"Osteoarthritis, hip" OR (osteoarthritis AND hip)
AND
"Motor activity" OR activity OR activities OR "physical activity" OR "task performance and analysis" OR performance OR capacity OR gait OR walking OR "stair climbing" OR "sit to stand" OR functioning OR "activities of daily life" OR disability OR disabilities
AND
"Cohort study" OR "controlled study" OR "follow-up study" OR "prospective study" OR cohort OR compared OR groups.

Appendix 2. Risk of bias assessment checklist

Risk of bias assessment

Reporting (8 items):
1. Is the hypothesis/aim/objective of the study clearly described?
2. Are the main outcomes to be measured clearly described in the "Introduction" or "Methods" section?
3. Are the characteristics of the patients included in the study clearly described?
4. Are the interventions of interest clearly described?
5. Are the main findings of the study clearly described?
6. Does the study provide estimates of the random variability in the data for the main outcome?
7. Have the proportion and characteristics of patients lost to follow-up been described?
8. Have actual probability values been reported (eg, 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?

External validity (2 items):
9. Were the individuals asked to participate in the study representative of the entire population from which they were recruited?
10. Were those individuals who gave consent to participate representative of the entire population from which they were recruited?

Internal validity (3 items).
11. Were the main outcomes measures used accurate (valid and reliable)?
12. Were appropriate statistical tests used to assess the main outcomes?
13. If any of the results of the study were based on 'data dredging', was this made clear?

Appendix 3. Results of the risk of bias assessment

Study	Aim clearly described	Main outcomes clearly described	Characteristics clearly described	Interventions clearly described	Main findings clearly described	Estimates of random variability	Loss to follow-up described	Actual probability values	Individuals asked to participate representative	Individuals who gave consent representative	Outcome measures accurate	Appropriate statistics	Data dredging	Total
Ajemian et al 2004[45]	1	1	0	0	1	0	0	1	0	0	1	0	1	**6**

Bachrach-Lindström et al 2008[30]	1	1	0	0	1	1	0	1	1	1	1	1	1	**10**
Bennett et al 2006[20]	1	1	1	1	1	0	0	0	0	0	1	1	1	**8**
Berge et al 2004[26]	1	1	0	0	1	1	0	1	0	1	1	1	1	**9**
Boardman et al 2000[31]	1	1	0	0	1	1	0	0	0	1	1	1	1	**8**
Brown et al 1980[46]	1	1	1	0	1	0	0	0	0	0	1	0	1	**6**
Busija et al2008[32]	1	1	0	0	1	1	0	0	0	0	1	1	1	**7**
Chiu et al 2000[33]	1	1	0	0	1	1	0	1	1	0	1	1	1	**9**
Chiu et al2001[34]	1	1	0	0	1	1	0	0	1	0	1	1	1	**8**
Dawson et al1996[35]	1	1	0	0	1	0	0	0	1	0	1	1	1	**7**
Dawson et al1996[36]	1	1	0	0	1	1	0	0	1	0	1	1	1	**8**
Dorr et al2007[23]	1	1	1	1	0	0	1	1	0	0	1	1	1	**9**
Fitzpatrick et al 2000[37]	1	1	0	0	1	1	0	0	1	0	1	1	1	**8**
Fortin et al 1999[38]	1	1	0	0	1	1	0	1	0	0	1	1	1	**8**
De Groot et al 2008[39]	1	1	1	0	1	1	0	1	0	1	1	1	1	**10**
Huber et al 2006[40]	1	1	1	1	0	1	0	0	1	0	1	1	1	**9**
Laupacis et al 1993[41]	1	1	0	1	1	1	0	0	0	0	1	1	1	**8**
Laupacis et al 2002[24]	0	1	0	1	1	1	0	1	0	0	1	0	1	**7**
Leuchte et al 2007[21]	0	1	0	1	1	1	0	1	0	0	1	1	1	**8**
Lindemann et al 2006[42]	1	1	1	0	1	1	0	1	1	0	1	1	1	**10**
McBeath et al 1980[47]	1	1	0	0	1	1	0	0	0	0	1	0	1	**6**
Rooks et al 2006[27]	1	1	1	0	1	1	0	1	0	0	1	1	1	**9**
Salmon et al 2001[43]	1	1	0	0	0	0	0	0	0	1	1	1	1	**6**
Shrader et al 2009[48]	1	1	1	1	1	0	0	1	0	0	1	0	1	**8**

Stauffer et al 1974[49]	1	1	0	1	1	0	0	0	0	0	1	0	1	**6**
Unver et al 2004[29]	0	1	0	1	1	1	1	1	0	0	1	1	1	**9**
Van den Akker – Scheek et al 2007[22]	1	1	1	0	1	1	0	1	0	0	1	1	1	**9**
Van den Akker – Scheek et al 2008[44]	1	1	1	0	1	1	0	1	0	0	1	1	1	**9**
Vendittoli et al 2006[25]	1	1	1	1	1	0	0	1	0	0	1	1	1	**9**
Wall et al 1980[50]	0	1	0	0	1	1	0	0	0	0	1	0	1	**5**

Appendix 4. Forest Plots [a]

Figure 1 WOMAC PF change between preoperative and 1 to 3 months postoperative

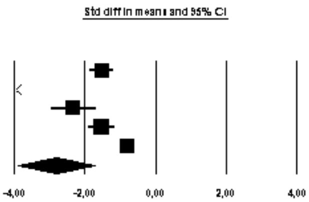


Figure 2 WOMAC PF change between preoperative and 6 to 8 months postoperative

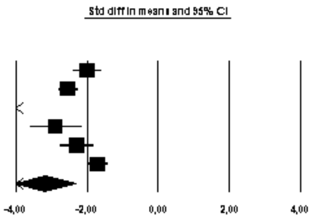


Figure 3 SF-36 PF change between preoperative and 1 to 3 months postoperative

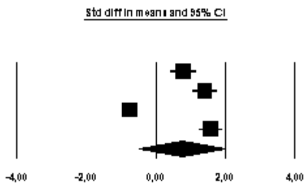


Figure 4 SF-36 PF change between preoperative and 6 to 8 months postoperative

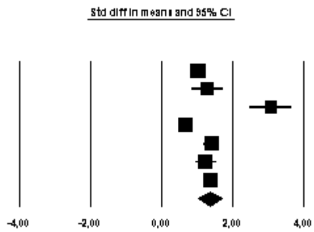


Figure 5 Walking speed change between preoperative and 1 to 3 months

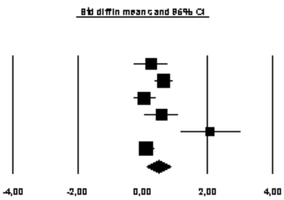


Figure 6 walking speed change between preoperative and 6 to 8 months postoperative

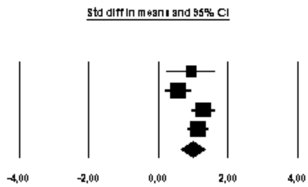
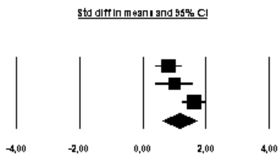


Figure 7 Walking speed change between preoperative and 12 months postoperative



[a] Results are presented as standardized difference in means (Cohen d) compared with the preoperative situation. WOMAC PF = Western Ontario and McMaster Universities Osteoarthritis Index physical functioning subscale, SF-36-PF = Medical Outcomes Study 36-Item Short-Form Health Survey questionnaire physical functioning subscale, 95% CI = 95% confidence interval.

Chapter 3

Walking and chair rising performed in the daily life situation before and after total hip arthroplasty

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ABSTRACT

Objective. An earlier study showed that 6 months after total hip arthroplasty (THA) patients' overall daily activity level had not increased, despite significant improvement in their perceived physical functioning. This discrepancy might be because postoperative recovery is not expressed by a more overall active lifestyle, but by the fact that patients could perform the individual activities of daily living (ADL) faster and/or for a longer period of time. The aim of this study was to assess whether patients perform ADL faster and/or for a longer period of time 6 months post-THA compared to baseline. Also examined was whether patients perform activities on the level of healthy matched controls.

Method. Thirty patients were measured at home with an accelerometry-based Activity Monitor, pre-operatively and 6 months post-THA. Patients were matched with healthy controls on gender and age (± 2 years).

Results. Compared with baseline, 6 months post-THA the stride frequency and body motility during walking of patients had increased [56.1 (54.3, 57.8) strides/min vs. 52.1 (50.3, 54.1) strides/min; p-value <0.0001, and 0.265 (0.245, 0.286) g vs. 0.219 (0.197, 0.240) g; p-value <0.0001], and they rose faster from a chair [2.6 (2.5, 2.8) s versus 3.0 (2.8, 3.2) s; p-value <0.0001]. Compared with controls, preoperative all patients had lower values for these parameters. Six months post-THA the stride frequency and body motility during walking were similar to that of controls, but patients rose slower from a chair than controls.

Conclusion. Six months post-THA patients walked faster and rose from a chair faster compared to baseline. Patients walked as fast as healthy controls but took longer rising from a chair.

INTRODUCTION

Osteoarthritis (OA) of the hip causes pain and loss of joint mobility, leading to limitations in physical functioning. When conservative treatment fails to alleviate hip pain and limitations in physical functioning, total hip arthroplasty (THA) is a cost-effective surgical option[1]. Patients nowadays, who tend to be younger and more active, have high expectations regarding functional outcome after THA[2]. If such expectations are not met, they may still be dissatisfied with the outcome of a technically successful procedure. Therefore, apart from aiming at pain relief, health-related quality of life and patient satisfaction, clinical practice also focuses on recovery of physical functioning after THA.

Physical functioning is multi-dimensional. Previous studies have shown that self-reported physical functioning and more objectively measured physical functioning differ and measure different aspects of physical functioning. Weak relationships have been reported between the different aspects of physical functioning[3, 4]. Furthermore, it has been shown that patients highly overestimated their level of activity when they filled in a questionnaire compared to objective measurements of activity level[5, 6]. Therefore, in addition to self-reported measures, it is important to evaluate the recovery of physical functioning objectively in the natural environment of the patients.

This objective evaluation has been done in a previous study of our group, focusing on one aspect: actual daily activity level measured with an accelerometry-based Activity Monitor (AM) in hip patients before and 6 months after THA. That study showed that patients on the waiting list for THA were significantly less active than healthy matched controls; 6 months post-surgery patients had not increased their overall daily activity level, despite a significant improvement of perceived physical functioning[5, 6]. This discrepancy might be explained by the fact that postoperative recovery is not expressed by the parameters studied so far, representing the actual daily activity level, but by other parameters of objectively measured physical functioning. For example, after a THA patients may be able to perform the individual activities of daily living (ADL) faster (better performance) and/or for a longer, uninterrupted period of time (increase in physical activity of the separate ADL). If patients perform these ADL faster and/or for a longer period of time, this indicates a better level of functioning, even if the total amount of physical activity does not change. Therefore, assessment of physical functioning in daily life should not only focus on the total amount of overall actual daily activity level, but also on how patients perform the individual activities.

Patients with OA and patients after THA mostly report problems with walking and rising from a chair[7-10]. Therefore, it is appropriate to examine the performance of these specific ADLs. Until now, the way in which both end-stage hip OA patients and patients after THA perform activities has been evaluated by standardized performance tests in a measurement environment (e.g. a laboratory). Most of these studies evaluated walking activity and showed that walking speed and stride frequency improved after THA[11-16]. However, a measurement environment differs from the situation in daily life; for example, patients are generally more focused when performing activities in a measurement setting, than at home.

To our knowledge, no studies have evaluated how patients with end-stage hip OA and patients after THA perform ADL in their natural setting. Therefore, the present study examines how patients before and after THA perform ADL in their natural environment. In addition, we examined how the results of both end-stage OA patients and THA patients differ from that of healthy matched controls.

METHODS

The present study uses data of a prospective follow-up study in which we examined the recovery of physical functioning after THA[6]. Patients underwent home-based AM measurements on average 6 weeks before (= baseline) and 6 months after surgery. Patients were matched on gender and age (± 2 years) with healthy controls without symptomatic hip or knee OA, or other health problems.

Patient selection

All patients with end-stage OA of the hip, scheduled for hip replacement at the Erasmus University Medical Centre Rotterdam in the period April 2004-May 2006, were eligible. Patients were included in the study by consecutive enrolment. Exclusion criteria were: age >80 years, wheelchair-bound, not living independently, the presence of disorders other than OA that could affect the level of physical activity, the presence of OA in the contralateral hip requiring surgery within 6 months, living more than 1.5 hours away from the medical centre, insufficient command of the Dutch language (spoken or written), not willing to sign an informed consent, and unknown/uncertain whether the patient would be available for follow-up measurements.

The procedures followed were approved by the local Medical Ethics Committee and in accordance with the Helsinki Declaration of 1975 (revised in 2000), and all patients provided informed consent.

Data for the comparison group were derived from an existing database of healthy persons without symptomatic hip or knee OA or other health problems that could affect the level of physical activity (such as stroke, cancer with chemotherapy, operated on foot or ankle). Match criteria were gender and age (± 2 years). These criteria were selected because gender and age are important determinants of ADL.

Materials

AM

The rationale for the AM sensor configuration, the steps of the signal analysis, and the method of activity detection have been described in detail elsewhere[17].

Briefly, the AM is based on long-term ambulatory (home-based) measurement of signals from body-fixed acceleration sensors (Temec Instruments, Kerkrade, the Netherlands). The sensors were attached to both upper legs and to the sternum. The sensors on both upper legs were sensitive in the anteroposterior direction while standing and were attached at the lateral side of each upper leg, 10 cm above the lateral femur condyle. The sensor on the trunk was sensitive in the anteroposterior and longitudinal direction while standing and was attached at the lower side of the sternum. All sensors were connected to a recorder based on Vitaport technology (Temec Instruments, Kerkrade, the Netherlands). The acceleration signals were digitally stored on a flash card. After measurements, all signals were downloaded to a personal computer for further analysis. Each second a body posture (sitting, standing, lying) or body motion (walking, cycling or general movements: all non-cyclic movements) was automatically detected from the acceleration signals. Furthermore, a motility signal is automatically calculated from each measured signal. The motility signal is a measure of the intensity of the movement. The body motility is the mean of the four motility signals. To avoid bias, the principles of the AM measurements were explained to the participants only after measurements were made.

Outcome measurements

For the present study, the period between getting up in the morning to going to bed in the evening was analysed. The two main activities for which OA patients report problems, i.e. walking and chair rising, were analysed. In addition, the overall daily activity level during the measurement period was calculated.

Walking

For this activity the following were measured: total time spent walking, number of walking periods, and the number of walking periods lasting ≤ 5 min and lasting ≥ 5 min.

For each patient, during the measurement period, 10 walking periods with a minimal duration of twenty steps were randomly selected by a computer program and analysed. The median stride frequency (strides/min) and body motility during walking of these 10 periods were computed for each patient. Body motility during walking is strongly and positively related to walking speed (R=0.88-0.90)[18,19].

Chair rising

First we calculated the time spent sitting, the number of sitting periods lasting ≤ 30 min, lasting 30 min to 1 h, and lasting ≥ 1 h, and the total number of chair rising movements.

Furthermore, for each patient 20 chair rising movements during the measurement period were randomly selected by a computer program and analysed to calculate the duration of the chair rising movements. The analysis was based on the detection of the following events: the start of trunk movement (t1), the end of trunk movement (t2), the start of leg movement (l1), and the end of the leg movement (l2). For patients we used the non-affected leg to compute chair rising durations, whereas for control subjects the right leg was always used. The total movement duration was calculated, i.e. the length of time between initiation of the chair rising movement (derived from t1) and completion of the movement (derived from t2 or l2)[20].

Statistical analysis

To examine the duration of the chair rising movements data had to be converted to ASCII files and imported in a Matlab program (Matlab 7.1, The MathWorks Inc., Natick, Massachusetts, USA). Matlab was used to process these data.

For the analysis, it was first established whether the variables had a normal distribution using the normality Shapiro-Wilk test. Based on these analyses, the results are presented as means and 95% confidence interval (lower limit, upper limit) or, if not normally distributed, as median and inter-quartile range.

Differences between baseline and post-THA measurements were evaluated using dependent *t* tests (for normally distributed variables), with Wilcoxon tests (for not normally distributed variables), or with Generalized Estimating Equations (GEE) for differences between the number of walking periods lasting ≤ 5 min and ≥ 5 min and the number of sitting periods lasting ≤ 30 min, 30 min-1 h, and ≥ 1 h.

Differences between patients and controls were evaluated by independent *t* tests (for normally distributed variables), by nonparametric Mann-Whitney *U* tests (for not normally distributed variables), or by GEE for differences between the number of walking periods lasting ≤ 5 min and ≥ 5 min and the number of sitting periods lasting ≤ 30 min, 30 min-1 h, and ≥ 1 h. Analyses were performed using statistical package for the social sciences (SPSS) 17.0 (SPSS Inc., Chicago, USA) or SAS 9.2 (SAS institute Inc., Cary, USA). An alpha value of 0.05 was set as the level of significance.

RESULTS

A total of 36 patients were eligible and willing to participate in the study. Of these, 4 patients lacked the postoperative measurements at 6 months, and in two patients the

AM measurements were invalid due to technical problems. Finally, the preoperative (baseline) and postoperative data of 30 patients were available for analysis. For these patients, 30 healthy comparison subjects were matched on gender and age (± 2 years). Characteristics of the patients and controls are presented in Table 1.

For all hip replacements a posterolateral approach with posterior capsular repair was used. All replacements were cemented. All patients had second-generation cephalosporin at anaesthetic induction followed by two additional doses. Pre and postoperatively, low-molecular-weight heparin was administered prophylactically for prevention of deep vein thrombosis for a period of 6 weeks. Because the Erasmus MC University Medical Centre is a teaching hospital, during the study period the procedures were performed by 6 different orthopaedic surgeons with different medical assistants. Post surgery, the mean number of days in hospital was 8 days and all patients received a standard physical therapy management protocol. They were mobilized early with full weight bearing as tolerated.

Compared with baseline data, 6 months post-THA patients showed a tendency towards a decrease in overall daily activity level, but the difference was not significant ($P = 0.145$). Six months post-THA, patients were less active than healthy matched controls ($P = 0.024$) (Table 2).

Walking

Six months post-surgery, stride frequency and body motility during walking had increased compared to baseline [56.1 (54.3, 57.8) strides/min vs. 52.1 (50.3, 54.1) strides/min; p-value <0.0001, 0.265 (0.245, 0.286) g vs. 0.219 (0.197, 0.240) g; p-value <0.0001]. The time spent walking (in percentage) was significantly decreased 6 months postoperatively compared to baseline. No differences were seen for the other walking outcome measures (Table 2).

At baseline, patients with end-stage OA of the hip had a lower stride frequency and body motility during walking compared to healthy controls [52.1 ± (50.3, 54.1) strides/min vs. 57.6 (55.8, 59.3) strides/min; P-value <0.0001, 0.219 (0.197, 0.240) g vs. 0.276 (0.254, 0.298) g; P-value <0.0001]. The other walking outcome measures showed no significant difference compared with controls. Six months post-surgery, no significant

Table 1 Characteristics of the study patients and matched healthy controls[a]

	Total patients (n=30)	**Controls (n=30)**
Gender, % women (n)	63.3 (19)	63.3 (19)
Age at baseline (years)	60.3 ± 13.0	60.1 ± 12.9
Body mass index at baseline (kg/m^2)	26.4 ± 3.4	25.3 ± 3.3[b]

[a] Values are presented as mean ± standard deviation, unless otherwise indicated

[b] Data on body mass index were missing for 13 controls

Table 2 Activities of daily living in hip patients pre- and post-surgery compared to healthy matched controls[a]

	Patients pre-surgery T0 (n=30)	Patients 6 months post-surgery T1 (n=30)	Controls (n=30)	P-value T0 vs T1	P-value T0 vs controls	P-value T1 vs controls
Duration of measurement period, h (getting up until going to bed)	15.3 (14.6, 16.0)	15.6 (14.9, 16.3)	15.8 (15.4, 16.3)	0.454[b]	0.196[c]	0.563[c]
Movement-related activity						
- %	14.1 (11.8, 16.5)	12.9 (10.8, 15.0)	17.2 (14.0, 20.4)	0.145[b]	0.117[c]	**0.024**[c]
- h	2.2 (1.8, 2.5)	2.0 (1.7, 2.4)	2.7 (2.2, 3.2)	0.363[b]	0.063[c]	**0.027**[c]
Walking						
Time spent walking						
- %	10.3 (8.5, 12.1)	9.5 (8.1, 10.9)	12.2 (9.9, 14.5)	0.255[b]	0.198[c]	**0.047**[c]
- h	1.6 (1.3, 1.8)	1.5 (1.2, 1.7)	1.9 (1.6, 2.3)	0.462[b]	0.125[c]	0.052[c]
Number of walking periods, n	320 (279, 362)	312 (270, 354)	378 (331, 425)	0.653[b]	0.066[c]	**0.036**[c]
Duration of walking periods, numbers						
- < 5 min	335 (188)	294 (136)	362 (146)			
- > 5 min	0 (1)	0 (0)	1 (2)	-[d e]	-[d e]	-[d e]
Body motility during walking, g	0.219 (0.197, 0.240)	0.265 (0.245, 0.286)	0.276 (0.254, 0.298)	**<0.0001**[b]	**<0.0001**[c]	0.460[c]
Stride frequency, strides/min	52.1 (50.3, 54.1)	56.1 (54.3, 57.8)	57.6 (55.8, 59.3)	**<0.0001**[b]	**<0.0001**[c]	0.220[c]
Chair rising						
Time spent sitting						
- %	55.9 (51.6, 60.2)	55.5 (49.6, 61.3)	54.3 (49.2, 59.3)	0.856[b]	0.610[c]	0.750[c]
- hours	8.6 (7.8, 9.4)	8.7 (7.6, 9.8)	8.6 (7.7, 9.5)	0.839[b]	0.996[c]	0.8[c]
Duration of sitting periods, numbers						
- < 30 min	56 (42)	64 (42)	57 (24)			
- 30 min-1 hour	3 (2)	2 (2)	3 (4)	-[d e]	-[d e]	-[d e]
- > 1 hour	0 (1)	0 (2)	1 (1)			
Total number of chair risings	53 (45, 60)	55 (48, 63)	59 (52, 65)	0.375[b]	0.203[c]	0.480[c]
Duration of chair rising movement, s	3.0 (2.8, 3.2)	2.6 (2.5, 2.8)	2.3 (2.2, 2.5)	**< 0.0001**[b]	**<0.0001**[c]	**0.001**[c]

[a] Values are presented as mean and 95% confidence interval (lower limit, upper limit) when normally distributed or median (inter quartile range) when not normally distributed. Significant p-values are printed bold. [b] Dependent t-test was used to obtain the p-value [c] Independent t-test was used to obtain the p-value [d] Generalized Estimating Equations was used to obtain the p-value. [e] Analyses were not performed, because in one or more categories too few data were available.

differences were seen in the walking outcome measures between patients and controls (Table 2).

Chair rising

Six months post-surgery, the duration of the chair rising movement was shorter compared to baseline [2.6 (2.5, 2.8) s vs. 3.0 (2.8, 3.2) s; P-value <0.0001]. No differences were seen in the other outcome measures (Table 2).

At baseline and at 6 months post-surgery, the duration of the chair rising movement was longer for patients compared to healthy controls (P-value <0.0001 and P-value = 0.001 respectively). No differences were seen in the other outcome measures (Table 2).

DISCUSSION

Compared to baseline, 6 months post-THA patients had a higher stride frequency and body motility during walking (indicating a higher walking speed). Furthermore, they needed less time to perform a chair rising movement. However, the time spent walking/sitting, the number of walking/chair rising activities, and the duration of the walking/sitting periods had not increased. Thus, it seems that patients could walk faster and rose faster from a chair, but did not perform the activities more often or for a longer period of time.

At baseline, compared to healthy matched controls, patients with end-stage OA of the hip had a lower stride frequency and body motility during walking and needed more time to rise from a chair. The differences in stride frequency and body motility during walking between patients and healthy controls had disappeared at 6 months post-THA. However, patients still need more time to rose from a chair compared to healthy matched controls. In other words, it seems that 6 months post-surgery patients could walk as fast as the controls, but still needed more time to rise from a chair.

Thus, the present study indicates that even at six months after THA patients need relatively much time to perform the activity rising from a chair. Our earlier systematic review showed that few prospective studies have evaluated the performance of chair rising in hip patients[21]. Therefore, future research needs to evaluate the performance aspects of this activity before and after THA.

Patients with OA and patients having undergone THA report, besides problems with walking and chair rising, also problems with the activity climbing stairs. Within the present study population 20% of the hip patients compared to 40% of the healthy controls had more than one period of climbing stairs during the measurement period. Due to the low number of patients performing the activity of climbing stairs, we were unable to further evaluate this activity. Six months after THA the number of patients that climbed stairs had not changed. It is possible that patients with end-stage hip OA either adapt their home situation, or avoid climbing stairs.

Similar to the present study, previous prospective studies that evaluated walking and chair rising in a measurement environment in both end-stage hip OA patients and patients after THA, showed that both the speed of walking and chair rising increased after surgery [11-16,22]. A recent study of Foucher et al.[23] compared walking speed measured with gait analysis in a laboratory setting with habitual walking speed measured with an AM. This study found that at 3 weeks and 1 year post-surgery patients walked faster in the gait laboratory than in their habitual settings. So an advantage of laboratory measurements is that more sophisticated analysis can be done. But, the conditions in a laboratory setting are controlled and consequently artificial. Therefore, the behaviour in these laboratory settings does not necessarily simulate behaviour and function in real world setting. Therefore, measurements in the natural environment of patients are needed to provide greater insight into functioning in daily life.

The AM is a unique instrument to measure actual daily ADL at home, in contrast to other currently available instruments which only examine overall activity level. The AM provides information on overall activity level but also evaluates (at each second) body postures and motions. Therefore, because the AM evaluates actual ADL in terms of performance in addition to the overall daily activity level, the present results give greater insight into a patient's physical functioning before and after THA in their home situation.

Some limitations of the study need to be addressed. First: due to the strict inclusion/exclusion criteria and because measurement/analysis of the data is time consuming, a relatively small number of patients could be included. Furthermore, all patients were recruited from a university hospital, which may have reduced the representativeness of the sample. However, because the characteristics of the study patients were comparable with other studies, our sample is probably representative for the THA population as described by others[11-13,16]. Second: with the AM the actual walking speed is not calculated, but a measure (body motility) which is closely related to walking speed. However, because body motility during walking and walking speed are strongly correlated, we believe it is feasible to draw conclusions about walking speed. Third: because data on body mass index (BMI) were missing for 13 of the 30 controls, we cannot ascertain whether BMI was totally comparable between patients and controls. However, in our study population BMI was not related to walking speed, stride frequency and/or duration of chair rising (either pre- or post-surgery); therefore, had a difference in BMI existed between the groups, this is unlikely to have influenced the study results. Fourth: in this study we examined how fast and how often the activities walking and chair rising were performed. A limitation is that the AM can not address outcome measures such as safety and stability. In particular for the chair rise task a decrease in rise time could be indicative of the patient using a momentum strategy which could result in a decrease in balance when they rise to a standing position. So, one can question whether a decrease in rise time is an improvement of the chair rising activity. Therefore, more outcome measures of the AM need to be validated to gain more complete insight into the performance of activities in the natural environment of patients.

Furthermore, in this study we did not evaluate all walking and chair rising activities but a random selection of the activities, given the time consuming nature of processing and converting AM data into an analytically useful format. For the walking periods we have randomly chosen 10 periods with minimally 20 steps. We analysed for these 10 periods the stride frequency and body motility during walking. The variation between the 10 periods was relatively small, but to minimize the effect of variation, we took the overall median of these 10 selected walking periods. For the chair rising transitions, we also examined 10 randomly selected chair rising movements for each patient and analysed the duration and took the overall median of the 10 randomly selected transitions. We assume that because we evaluated randomly selected periods and the variation between the evaluated periods was small this is representative for how patients perform these activities during the day. Finally, a limitation of measurements in the natural environment of patients is that some factors are not standardized. Chair/couch height and walking surface could have an influence on how patients perform the activities chair rising and walking. We do not have information about the chair/couch height or walking surface for either the patients or controls.

Based on the results of the present study (and our previous study[21]), we cannot draw conclusions about physical functioning longer than 6 months after THA. For example, the level and/or performance of ADL may increase/improve in the period longer than 6 months post-surgery. If the level of actual daily activity is related to behaviour, the change to a more active lifestyle may need longer than 6 months. Therefore, future research needs to evaluate the longer-term recovery of both the level of actual daily activity and performance of ADL (especially rising from a chair) in the home situation of patients.

In conclusion, postoperative recovery is not expressed by a more active lifestyle, but by an improvement in body motility during walking (indicating a higher walking speed) and time needed to rise from a chair. Six months post-THA, the body motility during walking was similar to healthy matched controls but hip patients still needed more time to rise from a chair. These findings may help physicians to better inform patients pre-surgery about the possibilities related to recovery of physical functioning after surgery.

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Chapter 4

Performance of walking and chair rising in daily life before and after total knee arthroplasty

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submitted

Chapter 5

Physical functioning four years after total hip and knee arthroplasty

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Gait and Posture 2011 submitted

ABSTRACT

Objective. Our earlier studies showed that 6 months after total hip arthroplasty (THA) and total knee arthroplasty (TKA) patients reported less difficulty with daily activities, had a better functional capacity, and they performed activities in their natural environment faster. However, their actual daily activity level was not relevantly improved. Six months is a rather short follow-up and the discrepancy between the different aspects of functioning might be explained by this relatively short follow-up period. The objective of this study was to examine the recovery of the different aspects of physical functioning at a follow-up 4 years after THA/TKA. Special focus was given on whether the actual daily activity level increased 4 years after THA/TKA compared to 6 months postoperatively.

Method. The 77 (35 hip, 42 knee) patients who had both preoperative and six months measurements from our earlier study were invited to participate again. These data were compared with the preoperative and 6 month postoperative data.

Results. After 4 years the daily activity level had still not increased compared to 6 months postoperative (128 min vs. 138 min activity per 24 h; p-value 0.48). However, patients did further improve on the other aspects of physical functioning.

Conclusion. Four years post surgery patients further improved on perceived physical functioning, capacity, and performance of activities in daily life. However, even in this relatively healthy study population, patients did not adapt a more active lifestyle 4 years after surgery.

INTRODUCTION

Osteoarthritis (OA) of the hip and knee causes pain and loss of joint mobility, which leads to limitations in physical functioning. When conservative treatment fails to alleviate hip/knee pain and limitations in physical functioning, total hip arthroplasty (THA) and total knee arthroplasty (TKA) are cost-effective surgical options for patients with end stage OA[1]. An important outcome measure of THA/TKA is the recovery of physical functioning. Physical functioning is a multi-dimensional construct covering various aspects of health as expressed in the International Classification of Functioning, Disability and Health (ICF)[2]. Physical functioning encompasses different aspects: actual daily activity in the natural environment (both the activity level and *how* activities in daily life are performed), perceived (problems in) daily functioning, and functional capacity to perform activities. In a systematic review we found that the different aspects of physical functioning have different patterns of recovery[3].

That aspects of physical functioning differ from each other can also be concluded from our previous reports on recovery of physical functioning 6 months after THA/TKA[4-7]. In these studies daily activities were objectively measured with an activity monitor (AM). Results showed as expected that patients on a waiting list for THA and TKA are significantly and clinically relevantly less active than healthy matched controls. Six months post surgery patients improved on perceived functioning, capacity, and performance of activities in daily life. However the patient's level of daily activity had not been improved[4-7]. Thus, after THA and TKA, the recovery pattern of one functional aspect is not necessarily the same as that of other aspects.

Length of follow-up is an important issue in recovery after surgery. The discrepancy between the different aspects of functioning might be explained by the relatively short follow-up period of 6 months. Change to a more active lifestyle may need longer than 6 months. For the other parameters a 6-month follow-up period may also be too short. It has been reported that 8 months after surgery full recovery was not established for the three aspects of functioning[3]. Although several studies have evaluated physical functioning up to 1 year after THA/TKA, little is known about the results more than 1 year after these procedures[3].

Therefore, this study examines whether the different aspects of physical functioning increased 4 years after THA/TKA compared to the 6 month postoperative data.

PATIENTS AND METHODS

Patient enrolment

The 77 (35 hip, 42 knee) patients who participated in our earlier THA/TKA study[5] and had both preoperative and six months postoperative measurements were invited to participate in the present study.

In the earlier study patients meeting the following criteria were excluded: older than 80 years, wheelchair-bound or not living independently, osteoarthritis (OA) in the contralateral hip or knee requiring surgery within 6 months, co-morbidities other than OA that could affect the level of actual daily activity, living more than 1.5 h away from the medical center, insufficient command of the Dutch language, not willing to sign informed consent, and uncertain whether they would be available for follow-up measurements[5]. Furthermore, for the present study patients were excluded who had THA/TKA during the past 12 months, who had revision of a primary THA/TKA, or who had co-morbidities which affect physical functioning. The local Medical Ethics Committee approved the study and all patients signed an informed consent.

Measurements

All patients were measured 4 years post surgery (mean 45 months ± 3.7 months). For the present study, the preoperative data and 6 month postoperative data from the earlier study were used[5]. Physical functioning was measured using several outcome measures.

Level of actual daily activity

The level of actual daily in the natural environment was objectively measured using an AM[8]. The AM is based on body-fixed accelerometers and a portable recorder (Rotterdam Activity Monitor based on Vitaport technology, Temec Instruments, Kerkrade, the Netherlands; size 15 x 9 x 3.5 cm, weight 500 g) and has been extensively used and validated[8-12]. The AM is described in detail elsewhere[8].

Briefly, four accelerometers were used in the following configurations: two sensors on the sternum and one sensor at each thigh. During standing, the sensors on the thigh and the trunk are sensitive in the anterior-posterior direction. The trunk sensor is also sensitive in the longitudinal direction. The accelerometers are connected to a digital recorder worn in a padded bag around the waist. Accelerometer signals are stored digitally on a personal computer memory card. Furthermore, the body motility is automatically calculated from each measured signal. This signal depends on the variability of the measured signal around the mean. After measurement, the data are downloaded on a computer for analysis. The AM data were collected for 48 hours. Data of the AM measurement were calculated per day (24 hour period) and averaged over two measurement days. The level of actual physical activity was expressed by the percentage of time a patient was active per 24 hours (walking, cycling, climbing stairs and general movement).

Performance of activities in the home situation

Besides information on the level of actual daily activity, information on the performance of an activity (*how* the activity is performed) can also be acquired with the AM. Therefore we also analyzed the performance of two frequently occurring activities which OA patient report to be problematic, i.e., walking and chair rising.

For the walking activity two different outcome measures were calculated: body motility [strongly related to walking speed (R = 0.88-0.90)[13,14] and expressed in gravitation (g)] during walking, and stride frequency (strides/min). For each patient 10 walking periods during the measurement period were randomly selected and analysed. The median body motility during walking and stride frequency of these 10 walking periods were computed for each patient.

For the activity rising from a chair, two different movements were analyzed: the sit-to-stand movement, and the sit-to-walk movement. For the sit-to-stand movements patients stand for at least 1 second after rising from the chair. For the sit-to-walk movement patients start to walk immediately after rising from the chair. For each patient 10 sit-to-stand and 10 sit-to-walk movements during the measurement period were randomly selected and analyzed to calculate the duration of the chair rising movements. Analysis was based on detection of the following events: the start of trunk movement (T1), the end of trunk movement (T2), the start of leg movement (L1), and the end of the leg movement (L2). The non-affected leg was used to compute chair rising durations. The total movement duration was calculated: the length of time between initiation of the chair rising movement (derived from T1) and completion of the movement (derived from T2 or L2).

Perceived daily functioning

Perceived functioning was measured with the Hip disability and Osteoarthritis Outcome Score (HOOS) and the Knee injury and Osteoarthritis Outcome Score (KOOS) questionnaires. Both these questionnaires include 5 subscales: pain, symptoms, function in daily living, function in sport and recreation, and hip or knee-related quality of life. Standardized response options are given and each question is scored (on a 5-point Likert scale) from 0 to 4. A normalized score (100 indicating best score and 0 indicating worst score) is then calculated for each subscale[4,5].

Functional capacity

Functional capacity was expressed by three tests (walking, stair climbing, chair rising) performed at the outpatient clinic. The Six-Minutes Walk Test (6MWT) was performed to quantify walking ability. This is a valid and inexpensive clinical tool that involves recording the distance participants can cover while walking indoors for 6 min. It has good test-retest reliability and has been used to measure the effectiveness of interventions in populations with knee OA[15, 16]. Patients were allowed to use a walking aid.

We also measured how long patients took to perform five sit-to-stand movements. Patients were asked to perform this task as fast as possible[17] and were allowed to use their arms while performing these movements.

To assess stair climbing capacity, we measured how long the patients took to ascend five steps, turn around, and descend[18]. The patients were allowed to use the stair railing.

Statistical analysis

First it was established whether the variables had a normal distribution using the normality Shapiro-Wilk test. Based on these analyses, the results are presented as means and standard deviations, or, if not normally distributed, as median and minimum; maximum.

Then the 6-month data of patients participating in the present study were compared with data of the excluded patients and of patients choosing not to participate. Differences between the participating patients on the one hand, and the excluded patients and non-participating patients on the other, were evaluated by independent t-tests (for normally distributed variable) or by nonparametric Mann-Whitney u-tests (for not normally distributed variables).

Differences between the 6-month and 4-year postoperative data were evaluated by a paired samples t-test (for normally distributed variables) or by the Wilcoxon test (for not normally distributed variables).

Data of the 10 sit-to-stand and the 10 sit-to-walk movements were converted to ASCII files and imported and analysed in a Matlab program (Matlab 7.1, The MathWorks Inc., MA, USA). Statistical analyses were performed with SPSS 17.0 (SPSS Inc., Chicago, USA). An alpha value of 0.05 was set as the level of significance.

RESULTS

Finally, 44 (23 hip, 21 knee) patients were willing to participate and signed informed consent. The patient enrolment is presented in Figure 1.

We compared the patient characteristics and 6 month data of the 44 patients willing to participate on the one hand with the excluded and non-participating patients on the other (Table 1). Six months post surgery there were no differences in age, gender, BMI, level of actual daily activity, and performance of activities in daily living between the three groups. However, the excluded patients had more often had TKA and the participating patients scored better on some of the perceived physical functioning aspects

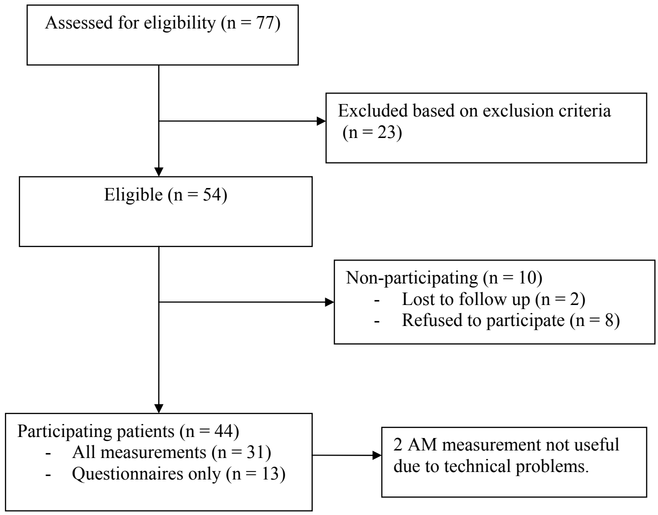

Figure 1 Patient enrollment

and capacity tests than the excluded patients. No differences were found between the participating and non-participating patients (Table 1).

In the patients who were measured again 4 years post surgery (mean 45 months ± 3.7 months), the level of actual daily activity had not increased (9.3 ± 3.6%) compared to the 6-month postoperative data (9.6 ± 3.0%; p-value 0.238). These patients spent significantly more time lying and less time sitting 4 year postoperative, i.e. 44.7% vs. 37.5% lying and 31.2% vs. 38.1% sitting (Table 2).

In contrast to actual daily activity, at 4 years post surgery patients had significantly improved on the subscales pain, symptoms, function in daily living, and hip or knee-related quality of life (HOOS/KOOS questionnaire). Furthermore, patients further improved on functional capacity, and needed less time to rise from a chair in daily life (Table 3).

DISCUSSION

This study examined recovery of physical functioning 4 years after THA or TKA. The result showed the well-know great success of these procedures. We found a great improvement in perceived physical functioning, capacity, and how patients perform activities in daily life in the first six months post surgery. Four years post surgery many patients further improved on these aspects compared to the situation at 6 months after surgery, although less strongly than the first 6 months. So, if a study focuses on full recovery on these outcome measures after THA and TKA, a follow-up period of six months is too short.

Table 1 Patient characteristics and six months results of the participating, excluded and non-participating patients[a]

	Participating n=44 Group 1	Excluded n=23 Group 2	Non-participating n=10 Group 3	p-value Group 1 vs. 2	p-value Group 1 vs. 3
Age, years	63.8 ± 9.4	62.9 ± 9.9	56.8 ± 17.5	0.734	0.304
Gender, % women (n)	59.1 (26)	69.6 (16)	40.0 (4)	0.400	0.273
BMI, kg/m^2	29.7 ± 5.0	29.6 ± 6.8	28.8 ± 6.0	0.940	0.643
Arthroplasty, % hip (n)	52.3 (23)	26.1 (6)	60.0 (6)	**0.040**	0.658
Actual daily activity, level of actual daily activity					
- **movement related activity, % of 24 h**	9.6 ± 3.0	9.2 ± 4.4	11.1 ± 5.5	0.862	0.115
HOOS/KOOS					
- **pain**	68.0 ± 14.0	52.1 ± 22.3	62.7 ± 11.5	**0.004**	0.318
- **symptoms**	56.6 ± 16.5	45.2 ± 15.2	46.9 ± 15.2	**0.011**	0.132
- **ADL**	67.5 ± 13.1	53.5 ± 22.1	58.2 ± 11.1	**0.009**	0.066
- **sport and recreation**	43.3 ± 23.7	31.2 ± 24.2	25.3 ± 15.9	0.060	0.060
- **QOL**	44.8 ± 16.8	35.7 ± 12.6	32.5 ± 19.1	**0.026**	0.070
Functional capacity					
- **6 minutes walk test, m**	404.9 ± 96.4	360.0 ± 92.7	399.8 ± 92.0	0.102	0.898
- **Chair rising, s**	14.4 ± 3.7	17.6 ± 5.0	13.5 ± 4.5	**0.008**	0.570
- **Stair climbing, s**	8.4 ± 2.7	9.8 ± 4.1	6.7 ± 1.8	0.141	0.111
Actual daily activity, performance of activities in home situation					
Walking					
- **Walking speed, body motility during walking, g[b]**	0.278 ± 0.06	0.271 ± 0.05	0.244 ± 0.03	0.666	0.128
- **Stride frequency, strides/min**	55.7 ± 4.7	56.7 ± 4.7	56.7 ± 4.7	0.488	0.256
Chair rising					
- **Duration of sit-to-stand movement, s**	2.9 ± 0.6	2.7 ± 0.6	2.8 ± 0.4	0.357	0.915
- **Duration of sit-to-walk movement, s**	2.8 ± 0.3	2.7 ± 0.4	2.7 ± 0.3	0.275	0.351

[a] Values are presented as mean ± standard deviation, unless otherwise indicated.
Significant p-values are printed **bold**. [b]g = gravity

Table 2 Level of actual daily activity in the 29 patients measured at 6 months and 4 years post surgery[a]

	Preoperative n=29	6 months postoperative n=29	4 years postoperative n=29	p-value 4 years vs. 6 months
Actual daily activity, level of actual daily activity				
- **movement related activity, % 24 h**	8.8 ± 4.0	9.6 ± 3.0	9.3 ± 3.6	0.238
- **walking, % 24 h**	6.5 ± 2.8	6.9 ± 2.1	6.5 ± 2.9	0.385
- **standing, % 24 h**	15.6 ± 6.2	14.7 ± 3.9	14.8 ± 4.5	0.941
- **sitting, % 24 h**	35.6 ± 7.8	38.1 ± 8.8	31.2 ± 10.6	**0.001**
- **lying, % 24 h**	39.0 ± 7.6	37.5 ± 7.5	44.7 ± 10.3	**<0.0001**

[a] Values are presented as mean ± standard deviation. Significant p-values are printed **bold**

Table 3 Data on perceived physical functioning, functional capacity, and performance of activities[a]

	Preoperative	6 months postoperative	4 years postoperative	p-value 4 years vs. 6 months
Perceived Physical Functioning (n=44)				
- **HOOS/KOOS pain**	37.1 ± 16.3	68.0 ± 14.0	89.8 ± 13.5	**<0.0001**
- **HOOS/KOOS symptoms**	39.5 ± 18.5	56.6 ± 16.5	79.2 ± 19.4	**<0.0001**
- **HOOS/KOOS ADL**	36.0 ± 12.7	67.5 ± 13.1	86.2 ± 15.2	**<0.0001**
- **HOOS/KOOS sport and recreation**	23.1 ± 34.0	43.3 ± 23.7	47.4 ± 32.3	0.338
- **HOOS/KOOS QOL**	34.7 ± 27.4	44.8 ± 16.8	73.3 ± 21.6	**<0.0001**
Functional capacity (n=31)				
- **6 minutes walk test, m**	317 ± 105	415 ± 84	561 ± 131	**<0.0001**
- **Chair rising, s**	18.9 ± 6.6	14.1 ± 3.4	12.3 ± 3.9	**0.002**
- **Stair climbing, s**	11.6 ± 5.5	8.3 ± 2.3	7.0 ± 2.7	**0.001**
Actual daily activity, performance of activities in home situation (n=29[b])				
Walking				
- **Walking speed, body motility during walking, gravity**	0.214 ± 0.06	0.256 ± 0.06	0.236 ± 0.05	0.060
- **Stride frequency, strides/min**	50.0 ± 6.3	53.4 ± 5.0	53.4 ± 5.3	0.929
Chair rising				
- **Duration of sit-to-stand movement, s**	3.7 ± 0.8	3.2 ± 0.7	2.7 ± 0.4	**<0.0001**
- **Duration of sit-to-walk movement, s**	3.0 ± 0.5	2.8 ± 0.5	2.4 ± 0.4	**0.001**

[a]Values are presented as mean ± standard deviation. Significant p-values are highlighted in **bold.**
[b]In 2 of the 29 patients, activity monitor signals at 6-month measurement had errors and performance of activities could not be analysed.

In contrast, the level of actual daily activity did not increase 4 years post surgery compared to the situation at 6 months after surgery. So, it seems that despite the fact that 4 years after THA/TKA the perceived amount of pain, symptoms and limitations in physical functioning are negligible, patients do not adapt a more active lifestyle and remain less active. This is especially remarkable, because the participants of the current study formed a relatively healthy study population: due to the strict inclusion/exclusion criteria of our study, and because the participating patients scored better on some of the perceived functioning and capacity outcome measures compared to the excluded patients. Therefore, the results of this study probably overestimate the actual recovery of physical functioning in the overall group of persons after THA/TKA. It can be concluded that despite an effective surgical procedure and improvement on many outcome parameters, patients do not adapt a more active lifestyle after THA and TKA.

The results of this study are unique and give new insight in the recovery of physical functioning after THA and TKA. Numerous follow-up studies after THA and TKA have been performed evaluating perceived physical functioning and capacity in the first year post surgery. These previous studies also showed, similar to our results, that THA and TKA have good results regarding perceived physical functioning and capacity post surgery[19-24]. However, information on longer term results (> 1 year post surgery) is limited. Recent studies of Nilsdotter et al. also evaluated physical functioning longer after THA and TKA. However, they only evaluated perceived physical functioning 5 years after TKA and 7 years after THA[25, 26]. In the present study, besides perceived physical functioning, actual daily activity in the natural environment (both the activity level and *how* activities in daily life are performed) and functional capacity to perform activities were evaluated. So the results of the present study give a complete insight in the recovery of physical functioning after THA and TKA.

However, this study has also some limitations. The previous studies of Nilsdotter et al. found that the best results were reported at one year post surgery and declined thereafter up to 5 years post TKA and 7 years post THA[25, 26]. Thus, a limitation of the present study could be that we might have missed the peak result of physical functioning, because our measurements were made at 6 months and 4 years postoperatively. Additional studies are needed to evaluate the recovery of physical functioning at more time points to establish when the peak result occurs.

Furthermore, of the 56 eligible patients, only 44 (79%) were willing to participate. The 6-month data show that the patients who were willing to participate 4 years postoperatively had a better function than patients who did not participate to the 4 years follow-up. However we do not know if they have improved after 6 months more than the patients we have assessed at 4 years and therefore the high dropout rate is a limitation of this study. But, as stated before, even in the relatively healthy and at 6 months well functioning group, the level of actual daily activity did not increase 4 years post surgery.

It seems less plausible that patients with a lower level of functioning at six months post-operative will increase the level of actual daily activity more than the studied group. Thus, despite the healthy selection bias, we think the conclusions of our study are valid.

The question arises why patients do not become more active 4 years after THA/TKA. One explanation could be the age component. From literature it is known that people become less active with increasing age[30,31], and the time interval of almost 4 years might influence activity level. This age effect was also found in our study: activity level was significantly related to age, with older patients spending more time lying and less time sitting compared to younger patients. However, patients are still less active four years post surgery compared to healthy controls in the same age category. Four years postoperatively the level of actual daily activity of patients was 9.3% per 24 h, i.e. the patients were (on average) 134 min physically active per 24 h. A previous study showed that in healthy controls (in the same age category) the average level of activity was 11.0% active per 24 h, i.e. 158 min per 24 h[4]. Thus, 4 years after THA/TKA patients are 24 min per 24 h less active compared to those healthy controls with the same age. Another important finding in this respect is that in these healthy subjects the increase of 4 years in age has no influence on actual daily activity level. This all indicates that there might be some age effect, but the age component in a 4 year period does not fully explain why patients do not became more active four years post surgery.

Another good explanation could be that patients had clinical OA for numerous years and had adapted their lifestyle to the limitations caused by the disease. From the results of this study it seems that patients do not change their lifestyle spontaneously after successful surgery. From our study we cannot conclude if they are not physically able to change their lifestyle, or whether it is a matter of habitual behaviour that is difficult to change.

In conclusion, four years post surgery patients further improved on perceived physical functioning, capacity, and performance of activities in their natural environment. However, even in a relatively healthy population the level of actual daily activity did not increase 4 years postoperatively compared to the data at 6 months. Even though patients improved on other aspects of physical functioning (to an almost maximum level), they remained less active.

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Chapter 6

Psychological factors affecting the outcome of total hip and knee arthroplasty: a systematic review

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ABSTRACT

Objectives. Recently, numerous studies have reported that psychological factors can influence the outcome of total knee arthroplasty (TKA) and total hip arthroplasty (THA). However, a systematic overview is missing. The objective of this study was to examine which psychological factors influence the outcome of TKA and THA and to what extent.

Methods. Data were obtained from the MEDLINE and EMBASE databases from inception to January 2011. Search terms included TKA and THA, outcome measures, and psychological aspects. Two reviewers independently selected the studies. Studies with a prospective before-after design with a minimum follow-up time of 6 weeks were included. One reviewer extracted the results and 2 reviewers independently conducted quality assessment. We distinguished between follow-up shorter and equal or longer than 1 year.

Results. Thirty-five of 1,837 studies met the inclusion criteria and were included in this systematic review. In follow-ups shorter than 1 year, and for knee patients only, strong evidence was found that patients with pain catastrophizing reported more pain postoperatively. Furthermore, strong evidence was found that preoperative depression had no influence on postoperative functioning. In long-term follow-up, 1 year after TKA, strong evidence was found that lower preoperative mental health (measured with the SF-12 or SF-36) was associated with lower scores on function and pain. For THA, only limited, conflicting or no evidence was found.

Conclusions. Low preoperative mental health and pain catastrophizing have an influence on outcome after TKA. With regard to the influence of other psychological factors and for hip patients, only limited, conflicting or no evidence was found.

INTRODUCTION

When conservative treatment fails to alleviate knee or hip pain and limitations in physical functioning, total knee arthroplasty (TKA) and total hip arthroplasty (THA) are cost-effective surgical options for patients with end-stage osteoarthritis (OA)[1]. Surgical techniques and prostheses have improved in recent years and outcomes after TKA and THA are good. However, a subset of patients has lower postoperative improvement in pain, physical functioning, and quality of life and is not satisfied with the results of their TKA or THA. These suboptimal results could not be completely explained by physical characteristics and procedures, like adverse events, physical comorbidities and variations in the surgery itself, but seem to be related to other psychological aspects of the patient or the procedure[2]. In this article we report our results of a systematic review of the relationships between psychological factors and outcomes in TKA and THA.

During the last several years a number of studies have reported that patients with preoperative psychological symptoms have a worse outcome after TKA or THA. Furthermore, a previous study by our group showed that patients with a preoperative lower mental health score were more often dissatisfied with the results after TKA[3]. So far, the evidence has not yet been systematically reviewed. Such an overview could aid in answering questions like: 1) Which psychological symptoms influence the outcome of TKA and THA? and 2) How much influence do these psychological symptoms have on the outcome of TKA and THA? This knowledge is important for informing patients and in deciding whether such influences are strong enough to warrant intervention. With this article we have sought to answer these questions. Studies with a prospective before-after design with a minimum follow-up time of 6 weeks were included. We evaluated the influence of psychological factors on different outcome measures such as pain, function, patient satisfaction, quality of life, mortality, and revision.

METHODS

Data sources and searches

A search for relevant studies was performed in MEDLINE and EMBASE since their inception up to January 2011. Search terms included total hip and knee arthroplasty, different outcome measures (pain, functioning, patient satisfaction, quality of life, mortality, and revision), and different psychological symptoms (patient expectations, depression, anxiety, mental health, physiological stress, self-efficacy, coping, vitality and emotion). The full electronic search strategy for the MEDLINE database is presented in Table 1.

Table 1 Search strategy MEDLINE

(arthroplasties, replacement, hip[mesh] OR arthroplasty, replacement, knee[mesh] OR hip arthroplast*[tw] OR hip endoprosthe*[tw] OR hip joint endoprosthe*[tw] OR hip joint prosthe*[tw] OR hip joint replacement*[tw] OR hip prosthe*[tw] OR hip replacement arthroplast*[tw] OR hip replacement*[tw] OR knee arthroplast*[tw] OR knee endoprosthe*[tw] OR knee joint endoprosthe*[tw] OR knee joint prosthe*[tw] OR knee joint replacement*[tw] OR knee prosthe*[tw] OR knee replacement*[tw] OR mckee farrar*[tw] OR mckee ferrar*[tw])
AND
("Outcome Assessment (Health Care)"[mesh] OR outcome*[tw] OR survival[tw] OR vital statistics[mesh] OR life expect*[tw] OR life year*[tw] OR morbidit*[tw] OR mortalit*[tw] OR incidenc*[tw] OR prevalenc*[tw] OR convalescence[tw] OR death*[tw] OR quality of life[tw] OR life qualit*[tw] OR reoperat*[tw] OR surgical revis*[tw] OR surgery repeat*[tw] OR repeat surger*[tw] OR repeated surger*[tw] OR revised surger*[tw] OR repeated operation*[tw] OR revised operation*[tw] OR patient satisfact*[tw] OR patient prefer*[tw] OR recovery of function*[tw] OR function recover*[tw] OR functional recover*[tw] OR physical function*[tw] OR pain[tw] OR sciatic*[tw] OR ischalg*[tw])
AND
(psycholog*[tw] OR expect*[tw] OR depress*[tw] OR mental health*[tw] OR anxiet*[tw] OR anxious*[tw] OR physiological stress*[tw] OR self efficacy[tw] OR emotion*[tw] OR vitalit*[tw])

Additionally, citation tracking was performed by manually screening the reference lists of eligible studies. Finally, personal communication with content experts was conducted.

Study selection

Two reviewers (MV, MR) assessed the studies on whether they met the following inclusion criteria:

- Patients in the study had to have primary THA or TKA for OA;
- A prospective study with a before-after design with a minimal follow-up period of 6 weeks;
- Full text of the article had to be available;
- The article had to be written in English, German, or Dutch;
- The original preoperative and postoperative data had to be available (no systematic review or meta-analysis);
- The study must have measured at least one of the following outcome measurements:
    - Severity of pain
    - Functioning of the patient
    - Patient satisfaction
    - Quality of Life
    - Mortality
    - Revision: revision rates, time to revision or survival analysis

AND

One of the following psychological aspects:
- Depression
- Anxiety
- Mental health
- Patient expectations
- Physiological stress
- Self-efficacy
- Coping
- Vitality
- Emotion
- Personality
- Other psychological determinants

AND
- The relationship between the outcome and the determinant must have been described.

Studies were excluded when they examined the relationship between determinant and outcome of the same questionnaire. Disagreements on inclusions were resolved by discussion, and a final decision of a third reviewer (JV) was not necessary.

Quality assessment

The methodological quality of observational studies can vary considerably, which may influence the results and conclusions of the studies, and consequently the results and conclusions of a systematic review. In this systematic review, only studies with a before-after design were included, so retrospective and cross-sectional studies were excluded. We evaluated the selected studies on internal validity using 5 questions from existing quality assessment tools[4-6]. Because only studies with a before-after design were included, studies with a relatively low score on study design were excluded. The quality of the articles was evaluated using a checklist that consisted of 5 items about the internal validity:
- Were the main outcomes measures accurate (valid and reliable)?
- Were the determinants measures accurate (valid and reliable)?
- Were the statistical tests that were used to assess the main outcomes appropriate?
- Were losses of patients to follow-up taken into account?
- Was there adequate adjustment for confounding (age, gender, and preoperative score of the outcome measure) in the analyses from which the main findings were drawn?

Minimally, 2 reviewers (MV and MR or SB or JB) assessed quality independently. Disagreements were resolved by discussion, and a final decision of a third reviewer (JV) was not necessary.

Studies were classified as high quality when minimally 3 items were scored as "yes" *and* they scored "yes" on question 5 of the checklist (adjusted for confounding in the analysis).

Data extraction

One reviewer (MV) extracted the study characteristics, follow-up times, outcomes and determinants, and the relationship between outcome and determinant. The data extraction form was pre-tested using 5 articles, with data extraction performed by 2 reviewers independently, followed by a consensus meeting. No adaptations to the data extraction form were found to be necessary.

In this review we presented the data for THA and TKA combined and separately, as some studies also combined the data. Studies that combined the results of THA and TKA were only presented in the combined results. Because the influence of preoperative psychological symptoms could be different on short- and longer term results, we stratified the results into 2 time periods: those with a follow-up period shorter than 1 year and those with a follow-up period equal to or longer than 1 year. When a study had more than 1 measurement in the same time period, we used the results with the longest follow-up time.

If a multivariate analysis (both adjusted or not adjusted for our predefined confounders) between psychological determinant and outcome was performed, these results were presented.

Best evidence synthesis

Because the studies were considered heterogeneous with regard to the outcome measures studied, the determinants studied, and the methodological quality, we refrained from statistically pooling the data and performed "a best evidence synthesis"[7, 8].

The following ranking of the levels of evidence was formulated. 1) Strong evidence is provided by 2 or more studies with high quality (= quality assessment ≥ 3 *and* adjustment for confounders) and by generally consistent findings in all studies (≥ 75% of the studies reported consistent findings). 2) Moderate evidence is provided by 1 high-quality study and 2 or more low-quality studies and by generally consistent findings in all studies (≥ 75%). 3) Limited evidence is provided by low-quality studies or 1 high-quality study and by generally consistent findings (≥ 75%). 4) Conflicting evidence is provided by conflicting findings (< 75% of the studies reported consistent findings). 5) No evidence is provided when no studies could be found.

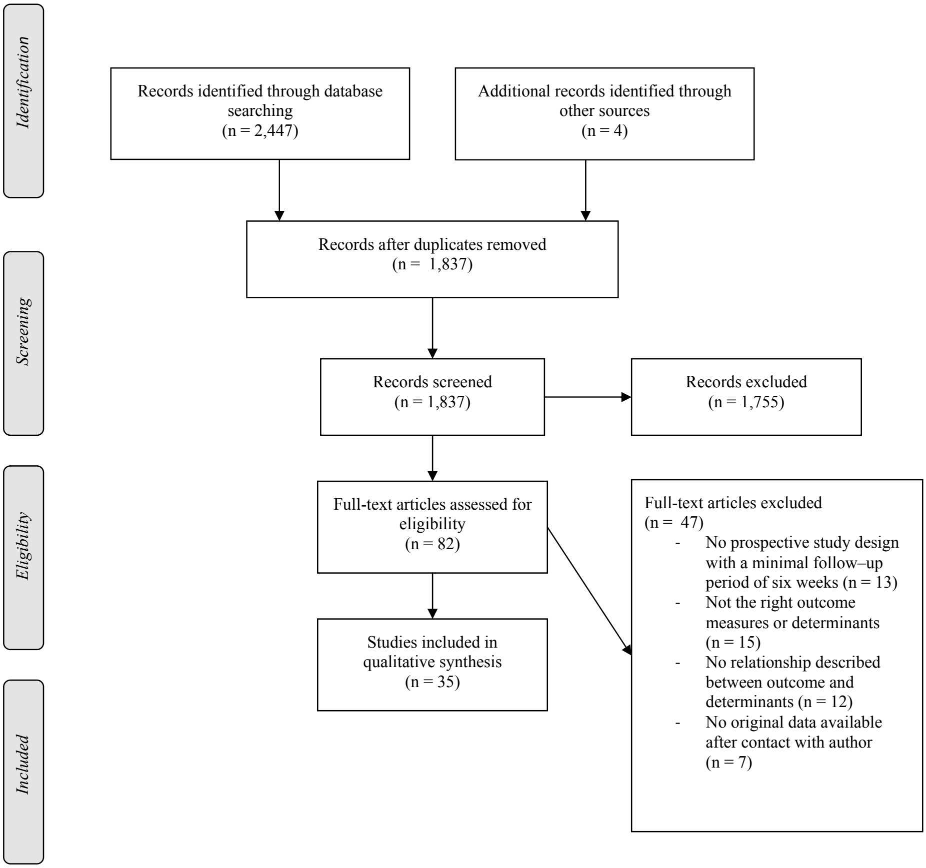

Figure 1 Study selection

RESULTS

Identification and selection of the literature

The search resulted in 1,837 articles, whose abstracts were reviewed. Through screening of the abstracts, 82 were identified as possibly relevant for which full articles were retrieved. After review of the full articles, 35 articles met all the inclusion criteria (Figure 1). The reasons for excluding articles were as follows: not a prospective study with a before-after design and a minimum follow-up of 6 weeks (n = 13); evaluated none of the pre-defined outcome measures or determinants (n = 15); no relationship described between outcome and determinants (n = 12); and no original data available even after contact with the author (n = 7).

Table 2 Characteristics of the included studies[a]

	Number of patients	Type of intervention, THA, TKA or both	Age, years	BMI, kg/m2	Gender, % women	Maximal follow-up, months	Outcome	Psychological determinants
Anakwe 2010 [9]	850	THA	68 ± 10.1		60.4	12	Patient satisfaction (Likert scale)	Depression (undefined) Mental health (SF-12 MCS)
Ayers 2005 [18]	165	TKA	68 ± 9.8		62.4	12	Function (WOMAC PF)	Mental health (SF-36 MCS)
Ayers 2004 [36]	100	TKA and THA	63 ± 12.2		63	6	Function (SF-36 PCS)	Depression (BDI) Anxiety (STAI-T) Mental health (SF-36 MCS) Coping (CSQ)
Badura – Brzoza 2009 [10]	102	THA	61 (54; 75)		58	6	Function (SF-36 PCS)	Depression (BDI) Anxiety (STAI-T) Personality (EPI) Sense of coherence (SOC)
Badura – Brzoza 2008 [11]	184	THA	63 (55; 76)	mean 28.2	59	6	Function (SF-36 PCS)	Depression (HADS) Anxiety (HADS)
Brander 2007[19]	83	TKA	66 ± 10.2	30.4 ± 6.4	55	60	Function (KSS)	Depression (BDI) Anxiety (STAI-T)
Brander 2003[20]	116	TKA	66 ± 10.5	mean 30.4	55	12	Pain (VAS pain)	Depression (BDI) Anxiety (STAI-T) Perceived stress (Perceived Stress Scale)
Brokelman 2008 [37]	44	TKA and THA	mean 68 (range 52; 81)			13	Patient satisfaction (VAS)	Patient expectations (VAS)
Edwards 2009 [21]	43	TKA	72 ± 7.0		58	12	Pain (VAS global daily pain and VAS night pain)	Depression (CES-D) Coping (CSQ)

Engel 2004 [22]	74	TKA	67 ± 8.3		49	6	Function (WOMAC PF / SF-36 PF) Pain (WOMAC pain / SF-36 pain)	Patient expectations (VAS) Coping (Likert Scale) Optimism/ pessimism (LOT-R)
Escobar 2007 [23]	640	TKA	72 ± 6.7	29.8 ± 4.1	74	6	Function (WOMAC PF) Pain (WOMAC pain)	Mental health (SF-36 MH)
Forsythe 2008 [24]	55	TKA	mean 69 (range 49; 85)		64	24	Pain (VAS pain and MPQ)	Pain catastrophizing (PCS)
Gandhi 2010 [25]	551	TKA	67 ± 9.8	30.1 ± 6.3	63	12	Function (WOMAC)	Mental health (SF-36 MH)
Gandhi 2010 [17]	636	THA	63.2 ± 13.7	27.6 ± 4.9	54	3	Function (WOMAC PF)	Mental health (SF-36 MH)
Gandhi 2009 [38]	1,799	TKA and THA				12	Function (WOMAC PF) Pain (WOMAC pain)	Patient expectations (Likert scale)
Gandhi 2008 [39]	1,720	TKA and THA				12	Patient satisfaction (Likert scale)	Mental health (SF-36 MH)
Hartley 2008 [40]	62	TKA and THA	64 ± 10.9	29.3 ± 5.6	34	1.5	Function (HHS / KSS)	Self-efficacy (SER) Hope (The Hope Scale)
Lingard 2007 [27]	952	TKA				24	Function (WOMAC PF) Pain (WOMAC pain)	Mental health (SF-36 MH)
Lingard 2006 [28]	598	TKA	mean 69 (range 38; 89)	29.3 ± 5.8	58	12	Function (WOMAC PF) Pain (WOMAC pain)	Patient expectations (Likert scale)
Lingard 2004 [26]	860	TKA	mean 70 (range 38; 89)		59	24	Function (WOMAC PF) Pain (WOMAC pain)	Mental health (SF-36 MH)
Mahomed 2002 [41]	222	TKA and THA	67 ± 9		55	6	Function (WOMAC PF / SF-36 PF) Pain (WOMAC pain)	Patient expectations (Likert scale / VAS)
Mannion 2009 [33]	112	TKA	67 ± 9		70	24	Patient satisfaction (Likert scale)	Patient expectations (Likert scale)

Merle-Vincent 2010 [34]	299	TKA	73.2 ± 7.9	28.4 ± 4.4	69	24	Patient satisfaction (percentage)	Depression ("do you feel depressed?")
Montin 2007 [12]	100	THA	64 ± 11.7		54	6	Quality of life (SIP)	Anxiety (STAI-T)
Quintana 2009 [13]	590	THA			49	24	Function (WOMAC PF) Pain (WOMAC pain)	Mental health (SF-36 MH)
Riddle 2010 [29]	140	TKA	mean 63.7	30.9 ± 7.1	71	6	Function (WOMAC PF) Pain (WOMAC pain)	Depression (PHQ-8) Anxiety (PRIME MD) Pain catastrophizing (PCS)
Riediger 2010 [14]	101	THA				2	Function (WOMAC PF / SF-36 PF)	Depression (HADS)
Rolfson 2009 [15]	6,158	THA	mean 69 (range 27; 96)		57	12	Patient satisfaction (VAS)	Depression (EQ-5d) Anxiety EQ-5d)
Salmon 2001 [16]	102	THA	69 ± 11		62	6	Function (WOMAC PF)	Mood (POMS)
Scott 2010 [35]	1,290	TKA	Mean 70.1 (range 35; 92)		61	6	Patient satisfaction (Likert scale)	Mental health (SF-12) Depression (undefined)
Smith 2004 [30]	64	TKA	67 ± 8.3		52	6	Function (WOMAC PF) Pain (WOMAC pain)	Purpose in life (PIL) Optimism/ pessimism (LOT-R) Emotionality (Scale of Emotional Arousability)
Sullivan 2009 [31]	75	TKA	67 ± 9.6	29.7 ± 5.2	61	1.5	Function (WOMAC PF) Pain (WOMAC pain)	Depression (PHQ-9) Pain catastrophizing (PCS) Fear of movement (TSK)
Van den Akker – Scheek 2007 [42]	103	TKA and THA	64 ± 10.9	27.0 ± 3.4	73	6	Function (WOMAC PF / SF-36 PF / walking speed)	Self-efficacy (SER)

Vissers 2010 [3]	44	TKA	64 (42; 78)	30.8 (24.2; 44.9)	55	6	Patient satisfaction (Likert Scale)	Depression (HADS) Anxiety (HADS) Mental health (SF-36 MH) Expectations (Likert scale)
Walton 2008 [32]	113	TKA				24	Function (reduced WOMAC)	Mental health (SF-12 MCS)

[a] Results are presented as mean ± standard deviation or median (minimum; maximum), unless otherwise indicated.
Abbreviations: THA, total hip arthroplasty; TKA, total knee arthroplasty; BMI, Body Mass Index; WOMAC, Western Ontario and McMaster University Osteoarthritis Index physical; PF, Physical functioning subscale; SF-36 / SF-12, Medical Outcomes Study Short-Form Health Survey; PCS, Physical Component Score; KSS, Knee Society Score; VAS, Visual Analogue Scale; MPQ, McGill Pain Questionnaire; HHS, Harris Hip Score; SIP, Sickness Impact Profile; MCS, Mental Component Score; BDI, Beck Depression Inventory; STAI-T, Spielberger Trait Anxiety Inventory; CSQ, Coping Strategies Questionnaire; EPI, Eysenck Personality Inventory; SOC, Sense of Coherence; HADS, Hospital Anxiety and Depression Scale; CES-D, Epidemiological Studies Depression Scale; CSQ, Coping Strategies Questionnaire; LOT-R, Life Orientation Test-Revised; MH, Mental Health subscale; PCS; Pain Catastrophizing Scale; SER, Self-Efficacy for Rehabilitation Outcome Scale; PHQ; Patient Health Questionnaire; PRIME MD, Primary Care Evaluation of Mental Disorders; EQ-5d, Euroqol System; POMS, Profile of Mood States; MMPI, Minnesota Multiphasic Personality Inventory; ICD; International Classification of Diseases; PIL, Purpose in Life; TSK, Tampa Scale for Kinesiophobia.

Description of the included studies

Table 2 presents the characteristics of the 35 included studies. Nine studies examined the influence of psychological factors on the outcome of THA[9-17], 19 of TKA[3, 18-35], and 7 of both THA and TKA[36-42]. Date of publication of the studies ranged from 2001 to 2010. The number of patients in the studies ranged from 43 to 8,050.

Fourteen studies evaluated the influence of psychological factors on the outcome measure pain[13, 20-24, 26-31, 38, 41], 23 on function[10, 11, 13, 14, 16-19, 22, 23, 25-32, 36, 38, 40-42], 8 on patient satisfaction[3, 9, 15, 33-35, 37, 39], 1 on quality of life[12], and none on mortality and revision.

The 4 most-often evaluated psychological aspects were depression[3, 9-11, 14, 15, 19-21, 29, 31, 34-36], mental health[3, 9, 13, 17, 18, 23, 25-27, 32, 35, 36, 39], anxiety[3, 10-12, 15, 19, 20, 29, 36] and patient expectations[3, 22, 28, 33, 37, 38, 41].

Quality assessment

The results of the risk of bias assessment are presented in Table 3. The scores on the 5 questions ranged from 0 to 5. One study scored 0 points and 2 studies scored 5 points on the checklist. Seventeen studies (49%) scored ≥ 3 on the checklist *and* adjusted for confounders in the analysis and were therefore classified as high-quality studies.

Table 3 Quality assessment

	Internal validity					Total
	Outcome accurate?	Determinant accurate?	Statistical tests appropriate?	Losses of follow-up taken into account?	Adjustment for confounding?	
High quality						
Gandhi 2010 [25]	1	1	1	1	1	**5**
Gandhi 2010 [17]	1	1	1	1	1	**5**
Ayers 2005 [18]	1	1	1	0	1	**4**
Ayers 2004 [36]	1	1	1	0	1	**4**
Escobar 2007 [23]	1	1	1	0	1	**4**
Gandhi 2009 [38]	1	0	1	1	1	**4**
Gandhi 2008 [39]	0	1	1	1	1	**4**
Hartley 2008 [40]	1	1	1	0	1	**4**
Lingard 2004 [26]	1	1	1	0	1	**4**
Lingard 2007 [27]	1	1	1	0	1	**4**
Quintana 2009 [13]	1	0	1	1	1	**4**
Riddle 2010 [29]	1	1	1	0	1	**4**
Rolfson 2009 [15]	0	1	1	1	1	**4**
Sullivan 2009 [31]	1	1	1	0	1	**4**
Van den Akker – Scheek 2007 [42]	1	1	1	0	1	**4**
Vissers 2010 [3]	0	1	1	1	1	**4**
Lingard 2006 [28]	1	0	1	0	1	**3**
Low quality						
Anakwe 2010 [9]	0	1	1	1	0	**3**
Badura – Brzoza 2009 [10]	1	1	1	0	0	**3**
Badura – Brzoza 2008 [11]	1	1	1	0	0	**3**
Brander 2007[19]	1	1	1	0	0	**3**
Brander 2003[20]	1	1	1	0	0	**3**
Edwards 2009 [21]	1	1	1	0	0	**3**
Forsythe 2008 [24]	1	1	1	0	0	**3**
Mahomed 2002 [41]	1	0	1	1	0	**3**
Montin 2007 [12]	1	1	1	0	0	**3**
Riediger 2010 [14]	1	1	1	0	0	**3**
Salmon 2001 [16]	1	1	1	0	0	**3**
Walton 2008 [32]	1	1	1	0	0	**3**
Brokelman 2008 [37]	0	0	1	1	0	**2**
Engel 2004 [22]	1	0	0	1	0	**2**

Mannion 2009 [33]	0	0	1	0	1	**2**
Merle-Vincent 2010 [34]	0	0	1	0	1	**2**
Scott 2010 [35]	0	0	1	0	0	**1**
Smith 2004 [30]	0	0	0	0	0	**0**

Influence on outcome shorter than 1 year postoperative

In 17 studies[3, 10-14, 16, 17, 22, 23, 29-31, 36, 40-42] the influence of psychological factors on outcome after TKA and THA shorter than 1 year postoperative was studied. When combining the results for TKA and THA, strong evidence was found that a lower preoperative mental-health status results in worse scores on function and pain. Furthermore, strong evidence was available that preoperative pain catastrophizing predicts more pain in follow-up. Pain catastrophizing can be described as a response style to painful experiences that is likely to be associated with negative pain outcomes. Pain catastrophizing is characterized by a tendency to focus excessively on pain sensations, to exaggerate the threat value of pain sensations and to perceive oneself as being unable to control pain symptoms. Only limited or conflicting evidence was found for the influence of the other psychological factors on outcome when combining the results after TKA and THA.

When we split the results for TKA and THA, only limited and conflicting evidence was found for the relationship between preoperative mental health and postoperative function and pain, because only a few studies evaluated this relationship in knee and hip patients separately. Furthermore, the strong evidence for pain catastrophizing on pain was completely explained by studies evaluating knee patients. In contrast to the combined results, for knee patients separately, strong evidence was found that preoperative depression had no influence on functioning after TKA.

Influence on outcome greater than or equal to 1 year postoperative

In 19 studies [9, 13, 15, 18-21, 24-28, 32-35, 37-39] the influence of psychological symptoms 1 year or longer after TKA and THA was evaluated. For the results of TKA and THA combined, strong evidence was found that a lower preoperative mental health status results in worse scores on function and pain. Only limited or conflicting evidence was found for an influence of the other psychological factors on outcome.

When we split the results for TKA and THA, strong evidence was found for the relationship between mental health and postoperative function and pain only for the knee patients. For THA separately, only limited, conflicting, or no evidence was found for the influence of psychological factors on the outcome after THA.

Patient expectations

Patient expectations were measured by using patient expectations questionnaires incorporating either visual analogue scales or Likert scales. The questions asked about patient expectations were very heterogeneous in the different studies. Therefore, we did not present the results of patient expectations in Table 4, 5 and 6. Questions were asked about patient expectations regarding overall recovery[22, 38], overall success[3, 37, 41], pain[3, 28, 33, 38, 41], limitations in activities[3, 28, 33, 38, 41], quality of life[22], joint complications[41], walking distance[28], walking aids[28], and recovery time[33]. Limited evidence was found that patients who had high preoperative expectations had better outcomes with respect to pain and function both in the short-term and the long-term after TKA and THA. Limited evidence was found that preoperative expectations had no influence on patient satisfaction.

DISCUSSION

In this systematic review we summarized the available evidence about the influence of psychological factors on the outcome after TKA and THA. We found that low preoperative mental health and pain catastrophizing have an influence on outcome. Different results were found for TKA and THA combined and separately. Therefore, the question arises whether we can combine the results of TKA and THA. From the results of this study it is not clear whether the differences are actually different between knee and hip patients or if the differences could be explained by the relatively few studies that evaluated the influence of psychological factors affecting the outcome after THA. Only in 9 of the 35 included studies (26%) were such influences on the outcome of THA studied. It could be that when more studies examine the influence of psychological factors on the outcome after THA, the evidence will be more convincing.

With the results of this systematic review we cannot answer our second research question of how much influence mental health and pain catastrophizing have on outcome. Only in the study of Riddle and coworkers[29] was an odds ratio (OR) presented. Those authors examined the relationship between pain catastrophizing and pain. They found that patients with more pain catastrophizing more often experienced improvement that was below 50% on the Western Ontario and McMaster Universities Arthritis Index (WOMAC) pain subscale after adjustment of our predefined confounders (OR = 2.67, 95% confidence interval 1.2; 6.1)[29]. The study of Ayers and coworkers[18] evaluated the relationship between preoperative mental health and functioning 12 months after TKA. That study presented a mean difference in WOMAC physical function change score between patients with a low and high preoperative mental health (mean difference = 7.48). However, the study did not describe how WOMAC physical functioning was scored. All other studies describing the influence of mental health or pain catastrophizing on outcome presented beta coefficients or R squared. Therefore, future research has to evaluate how much influence psychological characteristics have on THA and TKA.

Besides mental health, the 3 most evaluated psychological factors in the present systematic review were depression, anxiety, and patient expectations. The evidence for an influence of depression, anxiety and patient expectations on postoperative outcome was less convincing than for mental health. Mental health was measured with the Medical Outcome Study Short-Form Healthy Survey with 36 or 12 questionnaires (SF-36/SF-12) in all studies. In contrast, depression was measured with 5 different questionnaires and anxiety with 4 different questionnaires, and the specific questions asked about patient expectations differed between the studies. Therefore, a reason the evidence for the influence of depression, anxiety and patient expectations is less convincing than it is for mental health could be that these psychological symptoms were measured with many different questionnaires and questions. It could be that this heterogeneity leads to conflicting results. Another explanation could be that the SF-36/SF-12 questionnaire is more health-related than the other questionnaires, which are more symptom-specific. This could account for the SF-36/SF-12 questionnaire being more related to outcome than the more symptom-specific questionnaires.

Besides heterogeneity in the measurement of psychological factors, heterogeneity also existed in the outcome measures. Four different outcome measures (pain, function, patient satisfaction and quality of life) were evaluated. These outcome measures were evaluated with different questionnaires. Furthermore, the outcome measures functioning and pain were measured with both hip-/knee-specific measures (e.g. WOMAC) and with non-specific or generic functioning or pain measures. It could be that the latter may be confounded by the presence of other painful, disabling conditions. Unfortunately, most of the included studies did not present any results of comorbidities. Therefore, we do not know to what extend comorbidities could have had an influence on the generic measured outcome measures.

Strong evidence was found in 2 studies that preoperative depression had no influence on function less than 1 year after TKA. The question arises whether these studies had enough power to detect influences on outcome. One of the studies[29] presented a power calculation, and it seems to have had enough power to detect influences on outcome. The other study[31] presented no power calculation (n = 75), but found other significant influences on outcome. Therefore, it seems that preoperative depression has no influence on functioning within 1 year after TKA, but future research should evaluate more thoroughly the influence of depression on outcome after TKA and THA.

Mental health measured with the SF-36 or SF-12 questionnaire is a global mental construct, covering also psychological symptoms described by other outcome measures, such as depressive and anxiety symptoms. Therefore, some overlap exists between the psychological symptoms described in our systematic review. However, the questions of the SF-36 or SF-12 questionnaire are global and are about general mental wellbeing and not specifically about 1 aspect of mental wellbeing. Because we included in this systematic review studies that differentiated between (global) mental health measured with the SF-36 or SF-12 questionnaire and the other psychological symptoms, we decided to present (global) mental health and depressive and anxiety symptoms separately.

Van den Akker-Scheek and coworkers examined the effect of self-efficacy on functioning after THA and TKA[42]. They found that self-efficacy had a positive influence on walking speed, but had no influence on WOMAC physical functioning and SF-36 physical functioning. Therefore, in Table 4 both a positive influence and no influence are presented.

The heterogeneity of the studied determinants and outcome measures could limit the level of certainty of our conclusion. Because the studies were considered heterogeneous with regard to the outcome measures, the determinants, the questionnaires and the methodological quality, we refrained from statistically pooling the data and performed a best evidence synthesis. The wide variability in outcome measures and determinants makes it difficult to compare the results of different studies. Therefore, more standardization is needed when evaluating the influence of psychological symptoms on the outcome after THA and TKA.

In conclusion, from the results of this systematic review it seems that there are 2 psychological factors that have an influence on outcome, namely, mental health measured with SF-12 or SF-36 and pain catastrophizing. Patients who have more pain catastrophizing preoperatively have more pain shortly after TKA surgery. Furthermore, patients with low preoperative mental health have more pain and worse functioning lasting longer after TKA. From the results of this systematic review it is not clear how much influence these factors have on outcome. As to the influence of other psychological determinants and for hip patients, only limited, conflicting, or no evidence was found.

Table 4 Influence of psychological symptoms on the outcome of TKA and THA

Determinant	Outcome	< 1 year postoperative		Best evidence synthesis	≥ 1 year postoperative		Best evidence synthesis
		All studies	High quality[a]		All studies	High quality[a]	
Mental health	**Pain**	↑[23] ↑[13]	↑[23] ↑[13]	**Strong**	↑[26] ↑[27] ↑[13]	↑[26] ↑[27] ↑[13]	**Strong**
	Function	↑[36] ↑[23] ↑[13] -[17]	↑[36] ↑[23] ↑[13] -[17]	**Strong**	↑[18] ↑[25] ↑[26] ↑[27] ↑[13] ↑[32]	↑[18] ↑[25] ↑[26] ↑[27] ↑[13]	**Strong**
	Patient satisfaction	↑[3]	↑[3]	Limited	↑[39] -[9] ↑[35]	↑[39]	Conflicting
Pain catastrophizing	**Pain**	↑[29] ↑[31]	↑[29] ↑[31]	**Strong**	-[24]		Limited
	Function	↑[29] -[31]	↑[29] -[31]	Conflicting			No
Depression	**Pain**	-[29] ↓[31]	-[29] ↓[31]	Conflicting	↓[20] ↓[21]		Limited
	Function	-[36] -[10] ↓[11] -[29] ↓[14] -[31] -[16]	-[36] -[29] -[31]	Conflicting	↓[19]		Limited
	Patient satisfaction	↓[3]	↓[3]	Conflicting	↓[15] -[9] -[34] -[35]	↓[15]	Conflicting
Anxiety	**Pain**	-[29]	-[29]	Limited	↓[20]		Limited
	Function	-[36] ↓[10] ↓[11] -[29] -[16]	-[36] -[29]	Conflicting	-[19]		Limited
	Patient satisfaction	↓[3]	↓[3]	Limited	↓[15]	↓[15]	Limited
	Quality of life	↓[12]		Limited			No
Coping	**Pain**	↑[22]		Limited	↑[21]		Limited
	Function	-[36] ↑[22]	-[36]	Conflicting			No
Personality (optimism/ pessimism)	**Pain**	↓[22] -[30]		Conflicting			No
	Function	↓[10] -[22] -[30]		Conflicting			No
Perceived stress	**Pain**			No evidence	-[20]		Limited
Purpose in life	**Pain**	-[30]		Limited			No
	Function	-[30]		Limited			No
Emotionality	**Pain**	-[30]		Limited			No
	Function	-[30]		Limited			No
Fear of movement	**Pain**	↓[31]	↓[31]	Limited			No
	Function	-[31]	-[31]	Limited			No
Sense of coherence	**Function**	↑[10]		Limited			No
Self-efficacy	**Function**	-[40] ↑/-[42]	-[40] ↑/-[42]	Conflicting			No
Hope	**Function**	-[40]	-[40]	Limited			No
Fatigue	**Function**	↓[16]		Limited evidence			No

[a] High-quality studies = studies with score ≥ 3 on the quality assessment and with analysis adjusted for our predefined confounders. ↑ Positive influence of determinant on outcome; ↓ Negative influence of determinant on outcome; - No significant influence.

Table 5 Influence of psychological symptoms on the outcome of TKA

Determinant	**Outcome**	**< 1 year postoperative**		**Best evidence synthesis**	**≥ 1 year postoperative**		**Best evidence synthesis**
		All studies	**High quality**[a]		**All studies**	**High quality**[a]	
Mental health	**Pain**	↑[23]	↑[23]	Limited	↑[26] ↑[27]	↑[26] ↑[27]	**Strong**
	Function	↑[23]	↑[23]	Limited	↑[18] ↑[25] ↑[26] ↑[27] ↑[32]	↑[18] ↑[25] ↑[26] ↑[27]	**Strong**
	Patient satisfaction	↑[3] ↑[35]	↑[3]	Limited			No
Pain catastrophizing	**Pain**	↑[29] ↑[31]	↑[29] ↑[31]	**Strong**	-[24]		Limited
	Function	↑[29] –[31]	↑[29] –[31]	Conflicting			No
Depression	**Pain**	–[29] ↓[31]	–[29] ↓[31]	Conflicting	↓[20] ↓[21]		Limited
	Function	–[29] –[31]	–[29] –[31]	**Strong**	↓[19]		Limited
	Patient satisfaction	↓[3] –[35]	↓[3]	Conflicting	-[34]		Limited
Anxiety	**Pain**	-[29]	-[29]	Limited	↓[20]		Limited
	Function	-[29]	-[29]	Limited	-[19]		Limited
	Patient satisfaction	↓[3]	↓[3]	Limited			No
Coping	**Pain**	↑[22]		Limited	↑[21]		Limited
	Function	↑[22]		Limited			No
Personality (optimism/ pessimism)	**Pain**	↓[22] -[30]		Conflicting			No
	Function	-[22] -[30]		Limited			No
Perceived stress	**Pain**			No	-[20]		Limited
Purpose in life	**Pain**	-[30]		Limited			No
	Function	-[30]		Limited			No
Emotionality	**Pain**	-[30]		Limited			No
	Function	-[30]		Limited			No
Fear of movement	**Pain**	↓[31]	↓[31]	Limited			No
	Function	-[31]	-[31]	Limited			No

[a] High-quality studies = studies with score ≥ 3 on the quality assessment and with analysis adjusted for our predefined confounders ↑ Positive influence of determinant on outcome; ↓ Negative influence of determinant on outcome; - No significant influence.

Table 6 Influence of psychological symptoms on the outcome of THA

Determinant	Outcome	< 1 year postoperative		Best evidence synthesis	≥ 1 year postoperative		Best evidence synthesis
		All studies	High quality[a]		All studies	High quality[a]	
Mental health	**Pain**	↑[13]	↑[13]	Limited	↑[13]	↑[13]	Limited
	Function	↑[13] -[17]	↑[13] -[17]	Conflicting	↑[13]	↑[13]	Limited
	Patient satisfaction			No	-[9]		Limited
Pain catastrophizing	**Pain**			No			No
	Function			No			No
Depression	**Pain**			No			No
	Function	-[10] ↓[11] ↓[14] ↓[16]		Limited			No
	Patient satisfaction			No	↓[15] -[9]	↓[15]	Conflicting
Anxiety	**Pain**			No			No
	Function	↓[10] ↓[11] ↓[16]		Limited			No
	Patient satisfaction			No	↓[15]	↓[15]	Limited
	Quality of life	↓[12]		Limited			No
Coping	**Pain**			No			No
	Function			No			No
Personality (optimism/ pessimism)	**Pain**			No			No
	Function	↓[10]		Limited			No
Perceived stress	**Pain**			No			No
Purpose in life	**Pain**			No			No
	Function			No			No
Emotionality	**Pain**			No			No
	Function			No			No
Fear of movement	**Pain**			No			No
	Function			No			No
Sense of coherence	**Function**	↑[10]		Limited			No
Fatigue	**Function**	↓[16]		Limited			No

[a] High-quality studies = studies with score ≥ 3 on the quality assessment and with analysis adjusted for our predefined confounders ↑ Positive influence of determinant on outcome; ↓ Negative influence of determinant on outcome; - No significant influence

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Chapter 7

Depressive and anxiety symptoms before and after total hip and knee arthroplasty

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ABSTRACT

Background. Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are cost-effective surgical options for patients with end stage osteoarthritis (OA). However, a subset of patients has suboptimal postoperative results. Psychological factors could be related to these suboptimal results after THA and TKA.

Aim. To examine the prevalence of depressive and anxiety symptoms in patients with end-stage OA on the waiting list for THA/TKA and 3 months after the THA and TKA procedure. In addition, to evaluate the influence of preoperative depressive and anxiety symptoms on the outcome of THA and TKA.

Methods. This study has a prospective design with three assessment points. Patients were measured preoperatively while on the waiting list, and at 3 and 12 months after THA/TKA. Patients filled in three questionnaires at these three assessment points. Presented here are the preoperative and 3-month postoperative results.

Results. The prevalence of depressive symptoms decreased from 33.6% preoperatively to 12.1% 3 months postoperatively (p-value <0.001) in hip patients, and from 21.8% to 15.8%, respectively (p-value 0.05), in knee patients. The prevalence of anxiety symptoms decreased from 27.5% to 12.1% (p-value <0.001) in hip patients, and from 19.5% to 13.5%, respectively (p-value 0.01), in knee patients. Hip patients with preoperative depressive symptoms have lower change scores on functioning and sport outcomes 3 months postoperatively. Knee patients with preoperative anxiety symptoms have lower change scores on symptoms, sport and quality of life outcomes 3 months postoperatively.

Conclusion. Preoperatively, the prevalence of depressive and anxiety symptoms was relatively high in end-stage hip and knee OA patients compared with the prevalence in other chronic diseases. The prevalence of depressive symptoms was higher in hip than in knee patients. Three months postoperatively, the prevalence of symptoms showed a significant decrease in both hip and knee patients. However, patients with preoperative depressive and anxiety symptoms had worse outcomes 3 months after THA/TKA than patients without depressive and anxiety symptoms.

INTRODUCTION

Osteoarthritis (OA) of the hip and knee is one of the most frequently occurring disorders of the locomotor system, and the leading cause of pain and disability in the older population. When conservative treatment fails, total hip arthroplasty (THA) and total knee arthroplasty (TKA) are cost-effective surgical options for patients with end stage OA[1].

Surgical techniques and design of the prostheses have been improved, and the results after THA and TKA are generally good. However, a subset of patients has suboptimal postoperative results with respect to pain, physical functioning and quality of life, and may not be satisfied with the results of their THA/TKA. These suboptimal results cannot be entirely explained by patient characteristics, adverse events, physical co-morbidities or the surgery itself, but seem to be related to other characteristics, including psychological symptoms[2].

Psychological symptoms are also highly prevalent in the elderly and mainly affect those with a chronic medical illnesses[3]. Psychological symptoms were found to be associated with a lower quality of life and increased pain and symptom sensitivity[4]. In addition, psychological symptoms influence the motivation, energy, coping with the illness and adherence of patients. Therefore, psychological symptoms may have an important influence on the treatment results and recovery of OA.

The question arises whether patients with end-stage hip or knee OA, who have suffered chronic pain and disability for many years, have an increased prevalence of psychological symptoms. To our knowledge, the prevalence of psychological symptoms has not been examined in patients with end-stage OA. In other chronic diseases, such as coronary heart disease, diabetes and breast cancer, the prevalence of depressive symptoms measured with the Hospital Anxiety and Depression Scale (HADS) is reported to range from 16-24% and the prevalence of anxiety symptoms from 32-43%[5-7].

We hypothesized that, because of the close relationship between psychological symptoms and pain and disability, the prevalence of psychological symptoms will also be high in end-stage hip and knee OA patients.

Moreover, it is important to evaluate whether the prevalence of psychological symptoms decreases when the pain and disability decreases after THA/TKA. We hypothesized that when pain and disability decrease after THA/TKA, then the prevalence of psychological symptoms will also decrease.

Finally, it is important to examine whether preoperative psychological symptoms have an influence on the outcome of THA/TKA. Our group earlier showed that patients with a lower mental health before THA and TKA had a worse outcome post-surgery[8, 9]. However, it was unclear whether two important psychological symptoms, namely depressive and anxiety symptoms, had an influence on outcome after THA and TKA.

The primary aim of this study was to examine the prevalence of depressive and anxiety symptoms in patients with end-stage OA on the waiting list for THA and TKA, and at 3 months after THA and TKA. The second aim was to evaluate the influence of preoperative depressive and anxiety symptoms on the outcome after THA and TKA.

METHODS

This study was based on a prospective design with three assessment points. Patients were measured preoperatively while on the waiting list, and again at 3 and 12 months after the THA/TKA procedure. Patients filled in three questionnaires at these three assessment points. This study presents data on the preoperative situation and on short-term (3-month postoperative) follow-up.

Patients

All patients on the waiting list for primary THA or TKA at the department of Orthopaedics of Erasmus University Medical Center in Rotterdam, Reinier de Graaf Hospital in Delft, and St. Elisabeth Hospital in Tilburg in the period March 2009 and August 2010 were eligible. Patients who did not participate 'actively' on the waiting list because of severe co-morbidities (too ill to undergo surgery) were excluded. This study was approved by the local Medical Ethics Committee.

Measurements

Because patients on the waiting list (baseline measurement) were measured without a fixed time point, the amount of time patients were on the waiting list varied. Patients received the questionnaires by mail. In case of non-response a reminder was sent by mail after 3 weeks. If patients did not respond to the reminder, they were contacted again by telephone 3 weeks later.

The primary outcome measures were anxiety and depressive symptoms. These two symptoms were measured with the HADS, a validated questionnaire to screen anxiety and depressive symptoms. The HADS consists of 14 items, each rated from 0-3 according to the severity of distress experienced (0 indicates no distress and 3 indicates maximum distress). The HADS is divided into an Anxiety subscale and a Depression subscale, each with 7 questions; each subscale score ranges from 0-21.

There are two ways to analyze the HADS data. First, raw scores can be summed for each subscale separately. Second, raw scores of the subscales can be used to classify patients into those with and without depressive or anxiety symptoms. The optimal cut-off score for the presence of both anxiety and depressive symptoms is ≥ 8; the sensitivity and specificity for this cut-off is about 0.80[10-12].

The present study includes patients using antidepressants, or patients being treated by a psychologist or psychiatrist because of depressive or anxiety problems. It is possible that these patients do not reach the threshold for the presence of anxiety/depression on the HADS, although they were receiving treatment for these conditions. Therefore, we scored these patients as having depressive/anxiety disorders irrespective of the HADS scores.

The Hip disability and Osteoarthritis Outcome Score (HOOS)[13, 14] and the Knee injury and Osteoarthritis Outcome Score (KOOS)[15, 16] were used to evaluate hip and knee specific outcomes. The HOOS and KOOS questionnaires include five subscales: pain, symptoms, functioning in activities of daily living (ADL), function in sport and recreation, and hip or knee-related quality of life. Standardized response options are given (5-point Likert scale), and each question is scored from 0-4. Then, a normalized score from 0-100 is calculated for each subscale (100 indicating no symptoms, and 0 indicating extreme symptoms)[13-16]. Finally, patients filled in a general questionnaire about patient characteristics, use of pain medication, use of antidepressants, and treatment by a psychologist/psychiatrist because of depressive/anxiety problems.

Statistical analysis

Statistical analysis was performed using SPSS 17.0. Data on the hip and knee patients are presented separately. Differences between hip and knee patients, and differences between the study population and patients lost to follow-up, were analyzed using independent t-tests. Differences between the preoperative and 3-month postoperative data were analyzed with dependent t-tests. Effect sizes were calculated to examine the effect of THA/TKA on depressive/anxiety symptoms. Effect sizes were calculated as the mean of the 3 months results minus the mean of the baseline (preoperative) data divided by the standard deviation (SD) of the baseline results.

To evaluate the influence of preoperative depressive/anxiety symptoms on the outcome after THA/TKA multivariate analysis was used. The dependent variable was the change scores of the HOOS or KOOS subscales between the 3-month postoperative and the preoperative scores. The independent variables were the preoperative depressive/anxiety HADS score (dichotomized as < 8 and ≥ 8). This relationship was adjusted for age, gender, preoperative score on the HOOS and KOOS subscale and unbalanced characteristics between the study population and patients lost to follow-up.

RESULTS

Between March 2009 and August 2010, 451 patients were eligible to participate in the study and received questionnaires by mail. Of these eligible patients, baseline results of

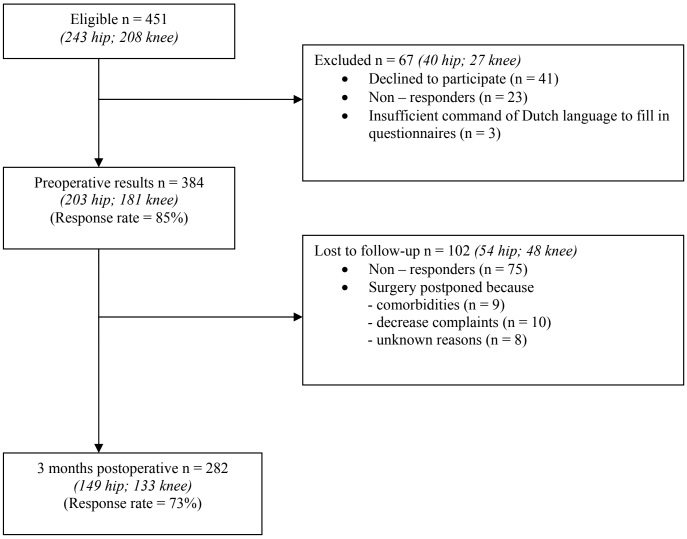

Figure 1. patient selection

384 patients were available (response rate 85%) (Fig. 1). At the 3-month follow-up, data were available for 282 patients (response rate 73%). The results of these 282 patients for whom both baseline and 3-month postoperative data were available, were used in the present analysis.

Table 1 presents the baseline characteristics of the study population and of patients lost to follow-up. There were no significant differences between the study population and patients lost to follow-up with respect to the primary outcome measures 'prevalence of depressive and anxiety symptoms' (Table 1). For the hip patients, the hospital (Erasmus University Medical Center in Rotterdam, Reinier de Graaf Hospital in Delft, or St. Elisabeth Hospital in Tilburg) and the presence of familial depression were unbalanced characteristics between the study population and the patients lost to follow-up. For the knee patients, the time on the waiting list at baseline measurement was an unbalanced characteristic.

Table 2 presents the preoperative and 3-month postoperative data on the HADS. The prevalence of depressive symptoms was significantly higher in hip than in knee patients (33.6% vs. 21.8%; p-value = 0.028). The preoperative prevalence of anxiety symptoms was similar between the hip and knee patients. Compared to baseline, 3 months postoperatively the mean score of both the HADS, and the prevalence of depressive/anxiety symptoms, showed a significant decrease. No differences were seen between hip and knee patients 3 months postoperatively for the prevalence of depressive/anxiety symptoms.

The effect sizes of THA on depressive/anxiety symptoms were higher than the effect sizes of TKA (on depressive symptoms 0.44 vs. 0.27, and on anxiety symptoms 0.36 vs. 0.28).

In hip patients, preoperative depressive symptoms predicted lower change scores on the HOOS subscales functioning (ADL) and sport. This relationship was independent of age, gender, preoperative score on the HOOS subscale, and the unbalanced characteristics hospital and familial depression. Furthermore, hip patients who had preoperative depressive symptoms had significantly lower 3-month postoperative scores on all subscales of the HOOS questionnaires, except for the symptoms subscale, compared to patients without depressive symptoms (Table 3). Preoperative anxiety symptoms had no independent influence on the change scores of the HOOS subscales. However, hip patients who had preoperative anxiety symptoms had lower 3-month postoperative scores on the pain and functioning subscales of the HOOS questionnaire (pain subscale 77.7 ± 20.5 vs. 69.0 ± 21.4 and functioning subscale 70.8 ± 20.9 vs. 61.8 ± 24.4).

For the knee patients preoperative depressive symptoms predicted lower change scores on the symptoms subscale of the KOOS questionnaire. This relation was independent of age, gender, the preoperative score on the KOOS subscale and the unbalanced characteristic time on the waiting list at baseline measurement. Furthermore, 3-months postoperatively knee patients with preoperative depressive symptoms had significantly lower scores on this subscale compared to patients without depressive symptoms. Preoperative anxiety symptoms had an independent influence on the change scores of the symptoms, sport and quality of life subscales. Furthermore, knee patients with preoperative anxiety symptoms had significantly lower postoperative scores on all subscales of the KOOS.

DISCUSSION

We hypothesized that, because of the close relationship between psychological symptoms and pain and disability, the prevalence of psychological symptoms would be high in end-stage hip and knee OA patients. Preoperatively, the prevalence of depressive symptoms differed between end-stage hip and knee OA patients. Compared with other chronic diseases the prevalence of depressive symptoms in hip OA patients was relatively high (33.1% compared with 16-23.8% in patients with coronary heart diseases, diabetes and breast cancer). The prevalence of depressive disorders in knee OA patients was similar to the prevalence of other chronic diseases[5-7]. The prevalence of anxiety disorders was relatively low in both hip and knee OA patients compared with the prevalence in other chronic diseases (27.0% and 19.6%, respectively, compared with 32.0-42.9% in coronary heart diseases, diabetes and breast cancer)[5-7]. Unfortunately, no data were unavailable

Table 1 Baseline characteristics of the study patients and of patients lost to follow-up[a]

	Hip			Knee		
	Study population n = 149	LTFU n = 54	p-value	Study population n = 133	LTFU n = 48	p-value
Age, years	68.7 ± 9.8	65.5 ± 13.7	0.19	66.1 ± 9.9	66.6 ± 8.8	0.75
Gender, women n, %	95 (63.8)	27 (50.0)	0.08[b]	77 (57.9)	35 (72.9)	0.07[b]
Hospital						
- EMC, n (%)	36 (24.2)	34 (63.0)	<0.0001[b]	49 (36.8)	24 (50.0)	0.28
- RdGG, n (%)	41 (27.5)	7 (13.0)		50 (37.6)	14 (29.2)	
- St. Elisabeth, n (%)	72 (48.3)	13 (24.1)		34 (25.6)	10 (20.8)	
Education						
- Less than high school, n (%)	43 (28.9)	13 (24.1)	0.47	36 (27.3)	18 (37.5)	0.19
Time on waiting list at baseline measurement, weeks	9.3 ± 13.6	13.9 ± 16.0	0.04[b]	14.5 ± 16.4	19.3 ± 18.9	0.10[b]
Total time spent on waiting list, weeks	22.6 ± 20.8	31.4 ± 22.9	0.02[b]	30.7 ± 22.7	35.5 ± 28.3	0.29
HOOS/KOOS, score 0-100; 100 best score						
- Pain	32.4 ± 18.2	37.5 ± 19.5	0.08[b]	36.2 ± 17.6	34.8 ± 20.5	0.65
- Symptoms	50.4 ± 10.8	46.0 ± 11.9	0.06[b]	43.6 ± 20.8	40.1 ± 19.7	0.32
- ADL	29.6 ± 18.6	34.8 ± 20.2	0.09[b]	38.0 ± 20.1	34.8 ± 20.5	0.36
- Sport	14.7 ± 19.8	19.1 ± 24.3	0.19	9.4 ± 17.9	12.2 ± 24.0	0.39
- QOL	21.2 ± 17.3	20.3 ± 18.2	0.75	18.0 ± 15.4	20.5 ± 16.5	0.35
History of depressive disorders, n (%)	29 (19.5)	9 (18.8)	0.91	24 (18.0)	6 (15.4)	0.70
Familial depression, n (%)	33 (22.1)	2 (4.2)	0.01[b]	14 (10.5)	4 (10.3)	0.96
HADS depressive symptoms						
- ≥ 8, n (%)	40 (26.8)	20 (37.0)	0.16	26 (19.5)	13 (27.1)	0.28
- use of antidepressants, n (%)	15 (10.1)	3 (6.4)	0.44	7 (5.3)	4 (9.5)	0.33
- treatment,[c] n (%)	2 (1.3)	1 (1.9)	0.28	2 (1.5)	0	0.90
- Total[d], n (%)	50 (33.6)	20 (37.0)	0.65	29 (21.8)	14 (29.2)	0.31
HADS anxiety symptoms						
- ≥ 8, n (%)	33 (22.1)	9 (16.7)	0.40	23 (17.3)	9 (18.8)	0.82
- use of antidepressants, n (%)	15 (10.1)	3 (6.4)	0.44	7 (5.3)	4 (9.5)	0.33
- treatment[c], n (%)	2 (1.3)	1 (1.9)	0.28	2 (1.5)	0	0.90
- Total[d], n (%)	41 (27.5)	10 (18.5)	0.17	26 (19.5)	10 (20.8)	0.85

[a] Values are presented as mean ± standard deviation, unless otherwise indicated.
Abbreviations: LTFU, lost to follow-up; EMC, Erasmus MC University Medical Center; RdGG, Reinier de Graaf Gasthuis; HOOS, Hip disability and Osteoarthritis Outcome Score; KOOS, Knee injury and Osteoarthritis Outcome Score; ADL, Activities of Daily Living; QOL, Quality of Life.
[b]Variables were inserted in the multivariate model to test for unbalanced characteristics
[c]Patients under treatment of a psychologist or psychiatrist [d] HADS score ≥ 8 or use of antidepressants or treatment by a psychologist or psychiatrist

Table 2 Preoperative and three-month postoperative prevalence of depressive and anxiety disorders for hip and knee[a]

	Hip (n=149)			Knee (n=133)		
	Preoperative	**Postoperative**	**p-value**	**Preoperative**	**Postoperative**	**p-value**
HADS depressive symptoms						
Score, mean ± sd	5.2 ± 4.1	3.4 ± 3.3	**<0.0001**	4.3 ± 3.7	3.3 ± 3.3	**<0.0001**
- ≥ 8, n (%)	40 (26.8)	11 (7.4)	**<0.0001**	26 (19.5)	18 (13.5)	**0.045**
- antidepressants, n (%)	15 (10.1)	10 (6.7)	0.10	7 (5.3)	6 (4.5)	0.66
- treatment[b], n (%)	2 (1.3)	3 (2.0)	0.32	2 (1.5)	2 (1.5)	0.66
Total[c], n (%)	50 (33.6)	19 (12.8)	**<0.0001**	29 (21.8)	22 (16.5)	**0.05**
HADS anxiety symptoms						
Score, mean ± sd	4.6 ± 4.2	3.1 ± 2.9	**<0.0001**	4.1 ± 3.6	3.1 ± 3.4	**<0.0001**
- ≥ 8, n (%)	33 (22.1)	13 (8.7)	**<0.0001**	23 (17.3)	14 (10.5)	**0.002**
- antidepressants, n (%)	15 (10.1)	10 (6.7)	0.10	7 (5.3)	6 (4.5)	0.66
- treatment[b], n(%)	2 (1.3)	3 (2.0)	0.32	2 (1.5)	2 (1.5)	0.66
Total[c], n (%)	41 (27.5)	19 (12.8)	**<0.0001**	26 (19.5)	19 (14.3)	**0.01**

[a] Values are presented as mean ± standard deviation, unless otherwise indicated.
Significant p-values are presented in bold.
Abbreviations: sd, standard deviation
[b] Patients under treatment of a psychologist or psychiatrist
[c] HADS score ≥ 8 or use of antidepressants or treatment by a psychologist or psychiatrist

Table 3 Relationship between baseline depressive symptoms and HOOS change scores; and mean HOOS scores[a]

Hip	**Depressive symptoms**				
	Adjusted relationship[b]	**HADS**		**HADS**	
	≥ 8	**< 8 n = 99**	**≥ 8 n = 50**	**< 8 n = 99**	**≥ 8 n = 50**
HOOS		**Change score**		**3 months postoperative score**	
Pain	-	43.3 ± 24.6	43.2 ± 23.6	78.7 ± 20.3	68.9 ± 21.1
Symptoms	-	8.0 ± 16.0	11.3 ± 13.6	60.0 ± 12.6	57.3 ± 13.0
ADL	+	40.3 ± 23.5	38.1 ± 23.5	72.0 ± 20.1	61.2 ± 22.0
Sport	+	37.6 ± 29.2	30.0 ± 28.6	55.1 ± 27.9	38.9 ± 28.2
QOL	-	35.3 ± 26.6	36.7 ± 26.0	59.6 ± 22.7	51.3 ± 24.2

[a] Values are presented as mean ± standard deviation
[b] Relationship between baseline HADS score (dichotomised < 8 and ≥ 8) and change scores of the HOOS subscales, adjusted for age, gender, preoperative score on the HOOS subscale and unbalanced characteristics between study population and patients lost to follow-up (hospital and familial depression).
+ significant independent relation between baseline depressive symptoms and change in outcome.
- no significant independent relation between baseline depressive symptoms and change in outcome
Abbreviations: HOOS; Hip disability and Osteoarthritis Outcome Score; ADL, Activities of Daily Living; QOL, Quality of Life.

Table 4 Relationship between baseline depressive and anxiety symptoms and KOOS change scores; and mean KOOS scores[a]

Knee	Depressive symptoms					Anxiety symptoms				
	Adjusted relationship[b]	HADS		HADS		Adjusted relationship[b]	HADS		HADS	
	≥ 8	< 8 n = 104	≥ 8 n = 29	< 8 n = 104	≥ 8 n = 29	≥ 8	< 8 n = 107	≥ 8 n = 26	< 8 n = 107	≥ 8 n = 26
KOOS		**Change score**		**3 months postoperative score**			**Change score**		**3 months postoperative score**	
Pain	-	30.1 ± 23.7	33.7 ± 24.7	68.0 ± 20.2	60.3 ± 20.9	-	30.8 ± 24.5	31.1 ± 22.2	68.7 ± 20.0	57.3 ± 20.0
Symptoms	+	19.1 ± 26.0	20.5 ± 24.6	65.0 ± 19.1	53.1 ± 21.1	+	19.2± 26.1	20.2 ± 24.1	65.1 ± 19.7	52.5 ± 18.5
ADL	-	28.8 ± 23.5	36.6 ± 23.9	69.8 ± 18.5	62.7 ± 22.4	-	29.9 ± 24.1	33.1 ± 22.2	70.5 ± 18.4	59.2 ± 22.0
Sport	-	17.8 ± 30.5	15.4 ± 29.0	28.1 ± 27.1	20.8 ± 27.9	+	19.2 ± 32.2	9.5 ± 17.8	29.4 ± 28.3	15.0± 20.0
QOL	-	32.1 ± 23.9	31.3 ± 19.5	51.3 ± 22.8	42.1 ± 18.8	+	32.8 ± 24.2	28.8 ± 17.4	52.3 ± 22.1	37.8 ± 19.0

[a] Values are presented as mean ± standard deviation

[b] Relationship between baseline HADS score (dichotomised < 8 and ≥ 8) and change scores of the KOOS subscales, adjusted for age, gender, preoperative score on the KOOS subscale and unbalanced characteristics between study population and patients lost to follow-up (time on waiting list at baseline measurement).

+ significant independent relation between baseline depressive or anxiety symptoms and change in outcome.

- no significant independent relation between baseline depressive or anxiety symptoms and change in outcome

Abbreviations: KOOS; Knee injury and Osteoarthritis Outcome Score; ADL, Activities of Daily Living; QOL,

on the prevalence of depressive/anxiety symptoms in a general Dutch population of similar age. However, we did find mean scores on the depressive and anxiety subscales of 4.6 ± 3.6 and 3.9 ± 3.6, respectively, in a general Dutch population of similar age[11]. Thus, it appears that the mean scores on the HADS of depressive/anxiety symptoms in end-stage hip and knee OA patients are comparable to those of the general Dutch population. The results of the present study indicate that the prevalence of depressive symptoms is indeed relatively high in patients with end-stage OA, especially in patients with hip OA, compared with other chronic diseases.

The results of the study also confirm our second hypothesis that, when the pain and disability decreases after THA/TKA, then the prevalence of psychological symptoms also decreases. Three months after the THA/TKA procedure both the raw score and the prevalence of depressive/anxiety disorders were significantly decreased compared with the preoperative situation. Three months postoperatively, the raw scores were even lower than reported in the general Dutch population. This might be explained by the so-called 'rejoice effect'. Because these patients are accustomed to their disability, 3 months after surgery the normal state is appreciated by them to a greater extent than by someone who has been constantly in the normal state. The decrease was larger in hip than in knee patients. The effect sizes of THA on depressive/anxiety symptoms were also higher than those of TKA. The long-term effect of the THA/TKA procedure on depressive and anxiety symptoms remains unclear. Therefore, we are currently examining the prevalence of depressive/anxiety symptoms 12 months after the THA and TKA procedure.

Our earlier systematic review which evaluated the influence of psychological symptoms on the outcome of THA/TKA, showed that global preoperative mental health and pain catastrophizing do influence the outcome after THA/TKA[9]. Less convincing evidence was found in the literature for the influence of depressive/anxiety symptoms on outcome. Our systematic review did not elucidate whether the influence of psychological symptoms differed between knee and hip patients. However, the present study shows that the influence of depressive/anxiety symptoms on outcome does indeed differ after THA and TKA. For hip patients, preoperative depressive symptoms have more influence on outcome, whereas for knee patients preoperative anxiety symptoms have more influence on outcome 3 months post surgery.

The identification of individuals at risk for poor post-surgical outcome is important for optimizing the results after THA and TKA. Treating patients with depressive/anxiety disorders with psychotherapy before surgery may lead to better results after THA/TKA. Furthermore, more intensive therapy after surgery for patients with depressive/anxiety disorders may lead to better results after THA/TKA. Additional studies are required to explore these hypotheses.

Some limitations of this study need to be addressed. First, the percentage patients lost to follow-up at 3 months postoperatively was relatively large (27%). However, the primary outcome measures did not differ between the study population and patients lost to follow-up. Therefore, although a bias may be present, it is probably minor and would not affect our results and conclusions. Second, because preoperative measurements were not taken at a fixed time point, the length of time patients were on the waiting list varied. The present study does not allow to conclude whether the prevalence of depressive/anxiety symptoms changes whilst on the waiting list. Furthermore, regression analyses to evaluate the influence of preoperative depressive/anxiety symptoms on the outcome after THA/TKA were adjusted for age, gender, preoperative score on the HOOS and KOOS subscale and unbalanced characteristics, but not for co-morbidities. Unfortunately, we had no information on the co-morbidity of our patients. Finally, having depressive and anxiety *symptoms* is not the same as having a depression or anxiety *disorder*. The HADS questionnaire is a tool for screening on depressive/anxiety symptoms. Having a depression or anxiety disorder has to be diagnosed by a specialist. Therefore, the prevalence of depressive/anxiety symptoms is an overestimation of the actual prevalence of depression or anxiety disorders.

In conclusion, the results of the present study show that the prevalence of depressive symptoms is relatively high in patients with end-stage hip and knee OA compared with other chronic diseases. The prevalence of depressive symptoms was higher in hip than in knee patients, and the influence of depressive/anxiety symptoms on the 3-month postoperative outcome differed after THA and TKA. At 3 months post-surgery, the prevalence of depressive/anxiety symptoms was significantly decreased in both hip and knee patients. However, patients with preoperative depressive/anxiety symptoms had worse outcomes 3 months after THA and TKA than patients without depressive/anxiety symptoms. The long-term effect of the THA and TKA procedure on depressive/anxiety symptoms remains unclear. Therefore, we are currently examining the prevalence of depressive and anxiety symptoms 12 months after the THA/TKA procedure.

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Chapter 8

Functional capacity and actual daily activity do not contribute to patient satisfaction after total knee arthroplasty

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ABSTRACT

Background. After total knee arthroplasty (TKA) only 75-89% of patients are satisfied. Because patient satisfaction is a prime goal of all orthopaedic procedures, optimization of patient satisfaction is of major importance. Factors related to patient satisfaction after TKA have been explored, but no studies have included two potentially relevant factors, i.e. the functional capacity of daily activities and actual daily activity. This present prospective study examines whether functional capacity and actual daily activity (in addition to an extensive set of potential factors) contribute to patient satisfaction six months after TKA.

Methods. A total of 44 patients were extensively examined preoperatively and six months post surgery. Functional capacity was measured with three capacity tests, focusing on walking, stair climbing, and chair rising. Actual daily activity was measured in the patient's home situation by means of a 48-hour measurement with an Activity Monitor. To establish which factors were related to patient satisfaction six months post surgery, logistic regression analyses were used to calculate odds ratios.

Results. Preoperative and postoperative functional capacity and actual daily activity had no relation with patient satisfaction. Preoperatively, only self-reported mental functioning was positively related to patient satisfaction. Postoperatively, based on multivariate analysis, only fulfilled expectations regarding pain and experienced pain six months post surgery were related to patient satisfaction.

Conclusions. Functional capacity and actual daily activity do not contribute to patient satisfaction after TKA. Patients with a better preoperative self-reported mental functioning, and patients who experienced less pain and had fulfilled expectations regarding pain postoperatively, were more often satisfied.

INTRODUCTION

Total knee arthroplasty (TKA) is a relatively safe and cost-effective surgical intervention for patients with end-stage osteoarthritis (OA)[1]. After surgery most patients improve with regard to pain and stiffness, self-reported physical functioning and quality of life[2-4]. The greatest improvement is reported within the first six months after surgery[5, 6].

Compared to hip arthroplasty, patients undergoing knee arthroplasty show less improvement on the above-mentioned outcome measures and are generally less satisfied[2,3,7]. After TKA only 75-89% of patients are satisfied with their outcome[8-13]. Furthermore, patient satisfaction is one of the ultimate goals of all orthopaedic procedures and, therefore, optimization is of major importance. Knowledge of which factors contribute to patient satisfaction can be incorporated in the care for TKA patients; preoperative and postoperative factors can be used for this purpose.

Satisfaction is reported to be associated with self-reported quality of life variables, preoperative mental functioning, expectations and fulfilment of expectations, postoperative pain, and joint stiffness[8,9,12,14,15]. However, none of these studies included two potentially relevant and modifiable aspects of functioning, i.e. the functional capacity of daily activity and actual daily activity. Studies in other patient groups have shown that these latter factors can be related to quality of life and mental health[16,17]. Therefore, we hypothesise that TKA patients with a higher functional capacity and actual daily activity level will more often be satisfied with the post-TKA results.

This prospective study examines whether functional capacity and actual daily activity, in addition to an extensive set of potential factors, are related to patient satisfaction six months post TKA. Actual daily activity was measured in the patient's home situation by means of a 48-hour measurement with an Activity Monitor (AM)[18]. The study aimed to determine pre- and postoperative factors related to patient satisfaction six months after TKA, focusing on functional capacity and actual daily activity.

METHODS

For the present study, data from a prospective follow-up study (which determined recovery of physical functioning after total knee/hip arthroplasty) were used[19]. In an earlier study by de Groot et al., the pre- and postoperative results focused on recovery of physical functioning after TKA, whereas the present study examines pre- and postoperative results in relation to patient satisfaction six months after TKA. The dependent outcome measure was patient satisfaction six months postoperatively.

The following potential factors related to patient satisfaction were measured (on average) six weeks before surgery: functional capacity of daily activity, actual daily activity, gender, age, body mass index (BMI), expectations, joint function (pain, stiffness and strength), self-reported physical functioning, and self-reported mental functioning. The time point of six weeks pre-surgery was used because all patients visit our outpatient clinic about six weeks prior to surgery for preoperative screening. Measurements for the present study were combined with this preoperative screening so that patients visited the outpatient clinic only one time. Six months post surgery the following potential factors related to patient satisfaction were measured: functional capacity, actual daily activity, fulfilled expectations, joint function, self-reported physical functioning and self-reported mental functioning.

All preoperative and postoperative measurements were done by one researcher (IBG) using standardized data collection forms.

Patient selection

Patients with end-stage OA of the knee who were scheduled for TKA at the Erasmus MC between April 2004 and May 2006 were eligible. Exclusion criteria for the study were: age >80 years, wheelchair-bound, not living independently, the presence of disorders other than OA that could affect the level of actual physical activity, living more than 1.5 h travelling distance from the medical center, insufficient command of the Dutch language (spoken or written), the presence of OA in the contralateral knee requiring surgery within six months, not willing to sign an informed consent, and not known whether the patient would be available for follow-up measurements.

The Medical Ethics Committee of the Erasmus MC approved the study and all patients signed an informed consent form. Patients underwent all measurements (on average) six weeks preoperatively and six months postoperatively.

Patient satisfaction

Six months after TKA, patient satisfaction with the results of the surgery was assessed: "How satisfied are you with the results of the surgery?" Responses were graded on a 5-point Likert scale: 1=very satisfied, 2=moderately satisfied, 3=neutral, 4=moderately dissatisfied, and 5=very dissatisfied. The responses were dichotomised into very satisfied and less satisfied (=moderately satisfied, neutral, moderately dissatisfied, and very dissatisfied)[20].

Potential factors related to patient satisfaction

Functional capacity of daily activity

The functional capacity of patients was measured six weeks preoperatively and six months postoperatively using three tests focusing on walking, stair climbing, and sit-to-stand. The Six-Minutes Walk Test (6MWT) was performed to quantify walking ability[21,22].

It is a valid clinical tool that involves recording the maximum distance participants can cover while walking indoors for six minutes. It has good test-retest reliability and has been used to measure the effectiveness of interventions in populations with knee OA[21,22]. Patients were allowed to use walking aids. Preoperatively 26.2% (n=11) of the patients used walking aids during the 6MWT compared to 9.5% (n=4) postoperatively.

To assess stair climbing capacity, the time needed for a patient to ascend five steps, turn around, and descend was measured[23]; patients were allowed to use the hand rails.

Chair rising capacity was assessed by measuring how long a patient needed to perform five sit-to-stand movements. Patients were asked to perform this task as quickly as possible[24]; patients were allowed to use their arms while performing the sit-to-stand movements.

Actual daily activity

Actual daily activity was measured in the home situation of the patient six weeks preoperatively and six months postoperatively. Actual daily activity was measured objectively using an AM[18]. The rationale for the AM sensor configuration, the subsequent steps of the signal analysis, and the method of activity detection have been described in detail previously[18]. In summary, the AM is based on long-term ambulatory (home-based) measurement of signals from body-fixed acceleration sensors (Temec Instruments, Kerkrade, The Netherlands) attached to both upper legs and the sternum. All sensors were connected to a recorder based on Vitaport technology (Temec Instruments, Kerkrade, The Netherlands). The acceleration signals were digitally stored on a flash card. After measurement, all signals were downloaded to a personal computer for further analysis. For each second, a body posture (sitting, standing, lying) or body motion (walking, cycling or other movements) was automatically detected from the acceleration signals. Three aspects of these postures and motions can be distinguished, i.e. quantity, quality and physical strain or motility.

The AM has been extensively validated[18, 25-28]. The AM data were collected for 48 h and then averaged. Two AM outcome measures were included: the percentage of time a patient was active per 24 h (walking, cycling, climbing stairs and general movement) and the percentage of time being upright per 24 h (standing and walking).

Patient-related factors

Preoperatively, gender, age and BMI were determined.

Expectations and fulfilled expectations

Six weeks preoperatively, the expectations of patients were measured. Assessment of expectations focused on a) pain after surgery b) limitations of activities of daily living after surgery and c) the overall success of the operation. Questions regarding patient expectations of pain and limitations were graded on a 4-point Likert scale (4=not at all painful/limited, 3=slightly painful/limited, 2=moderately painful/limited, and 1=very painful/limited). The responses were dichotomised: the highest response level was classified as 'high expectations' and the remainder was classified as 'low expectations'. Expectations regarding overall success were recorded on a Visual Analogue Scale (VAS) ranging from 0 - 10 (0 indicating no success, and 10 indicating optimal success). These responses were also dichotomised by a VAS score > 9 of success as having 'high expectations' and the remaining scores as 'low expectations'. A similar dichotomisation was applied by Mahomed et al.[29].

Six months post surgery, patients were asked whether their expectations regarding pain, limitations of activities of daily living, and the overall success of the surgery had been fulfilled. Responses of expectations were graded on a 4-point Likert scale (4=totally fulfilled, 3=considerably fulfilled, 2=slightly fulfilled, and 1=not at all fulfilled). The highest response was classified as 'fulfilled expectations' and the remaining responses were classified as 'unfulfilled expectations'[29].

Joint function

Joint function was measured six weeks preoperatively and six months postoperatively. The strength of the knee extensors on the affected side was measured with a Microfet hand-held dynamometer[30]. The experienced stiffness was measured using the stiffness subscale of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Experienced pain was measured using the pain subscale of the WOMAC (0 indicating the worst experienced stiffness/pain, and 100 indicating no experienced stiffness/pain)[31,32].

Self-reported physical functioning

Self-reported physical functioning was measured six weeks preoperatively and six months postoperatively. The self-reported physical functioning was assessed using the Physical Functioning subscales of the 36-Item Short Form Health Survey (SF-36)[33] and the WOMAC[31,32]. Both subscales range from 0-100, with higher scores indicating better functioning[31,32].

Self-reported mental functioning

Self-reported mental functioning was measured six weeks preoperatively and six months postoperatively. Self-reported mental functioning was measured using the mental health subscale of the SF-36[33] and the anxiety and depression subscales of the Hospital Anxiety and Depression Scale (HADS). The HADS consists of 14 items each rated from 0-3 according to severity of difficulty experienced. It is divided into an Anxiety subscale and a Depression subscale. Each subscale score can range from 0-21. The optimal cut-off score for presence of both anxiety and depression disorders is ≥8[34].

Statistical analysis

Statistical analysis was performed with SPSS 15.0 (SPSS Inc., Chicago, USA). First, it was established whether the variables had a normal distribution using the normality Shapiro-Wilk test. Based on these analyses, the results are presented as means and standard deviations (SD) or, if not normally distributed, as median (with minimum and maximum).

To establish which factors were related to patient satisfaction six months after TKA, logistic regression analyses were used to calculate odds ratios (OR). Satisfaction six months after TKA was used as dependent variable.

For the univariate logistic regression analysis the six months postoperative factors were adjusted for the preoperative scores using analysis of covariance. Because of the high number of significantly related postoperative factors, multivariate regression analysis was performed to examine which postoperative factors had an independent relationship with patient satisfaction after TKA. We performed multivariate, stepwise (forward) logistic regression. The quality of the multivariate regression models was based on the Akaike Information Criteria (AIC), a measure of the goodness of fit of an estimated model. The AIC aims to find a balance between the conflicting demands of accuracy (fit) and simplicity (small number of variables). Models with smaller AIC are preferred; a difference of two points on the AIC between models should be treated as significantly different models[35]. In all analyses, a two-sided p-value of ≤ 0.05 was considered significant.

RESULTS

Between April 2004 and May 2006, 45 patients complied with the inclusion criteria and were willing to participate in the study. For one patient only preoperative data are available so, finally, the results of 44 patients were evaluated (Table 1).

All patients received a Genesis II (Smith and Nephew, Memphis, USA) TKA. Because the Erasmus MC is a university hospital, during the study period the procedures were performed by six different orthopaedic surgeons with different medical assistants. Post surgery, the mean number of days in hospital was 7 (minimum 3, maximum 15) days and all patients received a standard physical therapy and pain management protocol. Three patients had a postoperative complication (neuropraxia, haematoma in the left rectus area, and lung emboli).

In this patient group 50% was very satisfied, 22.7% moderately satisfied, 11.4% neutral, 9.1% moderately dissatisfied and 6.8% very dissatisfied (Table 1).

Table 1. Characteristics of the study population[a].

	Total population n = 44
Gender, % women (n)	54.5 (24)
Age at baseline, years	63.5 (42.0; 78.0)
Body mass index at baseline, kg/m^2	30.8 (24.2; 44.9)
Satisfaction regarding overall results	
- Very satisfied, % (n)	50.0 (22)
- Less satisfied:	
moderately satisfied, % (n)	22.7 (10)
neutral, % (n)	11.4 (5)
moderately dissatisfied, % (n)	9.1 (4)
very dissatisfied, % (n)	6.8 (3)

[a] Values are presented as median (minimum; maximum), unless otherwise indicated

Preoperatively, functional capacity and actual daily activity were not related to patient satisfaction whereas a better self-reported mental functioning was (Table 2). Thus, patients with a better self-reported mental functioning before surgery were more often satisfied post surgery.

Postoperatively, most factors had a univariate relationship with patient satisfaction. However, actual daily activity showed no association with patient satisfaction, and only the walking test was related to patient satisfaction (Table 3).

The multivariate model that best describes the postoperative factors related to patient satisfaction was the model with fulfilled expectations regarding pain and the experienced pain six months post surgery as independent variable.

DISCUSSION

It was hypothesised that TKA patients with a higher functional capacity and actual daily activity level would more often be satisfied with the post-TKA results. However, the results indicate that functional capacity and actual daily activity (using the specific outcome measures in the present study) do not contribute to patient satisfaction. It is important to note that improving functional capacity and actual daily activity should not only be considered from a patient satisfaction viewpoint. For example, from the health viewpoint it is important to stimulate patients (also post-TKA patients) to be physically active and improve functional capacity.

In addition to functional capacity and actual daily activity, an extensive set of potential factors related to patient satisfaction six months after TKA were examined. Preoperatively, patients with a better self-reported mental functioning were more often satisfied

Table 2. Preoperative factors associated with satisfaction six months post surgery[a]

Determinants	Very satisfied n=22 (50%)	Less satisfied[b] n=22 (50%)	OR (95% CI)	p-value
Physical capacity				
6-MWT (m)	295 (59; 499)	278 (48; 523)	0.999 (0.994; 1.005)	0.844
Stair climbing (s)	11.4 (6; 28)	11.4 (5; 29)	1.000 (0.906; 1.103)	1.000
Rising from chair (s)	18.9 (9; 36)	16.7 (10; 34)	1.047 (0.956; 1.147)	0.317
Actual daily activity				
Movement-related activity, % of 24 h	7.6 (3.8; 17.5)	7.3 (2.7; 17.3)	1.008 (0.861; 1.180)	0.921
Upright, % of 24 h	17.0 (7.3; 37.2)	21.3 (6.2; 32.7)	0.984 (0.912; 1.062)	0.675
Patient characteristics				
Gender, % women (n)	63.6 (14)	45.5 (10)	2.100 (0.628; 7.027)	0.229
Age at baseline, years	57.0 (42; 78)	65.5 (48; 77)	0.957 (0.898; 1.019)	0.169
BMI at baseline, kg/m^2	30.8 (24; 41)	30.4 (24; 45)	0.962 (0.857; 1.079)	0.567
Expectations				
Pain, high expectations, % (number)	9.1 (2)	10.5 (2)	1.176 (0.149; 9.266)	0.877
Limitations, high expectations, % (number)	27.3 (6)	18.2 (4)	0.593 (0.141; 2.484)	0.593
Overall success, high expectations, % (number)	45.5 (10)	45.5 (10)	1.000 (0.305; 3.277)	1.000
Joint function and structure				
Strength quadriceps, Newton	145.5 (17; 273)	175 (53; 299)	0.993 (0.983; 1.002)	0.134
Stiffness (WOMAC stiffness)	30 (0; 80)	30 (0; 80)	0.999 (0.968; 1.030)	0.936
Pain (WOMAC pain)	36 (8; 60)	32 (4; 72)	1.009 (0.966; 1.054)	0.680
Self-reported physical functioning				
WOMAC Physical functioning	35.3 (9.4; 62.4)	34.1 (9.4; 63.5)	1.009 (0.964; 1.056)	0.693
SF-36 Physical functioning	32.5 (0; 65)	32.5 (5; 80)	0.997 (0.968; 1.027)	0.827
Self-reported mental functioning				
SF-36 Mental Health	**80 (40; 100)**	**60 (32; 96)**	**1.045 (1.007; 1.085)**	**0.019**
HADS anxiety, % case (n)	**18.2 (4)**	**50 (11)**	**0.222 (0.057; 0.873)**	**0.031**
HADS depression, % case (n)	**13.6 (3)**	**45.5 (10)**	**0.189 (0.043; 0.831)**	**0.027**

[a] Values are presented as median (minimum; maximum), unless otherwise indicated. OR = Odds Ratio, CI = Confidence Interval, 6-MWT = six-minutes walk test
Significant results are highlighted in bold.
[b] Less satisfied= patients who were moderately satisfied, neutral, moderately dissatisfied or very dissatisfied.

with the results after TKA. Postoperatively (based on multivariate analysis) patients with less experienced pain and fulfilled expectations regarding pain were more often satisfied. The univariate postoperative results showed that perceived physical functioning was related to patient satisfaction. In contrast, actual daily activity had no univariate relationship with patient satisfaction. However, the multivariate results of our study showed that the univariate results should be interpreted with caution, because of the relationships between the examined univariate variables.

Table 3. Postoperative factors associated with satisfaction six months post surgery.[a]

Determinants	Satisfied n=22 (50%)	Less satisfied[b] n=22 (50%)	OR (95% CI)	p-value
Physical capacity				
6-MWT (m)	**428 (152; 580)**	**368 (132; 485)**	**1.008 (1.001; 1.02)**	**0.034**
Stair climbing (s)	7.3 (5; 18)	9.1 (6.4; 22.8)	0.825 (0.67; 1.02)	0.073
Rising from chair (s)	15 (9.7; 20.8)	16.9 (10; 32.5)	0.872 (0.735; 1.033)	0.113
Actual daily activity				
Movement-related activity, % of 24 h	8.1 (3.2; 17.0)	9.8 (2.8; 18.8)	0.978 (0.839; 1.139)	0.773
Upright, % of 24 h	20.1 (13.7;39.9)	19.2 (7.2; 30.2)	1.039 (0.936; 1.153)	0.471
Fulfilled expectations				
Pain, totally, % (number)	**100 (22)**	**27.3 (6)**	-[c]	-[c]
Limitations, totally, % (number)	**68.2 (15)**	**13.6 (3)**	**13.6 (2.99; 61.59)**	**0.001**
Overall success, totally, % (number)	**90.9 (20)**	**22.7 (5)**	**34.0 (5.83; 198.15)**	**<0.0001**
Joint function and structure				
Strength quadriceps, Newton	216 (156; 307)	195 (106; 293)	1.010 (0.996; 1.023)	0.150
Stiffness (WOMAC stiffness)	**70 (30; 80)**	**40 (0; 80)**	**1.107 (1.04; 1.18)**	**0.001**
Pain (WOMAC pain)	**80 (4; 80)**	**52 (16; 76)**	**1.101 (1.04; 1.18)**	**0.002**
Self-reported physical functioning				
WOMAC Physical functioning	**74.1 (21.2; 80)**	**45.9 (5.9; 74.1)**	**1.112 (1.04; 1.19)**	**0.001**
SF-36 Physical functioning	**77.5 (20; 100)**	**45.0 (10; 90)**	**1.052 (1.02; 1.09)**	**0.003**
Self-reported mental functioning				
SF-36 Mental Health	**92 (36; 100)**	**56 (20; 96)**	**1.076 (1.03; 1.13)**	**0.001**
HADS anxiety, % case (n)	**13.6 (3)**	**45.5 (10)**	**0.189 (0.04; 0.83)**	**0.027**
HADS depression, % case (n)	**9.1 (2)**	**40.9 (9)**	**0.144 (0.03; 0.78)**	**0.024**

[a] Values are presented as median (minimum; maximum), unless otherwise indicated. OR= Odds Ratio, CI = Confidence Interval, 6-MWT = six-minutes walk test. Significant results are highlighted in bold
[b] Less satisfied; patients who were somewhat satisfied, neutral, somewhat dissatisfied or very dissatisfied.
[c] Analyses were not performed with SPSS, because 100% had fulfilled expectations in one group.

Gandhi et al. also found that a poorer preoperative mental health score predicts less satisfaction with surgery after a total joint arthroplasty; however, they combined the results for total hip and knee arthroplasties[14]. Compared with our univariate results, others have shown that postoperative experienced pain and stiffness, fulfilled expectations, and better postoperative self-reported physical and mental functioning are related to patient satisfaction after TKA[8, 9,12,15].

The present study focused on the group of very satisfied patients, which was compared with all the other groups (i.e. moderately satisfied, neutral, moderately dissatisfied, very dissatisfied). Therefore, we dichotomised the patients into ‘very satisfied’ patients and ‘less satisfied’ patients. Our relatively low satisfaction rate compared to other studies could be explained by the measurement tool used. In the present study, responses regarding the level of satisfaction were graded on a 5-point Likert scale (very satisfied, moderately satisfied, neutral, moderately dissatisfied, and very dissatisfied) whereas in other studies satisfaction was graded on a 2 or 3-point Likert scale (without the answer option "neutral"); consequently, patients had to choose between 'satisfied' or 'not satisfied'. This could have led to differences in satisfaction rates.

Furthermore, our follow-up period of six months was relatively short compared to other studies[8-13]. It is possible that, had our patients made further recovery after six months, this would have led to higher satisfaction rates. On the other hand, a longer follow-up period could result in lower satisfaction rates because patients may realize that no further improvement will be made after six months and become less satisfied. Therefore, the results of our study do not allow to infer whether or not patient satisfaction would increase or decrease had the follow-up period been extended beyond six months.

Our study is unique regarding the investigation of factors potentially related to patient satisfaction after TKA. All patients were extensively examined preoperatively and six months postoperatively. To our knowledge no other studies have examined the relationship between functional capacity and actual daily activity on the one hand, and patient satisfaction after TKA on the other.

However, some limitations of the study need to be addressed. First: the relatively small study population. Patients with end-stage OA of the knee (scheduled for TKA between April 2004 and May 2006) were eligible for inclusion but, due to the strict exclusion criteria, only a relatively small number could be included. This implies that the multivariate regression analyses are mainly explorative and must be interpreted with caution. Future prospective studies should aim for a larger study population. Second: the relatively short follow-up period implies that it remains unclear whether patient satisfaction would be higher or lower in this group had follow-up lasted longer than six months after TKA. On the other hand, the factors influencing patient satisfaction that emerged from the present study were the same as reported in previous studies[8,9,12]. Third: because of our strict inclusion and exclusion criteria and because all patients were recruited from a university hospital, our sample representativeness might have been reduced. However, because the characteristics of our patients and the preoperative and postoperative functioning scores were comparable with other studies[9,12], our sample is probably representative for the TKA population described by others. Another point is that actual performance of daily activity was collected during a relatively short 48-h period. Although a longer data collection period would have been preferred (and some currently available instruments allow this), compared with our AM system these other instruments provide less detailed information on a subject's activities. In contrast to other instruments, the AM not only provides information on the overall activity level, but at each second evaluates the body postures and motions. Therefore, the AM is a unique instrument to measure actual daily activity. Finally, six different surgeons performed the 44 TKAs and it is unknown whether surgeon-related factors influenced the outcome data. However, all TKA procedures were performed under the supervision of four senior surgeons according to a standard protocol with a similar approach and similar implant (Genesis II). Furthermore, the fact that several surgeons performed the TKAs may have increased the generalisability of the results.

The present study examined which factors contribute to patient satisfaction, with the aim to include them (directly or indirectly) in the care for TKA patients. Future studies should further examine the relationship between outcome measures of functional capacity and actual daily activity on the one hand and patient satisfaction on the other hand.

The results of the present study have some clinical implications. Our results suggest that self-reported preoperative mental functioning is related to patient satisfaction after TKA. The question arises whether: a) poor self-reported mental health is mainly caused by the presence of pain and disability and will improve after TKA when the pain and disability has decreased, or that b) interventions designed to reduce preoperative psychological distress should be established to determine whether they might improve patient satisfaction after TKA. Furthermore, our results suggest that pain experienced six months post surgery and fulfilled expectations regarding pain are related to patient satisfaction, both of which are modifiable. The satisfaction level of patients who experience pain after TKA might be increased by optimising post-surgical pain management. Moreover, patient satisfaction might be increased by optimising patient information regarding pain after TKA. These two factors should be targets for future clinical research and implementation.

Conclusions

Functional capacity and actual daily activity do not appear to contribute to patient satisfaction after TKA. Patients with a better preoperative self-reported mental functioning, and patients who experienced less pain and had fulfilled expectations regarding postoperative pain, were more often satisfied.

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Chapter 9

General Discussion

This thesis focuses on the recovery of physical and mental functioning after total knee arthroplasty (TKA) and total hip arthroplasty (THA). In the previous chapters, the main findings and limitations have been discussed. In this chapter the results of this thesis are discussed in a broader perspective and suggestions are made for future research.

PHYSICAL FUNCTIONING

The rationale for some of the studies presented in this thesis lies in earlier work published by De Groot et al.[1,2]. These authors showed that TKA and THA have considerable influence on the recovery of self-reported physical functioning and functional capacity six months after surgery, but the influence on the recovery of actual daily activity (expressed as the amount of actual daily activity) in the home situation was low. However, those studies did not answer the question as to why patients did not improve their actual daily activity.

In this thesis, two possible explanations for this are examined.

First, it is possible that patients perform activities in daily life easier or better, indicating a better performance of actual daily activity in the home situation, but without changes in the total amount of physical activity. Secondly, six months might be too short a period for TKA and THA patients to change their actual physical activity level; this is related to the fact that daily physical activity concerns behaviour, and actually changing behaviour might take longer than 6 months.

The results emerging from the work in this thesis support the first explanation. Six months after TKA and THA, patients performed the activities walking and chair rising in their natural environment faster compared to the preoperative situation (Chapters 3 and 4). Thus, it seems that six months after TKA and THA, patients are able to perform activities in their home situation easier and better. Furthermore, the correlation between self-reported physical functioning and the performance outcome measures was higher than the correlation between self-reported physical functioning and actual daily activity level. This may explain why TKA and THA could have a great influence on the recovery of self-reported physical functioning, but a small influence on the recovery of the amount of actual daily activity level. In this thesis we studied a broad spectrum of parameters of patients' activities in their home situation. Only the outcome measures stride frequency, walking speed and time needed to rise from a chair, showed a significant improvement. It is possible that other performance outcome measures, such as symmetry, trunk movement and balance, also improve after TKA and THA. However, at this moment, measurement of these outcome measures with the Activity Monitor (AM) is insufficiently implemented and validated. Future research needs to validate more outcome measures of the AM in order to gain complete insight into the performance of activities in the natural (home) environment of patients.

The second explanation, that six months might be too short for TKA and THA patients to change their actual physical activity level, does not seem to be substantiated by the results of the studies presented here. Even four years postoperatively, patients had not significantly increased their level of actual daily activity (Chapter 5).

Besides examining why patients did not improve their actual daily activity level, we also evaluated in more detail the recovery of three different aspects of functioning, as described by De Groot et al.[1, 2]. The aspects of self-reported physical functioning, functional capacity and actual daily activity, showed a different pattern of recovery after surgery. Preoperatively, patients scored relatively low compared with the reference values on the aspect self-reported physical functioning, and postoperatively a relatively higher level of recovery was scored (from < 50% to about 80% of the reference value). On the aspect functional capacity, preoperatively patients scored moderately compared to the reference values, and a modest recovery was scored after surgery (from 70% to about 80%). On the actual daily activity level, preoperatively patients scored relatively high, whereas the level of recovery was relatively small (from 80% to 84%). Thus, six months postoperatively all aspects had recovered to about 80% of the reference values. Four years after surgery self-reported physical functioning and functional capacity had increased to over 90% of the reference values. The actual daily activity level remained constant in 84% of healthy matched controls. Therefore, the impact of end-stage hip or knee OA on the amount of actual daily activity is small compared to the influence of the other aspects. It should be noted that, because preoperatively the patients score relatively high on the actual daily activity level, it does not seem realistic to expect them to improve considerably after TKA ant THA. Furthermore, after a TKA or THA, two determinants of activity level are improved, namely pain and joint function. However, in the patients, other important determinants of activity level remain unchanged. For example, patients with knee and hip OA generally have a higher body mass index (BMI) than healthy matched controls. Therefore, it remains debatable whether it is a realistic goal to expect patients after TKA and THA to become more active, or as active as healthy controls matched on age and gender. Furthermore, patients might retain some fears or reticence about becoming more physically active after undergoing TKA and THA. Finally, the results of Chapter 8 show that physical functioning does not contribute to patient satisfaction after TKA. Thus, it seems that improving physical functioning will not necessarily lead to more satisfied patients after TKA and THA.

PSYCHOLOGICAL FACTORS RELATED TO THE RESULTS OF JOINT ARTHROPLASTY

Factors that did contribute to patient satisfaction after a TKA were preoperative mental health, postoperative pain, and fulfilled expectations. Therefore, improving these factors may lead to more satisfied patients. Chapters 6 and 7 focused on the relationship between psychological factors and the outcome of TKA and THA. The prevalence of psychological symptoms, especially depressive symptoms, is high in preoperative knee and hip OA patients. It was found that three months postoperatively, the prevalence of depressive and anxiety symptoms was significantly decreased. However, preoperative depressive and anxiety symptoms had an independent influence on postoperative outcome after TKA and THA, even in those whose depressive and anxiety symptoms decreased postoperatively.

The question arises whether the influence of TKA and THA on psychological symptoms persists for a relatively long period post-surgery, and whether preoperative psychological symptoms also influence the long-term outcome of TKA and THA. If studies show that the influence of TKA/THA on psychological symptoms is small after a relatively long period post-surgery and that preoperative symptoms do indeed influence the long-term outcome of TKA/THA, then we need to examine whether interventions in patients with preoperative depressive and anxiety symptoms are effective, and whether these interventions will lead to better outcomes after TKA and THA.

LIMITATIONS OF THE STUDY

The Activity Monitor (AM) used in the work presented here is a unique instrument, providing information both on the amount of daily activity, and on how the individual activities are performed in the patient's natural environment. However, the AM used in these studies has some drawbacks and limitations. For example, simply wearing the AM might have some impact on the patient's activity level. Firstly, the patients are aware that they are being measured: on the one hand they may try to do their 'best', or they may want to 'show' the surgeon that they have serious problems in performing the activities. To minimize this effect, we made an agreement with the patients that we would inform them about the outcome measures of the study only after the measurements had been made. Secondly, wearing the AM may prevent/hinder the performance of certain activities. For example, the AM can be used during sports, but not whilst under the shower (the recorder and sensors are not water resistant), which may prevent some patients from taking exercise. Furthermore, the recorder of the AM used in these studies is relatively large, the system is not wireless, and the sensors cannot be removed from the body. Therefore, because AM measurements are somewhat invasive, some patients they may hesitate or refuse to participate in the studies. Therefore, wearing the AM can affect the actual daily activity level of patients. However, Bussmann et al.[3] have shown that wearing the AM did not systematically influence the amount of daily activity in spinal cord injury patients. Furthermore, development of the AM is an ongoing process of optimizing its capabilities and properties. In fact, a new wireless system is available which consists of 2-5 recorders, each with its own accelerometer, storage capacity and power supply. The sensors can be taken off, and measurements are now possible for longer than 48 hours. Because measurements with this new system are less invasive than with the system used in the present studies, more patients may be willing to participate in AM studies and larger study populations can be measured in their natural setting. Also, with the new device the analysis of AM data is less time consuming than with the device used in the present studies.

Another limitation that needs to be addressed is the choice of the measurement periods of six months and four years, as used in evaluating the recovery of physical functioning. Previous studies found a peak result of perceived physical functioning at one year after TKA and THA, and a significant decrease after this one-year time point[4,5]. Therefore, the activity level may be higher in the period between six months and four years post-surgery and we may have missed this peak result, e.g. because of the age effect. For optimalisation of preoperative patient education on the recovery of physical functioning after surgery, future research need to evaluate the recovery of physical functioning at more than just two follow-up moments.

Furthermore, in the present studies the number of patients measured four years after TKA and THA was too small to examine differences between patients after TKA and THA. The results presented in Chapters 3 and 4 show that, preoperatively, knee patients have a lower actual daily activity level than hip patients, but the improvement in actual daily activity level six months postoperatively is greater in knee patients than in hip patients. In addition, both preoperatively and postoperatively, knee patients walked with a significantly lower stride frequency compared to hip patients. The results presented in Chapters 6 and 7 show that the prevalence of psychological symptoms differs between knee and hip patients, and the impact on the outcome also differs after TKA and THA. Other researchers also reported differences in recovery after TKA and THA[6]. Thus, because both physical and mental functioning seem to differ between knee and hip patients, future studies should examine cohorts of knee and hip patients separately.

Finally, cohort studies are liable to selection bias. For example, in our studies examining physical functioning after TKA and THA we excluded patients who had co-morbidities that could affect physical functioning. It remains unclear how physical functioning recovers in these latter patients.

RECOMMENDATIONS FOR FUTURE RESEARCH

In this thesis we evaluated how patients performed individual activities in terms of how fast and how often they performed the activities. Other outcome measures related to performance, such as symmetry and trunk movement, can be derived from the acceleration signals of the AM. Future research needs to validate these outcome measures to gain more insight into the performance of activities in the natural environment of the patient.

In addition, we found that preoperative mental health, postoperative pain level, and fulfilled expectations were related to patient satisfaction. Although these two latter factors were not further examined in this thesis, improving pain management and helping patients to have more realistic expectations may improve the results after TKA and THA. However, improving pain management is generally complicated. Moreover, the management of a painful TKA and THA, which has no obvious clinical or radiological explanation, is particularly difficult. The first challenge is to accurately evaluate the actual pain symptoms. Nowadays, pain is often rated based on a single question on a visual analogue scale. However, pain in knee and hip OA patients, and in patients after TKA and THA, is not a simple matter and covers different aspects and different kinds of pain (such as nociceptive, inflammatory and also neuropathic pain), all of which need to be treated differently. Therefore, future research needs to evaluate the different aspects of pain in patients with knee and hip OA, and after TKA and THA, using a dedicated questionnaire that accurately evaluates the pain. Furthermore, because pain and psychological factors are closely correlated, the screening of knee and hip patients on psychological disorders needs to receive more attention. Treating the psychological factors of patients prior to undergoing TKA and THA may lead to a better pain outcome.

To help patients acquire a more realistic expectation, they may need more detailed preoperative information/education about the outcome after TKA and THA. Today's patients have multiple expectations regarding the outcome of TKA and THA[7,8]. Many patients come to their surgeon with information retrieved from the internet that may be inaccurate and/or misleading. Many expect and assume that the surgery will return their knee or hip back to 'normal'. Therefore, a discrepancy may exist between the expectations of the patients and those of the surgeon[9,10]. Moreover, it seems that surgeons better predict postoperative pain and function than do patients[11]. These findings suggest that specific information about preoperative expectations and postoperative outcome could lead to more realistic patient expectations. Future research needs to evaluate whether more detailed preoperative education leads to higher patient satisfaction and better outcome results after TKA and THA.

CLINICAL IMPLICATIONS

The results presented in this thesis can be used to optimize and improve preoperative patient education concerning the recovery of physical functioning following surgery. These present studies show that the patterns of recovery of the different aspects of physical functioning differ. Furthermore, six months after TKA and THA, the level of physical functioning is about 80% that of healthy controls. At a longer period after surgery, some of the aspects may further improve to about 90% of the reference values, but the majority of patients will not return to 'normal' values. In addition, physicians should be aware that preoperative psychological factors can lead to worse outcomes after TKA and THA.

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Chapter 10

Summary

In Western populations, osteoarthritis (OA) in adults is one of the most frequent causes of pain, stiffness, loss of function and disability. With regard to the major joints, OA is most prevalent in the knee and hip joint. When conservative treatment fails to alleviate pain and dysfunction, total knee arthroplasty (TKA) and total hip arthroplasty (THA) are cost-effective surgical treatments that can provide significant pain relief and improvement in physical functioning.

Physical functioning is nowadays an important outcome measure of TKA and THA, because today's patients (who tend to be younger and more active) have high expectations regarding functional outcome. If such expectations are not met, they may still be dissatisfied with the outcome of a technically successful procedure. Therefore, patients need to be well informed about the potential recovery of physical functioning after TKA and THA. To achieve this goal, surgeons must have accurate knowledge on the recovery of physical functioning after TKA and THA. Physical functioning is a multi-dimensional concept covering various aspects of health. Although previous studies have shown a low correlation between these aspects, recovery of the different aspects of physical functioning has not yet been systematically examined.

De Groot et al. reported that patients on the waiting list for TKA and THA show significantly and clinically relevant less activity than healthy matched controls, as measured with an accelerometry-based Activity Monitor (AM). Six months post-surgery the patient's level of daily activity was not clinically relevantly improved, despite improvements in perceived functioning and functional capacity. To date, we still do not understand why patients do not improve on the aspect 'actual daily activity', despite that they perceive fewer problems with physical functioning and that their functional capacity has improved.

Therefore, the first aim of this thesis was to evaluate why patients did not improve on actual daily activity six months post-surgery.

In general, the results after TKA and THA are good. However, a subset of patients has suboptimal postoperative improvement in pain, physical functioning, and quality of life. Characteristics that could be related to suboptimal outcome after TKA and THA include the psychological ones. Therefore, the second aim of this thesis was to examine the influence of psychological characteristics on the treatment results of OA, and rehabilitation after TKA and THA.

Finally, patient satisfaction is one of the goals of all orthopaedic procedures and, therefore, optimization is of major importance. Compared to hip arthroplasty, patients undergoing knee arthroplasty are generally less satisfied. Knowledge of which factors contribute to patient satisfaction can be applied to improve care for TKA patients. Therefore, the final question addressed in this thesis is whether the different aspects of physical and mental functioning are related to patient satisfaction after TKA.

Chapter 2 presents a study in which we systematically summarized the literature addressing the recovery of physical functioning after THA. In addition, we examined whether the different aspects of physical functioning (perceived daily functioning, functional capacity, and actual daily activity) showed the same pattern of recovery after THA.

Summarizing the literature revealed that these aspects of physical functioning showed different degrees of recovery during the first 8 months after THA compared to the preoperative situation. The aspect perceived physical functioning recovered from less than 50% preoperatively to about 80% that of healthy controls 6-8 months post-surgery. Functional capacity recovered from 70% preoperatively to about 80% that of healthy controls 6-8 months post-surgery. Actual daily activity recovered from 80% preoperatively to 84% that of healthy controls at 6 months post-surgery. Thus, at 6-8 months post-surgery a relatively greater recovery was seen in perceived problems with daily functioning, a moderate recovery in functional capacity, and a small recovery in actual daily activity. Even at 8 months after THA all three aspects have recovered to about 80% that of healthy controls. Little information was available regarding recovery of physical functioning for a period longer than 8 months after THA.

In **Chapter 3** we examined how patients perform activities in daily life before and six months after THA, using an accelerometry-based Activity Monitor. Six months postoperatively, the individual activities were not performed more often, but patients walked faster and they rose faster from a chair in their natural environment compared to the preoperative situation. Six months postoperatively, patients walked as fast as healthy controls but they still rose slower than controls from a chair.

How patients performed activities in their natural environment before and after TKA was examined in **Chapter 4.** Six months postoperatively, knee patients walked faster and rose faster from a chair in their natural environment compared to the preoperative situation. Furthermore, they performed more walking periods and chair rising movements. Compared to healthy controls, knee patients walked slower and needed more time to rise from a chair, even six months postoperatively. Both preoperatively and postoperatively, knee patients had a lower stride frequency than hip patients.

Chapter 5 evaluated the long-term effects of TKA and THA. This study examined whether the actual daily activity level increased four years after TKA and THA compared to six months postoperatively. In addition, we examined whether perceived daily functioning, functional capacity, and how patients performed activities, increased during that same time period. It was found that four years after TKA and THA the level of actual daily activity did not increase compared to six months postoperatively. In contrast, patients did improve on the other aspects of physical functioning.

In **Chapter 6** we systematically summarized the literature on the influence of preoperative psychological symptoms on the outcome of TKA and THA. It is shown that patients with lower preoperative mental health and patients who had pain catastrophising, had worse outcome after TKA. Because of the heterogeneity of the included studies regarding outcome measures, determinants and risk estimates, it remains unclear how much influence these characteristics have on actual outcome. The influence of other psychological symptoms on outcome was less convincing. Furthermore, relatively few studies examined the influence of psychological symptoms on outcome after THA.

In **Chapter 7** we examined the prevalence of two important psychological symptoms, i.e. depressive and anxiety symptoms, in patients on the waiting list for TKA and THA, and also at three months after TKA and THA. In patients on the waiting list for joint replacement, the prevalence of depressive symptoms was relatively high and the prevalence of anxiety symptoms relatively low, compared to other chronic diseases. The prevalence of depressive symptoms was significantly higher in hip patients than in knee patients. Three months after THA and TKA, the prevalence of depressive and anxiety disorders was significantly decreased compared to the preoperative situation.

In **Chapter 8** we evaluated whether the different aspects of physical functioning and mental functioning, in addition to patient characteristics, were related to patient satisfaction six months after TKA. Physical functioning did not appear to contribute to patient satisfaction after TKA. Patients with a better preoperative self-reported mental functioning, and patients who experienced less pain and had fulfilled expectations regarding postoperative pain, were more often satisfied.

Chapter 9 discusses the main topics of this thesis within a broader perspective, addresses the limitations of the presented studies, and makes some recommendations for future research.

Appendices

Nederlandse samenvatting

Dankwoord

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PhD Portfolio Summary

NEDERLANDSE SAMENVATTING

Artrose is in Westerse populaties één van de meest voorkomende oorzaken van pijn, stijfheid, functieverlies en invaliditeit bij volwassenen. Wat betreft de grotere gewrichten, komt artrose het meest voor in de knie en heup. Als conservatieve behandeling de pijn en beperkingen niet kan verhelpen, zijn een totale knieprothese (TKP) of totale heupprothese (THP) kosteneffectieve chirurgische behandelingen die aanzienlijke pijnverlichting en verbetering van het fysiek functioneren kunnen bieden.

Tegenwoordig is fysiek functioneren een belangrijke uitkomstmaat van een TKP en THP, omdat de huidige patiënten hoge verwachtingen hebben ten aanzien van de functionele fysieke uitkomst. Patiënten waarbij deze verwachtingen niet uitkomen, hebben een groter risico om ontevreden te zijn over een technisch geslaagde ingreep. Daarom moeten patiënten goed geïnformeerd worden over het mogelijke herstel van fysiek functioneren na een TKP en THP. Om dit doel te bereiken is het belangrijk dat chirurgen hierover een uitgebreide kennis hebben. Fysiek functioneren is echter een breed concept en bestaat uit verschillende aspecten. Eerdere studies hebben laten zien dat de verschillende aspecten van fysiek functioneren slecht met elkaar correleren. Maar het herstel van de verschillende aspecten van fysiek functioneren is nog niet eerder systematisch onderzocht.

Eerdere studies van De Groot et al. toonde aan dat patiënten op de wachtlijst voor een TKP en THP significant en klinisch relevant minder actief zijn dan gezonde gematchte controles gemeten met een op accelerometrie gebaseerde Activiteiten Monitor (AM). Zes maanden na de operatie verbeterde het activiteitenniveau niet klinisch relevant, terwijl de patiënten wel verbeterden op ervaren functioneren en functionele capaciteit. Tot nu toe weten we niet waarom patiënten niet actiever worden zes maanden na de operatie, terwijl ze minder problemen ervaren en vooruitgaan op capaciteit. Daarom was het eerste doel van dit proefschrift om te onderzoeken waarom patiënten niet verbeteren op het aspect daadwerkelijke activiteit zes maanden na de operatie.

Over het algemeen zijn de resultaten na een TKP en THP goed. Echter, een deel van de patiënten heeft suboptimale verbetering wat betreft pijn, fysiek functioneren en kwaliteit van leven. Eén van de aspecten die een relatie zou kunnen hebben met deze suboptimale resultaten na TKP en THP zijn psychologische kenmerken. Daarom was het tweede doel van dit proefschrift om de invloed van psychologische kenmerken op de behandeling van artrose en revalidatie na TKP en THP te onderzoeken.

Ten slotte is patiënt tevredenheid een belangrijk doel van alle (orthopaedische) procedures en optimalisatie van patiënt tevredenheid is dus van groot belang. Vergeleken met heup patiënten, zijn patiënten na een knie prothese over het algemeen minder vaak tevreden. Kennis over de factoren die bijdragen aan de tevredenheid van patiënten kan worden opgenomen in het verbeteren van de zorg voor TKP patiënten. Daarom was de laatste vraag van dit proefschrift om te bekijken of de verschillende aspecten van fysiek en mentaal functioneren gerelateerd zijn aan tevredenheid van patiënten na een TKP.

Hoofdstuk 2 beschrijft een studie waarin we een systematisch overzicht geven van de literatuur over het herstel van fysiek functioneren na een THP. Bovendien onderzochten we in deze studie de vraag of de drie verschillende aspecten van fysiek functioneren (ervaren functioneren, functionele capaciteit en de daadwerkelijke activiteit) hetzelfde patroon van herstel lieten zien na een THP. De literatuur samenvattend, blijkt dat deze aspecten van fysiek functioneren verschillende patronen van herstel laten zien in de eerste acht maanden na een THP vergeleken met de preoperatieve situatie. Ervaren fysiek functioneren herstelt van minder dan 50% van gezonde controles preoperatief tot ongeveer 80% 6 tot 8 maanden na de operatie. Functionele capaciteit herstelt van 70% van gezonde controles preoperatief tot ongeveer 80% 6 tot 8 maanden na de operatie. Het daadwerkelijke activiteitenniveau herstelt van 80% van gezonde controles preoperatief tot 84% 6 maanden na de ingreep. Dus 6 tot 8 maanden na de ingreep werd een relatief groot herstel gezien in ervaren fysiek functioneren, een gemiddeld herstel in functionele capaciteit en een relatief klein herstel in daadwerkelijk activiteitenniveau. Zelfs al acht maanden na een THP herstellen alle drie de aspecten tot ongeveer 80% van gezonde controle personen. Weinig informatie was beschikbaar over het herstel van fysiek functioneren op de langere termijn.

In **Hoofdstuk 3** hebben we, met een op accelerometrie gebaseerde Activiteiten Monitor, in detail onderzocht hoe patiënten de activiteiten in het dagelijks leven uitvoeren zowel voor als zes maanden na een THP. Zes maanden na de operatie werden de afzonderlijke activiteiten (lopen en opstaan) niet meer of vaker uitgevoerd, maar patiënten liepen wel sneller en stonden sneller op vanuit een stoel in hun natuurlijke omgeving vergeleken met preoperatief. Zes maanden na de operatie liepen patiënten net zo snel als gezonde controles, maar ze stonden nog wel langzamer op vanuit een stoel.

Hoe patiënten activiteiten in het dagelijks leven vóór en na een TKP uitvoeren is onderzocht in **Hoofdstuk 4.** Zes maanden postoperatief liepen knie patiënten sneller en stonden ze sneller op vanuit een stoel in hun natuurlijke omgeving ten opzichte van preoperatief. Bovendien voerden ze meer loopperiodes en opsta bewegingen uit. Vergeleken met gezonde controles liepen knie patiënten zes maanden na de operatie langzamer en stonden ze langzamer op vanuit een stoel. Zowel preoperatief als postoperatief hadden knie patiënten in de thuissituatie een lagere stapfrequentie dan heuppatiënten.

Hoofdstuk 5 richtte zich op de lange termijn effecten van een TKP en THP. We hebben in dit hoofdstuk onderzocht of het daadwerkelijke activiteitenniveau vier jaar na een TKP en THP toeneemt in vergelijking met zes maanden na de operatie. Bovendien hebben we onderzocht of ervaren functioneren, functionele capaciteit, en het uitvoeren van activiteiten in het dagelijks leven toenemen in hetzelfde tijdsinterval. In deze studie vonden we dat vier jaar na een TKP en THP het daadwerkelijke activiteitenniveau niet is toegenomen ten opzichte van zes maanden na de operatie. Patiënten verbeterden wel op de andere aspecten van fysiek functioneren.

In **Hoofdstuk 6** hebben we een systematisch overzicht gegeven van de literatuur over de invloed van preoperatieve psychische klachten op het resultaat van een TKP en THP. Uit dit overzicht bleek dat patiënten met een lagere preoperatieve mentale gezondheid en patiënten die catastroferen over pijn een slechter resultaat hadden na een TKP. Vanwege de heterogeniteit van de geïncludeerde studies wat betreft uitkomstmaten, determinanten en effectschatters, was het niet duidelijk hoeveel invloed deze klachten op het resultaat hebben. De invloed van de andere psychische klachten op de uitkomst was minder overtuigend. Bovendien hebben relatief weinig studies de invloed van psychische klachten op het resultaat van een THP onderzocht.

In **Hoofdstuk 7** hebben we de prevalentie onderzocht van twee belangrijke psychische klachten, namelijk depressieve en angst klachten, bij patiënten op de wachtlijst voor een TKP en THP. Daarnaast hebben we onderzocht of de prevalentie drie maanden na een TKP en THP veranderd. Bij patiënten op de wachtlijst voor een gewrichtsvervangende prothese was de prevalentie van depressieve klachten relatief hoog en van angst klachten relatief laag in vergelijking met andere chronische ziekten. De prevalentie van depressieve klachten was significant hoger in heup dan in kniepatiënten. Drie maanden na een TKP en THP zijn de prevalenties van depressieve en angstklachten significant gedaald ten opzichte van preoperatief.

In **Hoofdstuk 8** hebben we onderzocht of de verschillende aspecten van fysiek en mentaal functioneren, naast patiënt karakteristieken, gerelateerd zijn aan de tevredenheid met het resultaat van de operatie van patiënten zes maanden na een TKP. De verschillende aspecten van fysiek functioneren lijken niet onafhankelijk bij te dragen aan patiënt tevredenheid na een TKP. Patiënten met een betere preoperatieve mentale gezondheid, die minder pijn ervaren en waarvan de verwachtingen zijn uitgekomen ten aanzien van postoperatieve pijn waren vaker tevreden met het resultaat van de operatie.

In **Hoofdstuk 9** zijn de belangrijkste resultaten van dit proefschrift in een breder perspectief besproken. Daarnaast zijn de beperkingen van dit proefschrift beschreven en zijn er aanbevelingen gedaan voor toekomstig onderzoek.

DANKWOORD

Het onderzoek is afgerond, de artikelen zijn geschreven en het proefschrift is af. Het is me gelukt! Maar promoveren doe je zeker niet alleen. Tijdens dit proces heeft een groot aantal mensen mij begeleid, geïnspireerd, gemotiveerd en gesteund. Daarom wil ik graag een aantal mensen bedanken.

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De samenstelling van deze kamer heeft nogal wat veranderingen ondergaan in de afgelopen jaren. Eerst was het nog Max die "neerkeek" op de onderzoekers. Marein, in die tijd was jij maar anderhalve dag als onderzoeker aan het werk, maar je deed dit met erg veel enthousiasme en je was altijd in voor een gezellig praatje. Door jou ging ik zelfs actief Studio Sport volgen, anders had ik de volgende dag geen idee waar jij en Max het over hadden.

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ABOUT THE AUTHOR

Maaike Dikmans-Vissers was born on the 11th of January 1983 in Etten-Leur, the Netherlands. She completed secondary school at the Mencia de Mendoza Lyceum in Breda in 2001. In that same year she started the study Health Sciences at the University of Maastricht where she specialized in Human Movement Sciences. She performed a six months research internship at the Department of Rehabilitation Medicine, Erasmus University Medical Center in Rotterdam. She graduated in June 2005. After her graduation, she continued working at the Department of Rehabilitation Medicine in Rotterdam on the project 'Barriers to and facilitators of everyday physical activity in persons with a spinal cord injury after discharge from the rehabilitation centre. In September 2006 she started the work presented in this thesis at the Department of Orthopaedics at the Erasmus University Medical Center under supervision of Prof. Dr. J.A.N. Verhaar (Department of Orthopaedics), Dr. M. Reijman (Department of Orthopaedics) and Dr. J.B.J. Bussmann (Department of Rehabilitation Medicine). Maaike is currently working as Senior Associate Clinical Contracts and Budgets at Amgen B.V. in Breda. She is responsible for negotiating contracts, study budgets and milestones with sites. Maaike is married to Frank Dikmans and lives in Prinsenbeek, the Netherlands.

LIST OF PUBLICATIONS

Vissers M.M., Duivenvoorden T, Verhaar J.A.N., Busschbach J.J.V., Gosens T, Pilot P, Bierma-Zeinstra S.M.A., Reijman M. Depressive and anxiety symptoms before and after total hip and knee arthroplasty. Submitted

Vissers M.M., Boeddha A.V., de Groot I.B., Verhaar J.A.N., Reijman M., Bussmann J.B.J. Performance of walking and chair rising in daily life before and after total knee arthroplasty. Submitted

van Meer B.L., Meuffels, D.E., **Vissers M.M**., Bierma-Zeinstra S.M.A. Verhaar J.A.N., Terwee C.B., Reijman M. KOOS or IKDC: Which questionnaire is most useful to monitor patients with an anterior cruciate ligament rupture?

Vissers M.M., Bussmann J.B.J., de Groot I.B., Verhaar J.A.N., Reijman M. Physical functioning four years after total hip and knee arthroplasty. Submitted.

Vissers M.M., Bussmann J.B.J., Verhaar J.A.N., Busschbach J.J.V., Bierma-Zeinstra S.M.A., Reijman M. Psychological factors affecting the outcome of total hip and knee arthroplasty: a systematic review. Semin Arthritis Rheum. 2011 Oct 27. [Epub ahead of print]

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Vissers M.M., Bussmann J.B.J, Verhaar J.A.N., Arends L.R., Furlan A.D., Reijman M. Recovery of physical functioning after total hip arthroplasty: systematic review and meta-analysis of the literature. Phys Ther. 2011 May;91(5):615-29.

Vissers M.M., de Groot I.B., Reijman M, Bussmann J.B.J., Stam H.J., Verhaar J.A.N. Functional capacity and actual daily activity do not contribute to patient satisfaction after total knee arthroplasty. BMC Musculoskelet Disord. 2010 Jun 16;11:121.

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PhD PORTFOLIO SUMMARY

Name PhD student:	M.M. Vissers
Erasmus MC Department:	Orthopaedics
PhD period:	2006-2011
Promotors:	Prof. dr. J.A.N. Verhaar
Supervisors:	dr. M. Reijman, dr. J.B.J. Bussmann

Courses	**Year**	**ECTS**
Biomedical English writing and Communication	2008-2009	4
Regression analysis for clinicians, Nihes	2009	1.9
Survival analysis for clinicians, Nihes	2009	1.9
Clinical trials, Nihes	2009	0.7
Cohort studies, Nihes	2009	0.7
Repeated measurements, Nihes	2010	1.9
Missing values in clinical research, Nihes	2010	0.9
Basiscursus Regelgeving en Organisatie voor Klinische onderzoekers (BROK)	2010	1.0
Conferences and presentations	**Year**	**ECTS**
Podium presentations		
Patient satisfaction after total hip or knee artrhoplasty, Dutch Orthopaedic Society (NOV), Utrecht, The Netherlands	2008	1.0
Performance of activities in the natural environment before and after total hip arthroplasty, Dutch Orthopaedic Society (NOV), Utrecht, The Netherlands	2010	1.0
Physical functioning four years after total hip or knee arthroplasty, Dutch Orthopaedic Society (NOV), Veldhoven, The Netherlands	2010	1.0

Poster presentations

Patient satisfaction after total hip or knee arthroplasty, Osteoarthritis Research Society International, Montreal, Canada	2009	0.5
Recovery of physical functioning after total hip arthroplasty: a systematic review of the literature, Osteoarthritis Research Society International, Montreal, Canada	2009	0.5
Physical functioning four years after total hip and knee arthroplasty, Osteoarthritis Research Society International, Brussels, Belgium	2010	0.5
Performance of activities before and six months after total hip arthroplasty, Osteoarthritis Research Society International, Brussels, Belgium	2010	0.5

Teaching activities	**Year**	**ECTS**
Supervising Master's thesis "Physical functioning four years after total hip and knee arthroplasty", C.M. van Ekelenburg and L. Hooijdonk, Human Movement Sciences students, 21 weeks	2008	3.0
Supervising Master's thesis "Performance of activities before and six months after total knee arthroplasty", A.V. Boeddha, Medical Student, 21 weeks	2010	3.0
Supervising systematic review "Effect of lifestyle interventions in patients of 45 years or older with overweight and knee osteoarthritis: a systematic review", R. Zuur, K. Schuurbiers, Medical Students, 4 weeks	2010	0.4
Supervising systematic review "Physical functioning after total hip arthroplasty": a systematic review", N.D. Gonzalez, M. Doomen, Medical Students, 4 weeks	2008	0.4
Tutor minor orthopaedics "Orthopaedic Sports Traumatology", third year medial students	2010	1.5

Lecturing

Patient satisfaction after total hip or knee arthroplasty, education physicians and assistants, Erasmus MC, Rotterdam, The Netherlands	2008	0.6
Recovery of physical functioning after total hip arthroplasty: a systematic review of the literature, education physicians and assistants, Erasmus MC, Rotterdam, The Netherlands	2009	0.6
Performance of activities in the natural environment before and after total hip artrhoplasty, education physicians and assistants, Erasmus MC, Rotterdam, The Netherlands	2010	0.6
Physical functioning four years after total hip and knee arthroplasty, education physicians and assistants, Erasmus MC, Rotterdam, The Netherlands	2010	0.6
Depressive and anxiety disorders before and after total hip or knee arthroplasty, education physicians and assistants, Erasmus MC, Rotterdam, The Netherlands	2011	0.6

Other

Reviewer international journals under supervision of dr. M. Reijman and dr. J.B.J. Bussmann	2010	1.5