Recovery of Physical Functioning After Total Hip Arthroplasty: Systematic Review and Meta-Analysis of the Literature

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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 (ie, 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 a 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.
Recovery of Physical Functioning After Total Hip Arthroplasty

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. Evaluation of the results of THA traditionally has 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, health-related quality of life, and patient satisfaction after THA, are increasingly reported.

Besides these aspects, it is important to analyze 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. Furthermore, patients today (who tend to be younger and more active than those who previously underwent this surgical procedure) have high expectations regarding functional outcomes of the patients and those of the surgeon. Therefore, patients need to be well informed about potential recovery of physical functioning after THA.

Physical functioning is a multidimensional construct covering various aspects of health. Based on the International Classification of Functioning, Disability and Health 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.

The aim of the present study was to examine whether the 3 aspects of physical functioning showed different degrees of recovery after THA. For many patients, an important goal of surgery is the ability to return to a higher level of physical functioning. However, a discrepancy often exists between expectations of the patients and those of the surgeon. Therefore, patients need to be well informed about potential recovery of physical functioning after THA.

Study Selection
Two reviewers 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 measurements taken 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:
   - Perceived problems in daily functioning using validated questionnaires for patients with hip conditions. These validated questionnaires were the Western Ontario and McMaster Universities 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 physical activity scale of the Arthritis Impact Measurement Scales (AIMS-PA).
   - 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).
   - Actual daily activity in the home situation using activity monitoring, with devices such as pedometers or accelerometry-based activity monitors.

Materials and Method
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. 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.
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 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. The risk of bias of the studies was evaluated using a checklist consisting of 13 items divided among 3 subscales (Appendix 2). Two reviewers 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 was not necessary.

**Data Extraction**

Two reviewers independently extracted the study characteristics, follow-up times, and clinical outcome measures using a pretested standardized form. The data extraction form was pretested 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 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 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. For the SF-36-PF, we used the reference value of 76 obtained from age-matched controls in the Netherlands. For walking speed, we used the weighted mean of the walking speed measured in age-matched controls in 3 of the included studies. 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 (Fig. 1). The main reasons for excluding abstracts were: no prospective study with a before-after design, no follow-up period of minimally 6 weeks, and no primary THA for OA. 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 (Tab. 1).

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, 1 study evaluated a preoperative pain intervention, 1 study evaluated a preoperative exercise intervention, 1 study evaluated a preoperative and postoperative exercise intervention, and 1 study evaluated a postoperative rehabilitation intervention (Tab. 1).

Perceived problems in daily functioning were measured in 18 studies, functional capacity to perform activities in a laboratory setting or outpatient clinic was measured in 16 studies, and actual daily activity in the home situation was measured in 1 study (Tab. 1). Tables 2, 3, and 4 present the results (means 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 (Tab. 1). In all studies, the main outcomes were clearly...
described in the “Introduction” or “Method” 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 (Tab. 1). Because scoring of the WOMAC was not uniform in all studies (eg, 5-point Likert scale, visual analog scale, or numeric scale with scores ranging from 0 to 10), only results of studies using a 5-point Likert scale (range of scores=0-4) were pooled (Tab. 2). The mean pooled WOMAC-PF score
Table 1.
Information on the Included Studies\textsuperscript{a}

| Study, Year of Publication, and Country | No. of Patients | Age (y) | BMI (kg/m\textsuperscript{2}) | Sex, % | Maximum Follow-up in Months (No. of Follow-up Assessments) | Measurement | Study Design | Risk of Bias Assessment Total Score (13 Items) |
|----------------------------------------|-----------------|---------|------------------------------|--------|-------------------------------------------------------------|-------------|-------------|-----------------------------------------------|
| Ajemian et al,\textsuperscript{45} 2004, Canada | 11 | 62.6 (8.6) | NR | 18 | 8 (1) Gait analysis | Prospective cohort | 6 |
| Bachrach-Lindström et al,\textsuperscript{30} 2008, Sweden | 229 | 69.5 (10.0) | NR | 49 | 12 (1) WOMAC-PF | Prospective cohort | 10 |
| Bennett et al,\textsuperscript{20} 2006, Ireland | 17 | 60.4 (6.0) | NR | 35 | 1.5 (1) Gait analysis | Prospective cohort | 8 |
| Berge et al,\textsuperscript{26} 2004, United Kingdom | 40 | 71.3 (6.05) | NR | 68 | 12 (2) Capacity test (Four-Minute Walk Test) | RCT | 9 |
| Boardman et al,\textsuperscript{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,\textsuperscript{16} 1980, United States | 29 | 56 (range=21–73) | NR | 66 | 36 (4) Gait analysis | Prospective cohort | 6 |
| Busija et al,\textsuperscript{32} 2008, Sweden | 274 | 70.5 (8.9) | NR | 53 | 60 (2) SF-36-PF | Prospective cohort | 7 |
| Chiu et al,\textsuperscript{33} 2000, Taiwan | 46 | 52 (17) | NR | 46 | 6 (1) SF-36-PF | Prospective cohort | 9 |
| Chiu et al,\textsuperscript{34} 2001, Taiwan | 76 | N/A | NR | 47 | 12 (2) SF-36-PF | Prospective cohort | 8 |
| Dawson et al,\textsuperscript{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,\textsuperscript{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,\textsuperscript{21} 2007, United States | 60 | 67.0 (11.8) | 28.9 | 48 | 3 (2) Gait analysis | RCT | 9 |
| Fitzpatrick et al,\textsuperscript{17} 2000, United Kingdom | 7,151 | 67.8 (10.9) | NR | 60 | 12 (2) Oxford Hip Score | Prospective cohort | 8 |
| Fortin et al,\textsuperscript{38} 1999, United States and Canada | 220\textsuperscript{b} | 67.0 (9.0) | NR | 49 | 6 (2) WOMAC-PF SF-36-PF | Prospective cohort | 8 |
| Gilbey et al,\textsuperscript{28} 2003, Australia | 68 | 65.2 (11.0) | 27.9 (4.1) | 62 | 6 (2) WOMAC-PF | RCT | 6 |
| de Croot et al,\textsuperscript{39} 2008, the Netherlands | 36 | 61.5 (12.8) | 26.6 (4.2) | 64 | 6 (2) WOMAC-PF SF-36-PF Capacity test (Six-Minute Walk Test, timed chair rising test, timed stair climbing test) Actual physical activity | Prospective cohort | 10 |
| Huber et al,\textsuperscript{10} 2006, Switzerland | 73 | 66.8 (9.9) | 27.4 (4.5) | 47 | 24 (2) SF-36 | Prospective cohort | 9 |
| Laupacis et al,\textsuperscript{41} 1993, Canada | 188 | 64 (range=40–75) | NR | 48 | 24 (4) WOMAC-PF Capacity test (Six-Minute Walk Test) | Prospective cohort | 8 |

(Continued)
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 (SE=3.55) at 6 to 8 months postsurgery. The difference in scores between 1 to 3 months 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=.085) and to 63.04 (SE=4.17) at 6 to 8 months postsurgery (P=.0001) (Tab. 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.

### Table 1.
Continued

| Study, Year of Publication, and Country | No. of Patients | Age (y) | BMI (kg/m²) | Sex, % | Maximum Follow-up in Months (No. of Follow-up Assessments) | Measurement | Study Design | Risk of Bias Assessment Total Score (13 Items) |
|---------------------------------------|-----------------|---------|-------------|--------|-------------------------------------------------------------|-------------|-------------|---------------------------------------------|
| 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 Kingdom   | 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 et al,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-Minute Walk Test)                | RCT         | 9           |                                             |
| van den Akker-Scheek et al,42 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,30 1980, United Kingdom    | 16              | NR      | NR          | 63     | 12 (2) Gait analysis                                       | Prospective cohort | 5           |                                             |

*Results are presented as mean (SD) unless otherwise indicated. BMI=body mass index, NR=not reported, N/A—not applicable, 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.*

*The presented characteristics of this study also included patients with knee conditions.*
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 to 10, 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).

**Functional Capacity to Perform Activities**

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, and another study did not present standard deviations or SEs. 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=.086) and to 1.082 m/s (SE=0.048) at 6 to 8 months postsurgery (P=.046) and decreased to 1.032 m/s (SE=0.072) at 12 months postsurgery (P=.198) (Tab. 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 1.26 m (SE=0.024) at 6 to 8 months postsurgery (Tab. 4).

Cadence was measured in only 3 studies. In 1 study, because data had

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**Table 4.**

Data on Ability to Perform Activities: Gait Analysis

| Variable                   | Preoperative | 1–3 Months Postsurgery | 6–8 Months Postsurgery | 12 Months Postsurgery |
|----------------------------|--------------|------------------------|------------------------|-----------------------|
| Walking speed (m/s)        |              |                        |                        |                       |
| Ajemian et al              | 0.950        | 1.080                  | 1.082                  | 1.032                 |
| Boardman et al             | 0.990        | 1.17                   | 1.17                   |                       |
| Brown et al                | 0.680        | 0.730                  | 0.920                  |                       |
| Dorr et al                 | 0.970        | 1.100                  | 0.990                  |                       |
| Leuchte et al              | 1.070        | 1.080                  | 1.170                  |                       |
| Lindemann et al            | 1.060        | 1.160                  | 1.140                  |                       |
| McBeath et al              | 0.600        | 0.930                  | 0.900                  |                       |
| Shadrer et al              | 0.880        | 1.050                  | 0.900                  |                       |
| van den Akker-Scheek et al| 0.930        | 0.950                  | 1.140                  |                       |
| Pooled results             | **0.903**    | **1.026**              | **1.082**              | **1.032**             |

| Stride length (m)          |              |                        |                        |                       |
| Dorr et al                 | 1.13         | 1.18                   | 1.16                   |                       |
| Lindemann et al            | 1.20         | 1.26                   | 1.26                   |                       |
| Shadrer et al              | 1.05         | 1.18                   | 1.11                   |                       |
| van den Akker-Scheek et al | 1.12         | 1.16                   | 1.16                   |                       |
| Wall et al                 | 0.793        | 1.07                   | 1.07                   |                       |
| Cadence (steps/min)        |              |                        |                        |                       |
| Bennett et al              | 29.05        | 31.06                  |                        |                       |
| Dorr et al                 | 103.14       | 113.74                 |                        |                       |
| Stauffer et al             | 61.2         | 80.4                   |                        |                       |

*SE=standard error.
Results of these studies were not included in this meta-analysis because the standard errors were not presented.
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 with 113.74 steps/min (SE=10.55) at 1 to 3 months postsurgery and 80.4 steps/min at 6 to 8 months postsurgery (Tab. 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 and with the Six-Minute Walk Test in 5 studies. Patients were instructed to walk at a comfortable speed in 1 study, whereas they were instructed to walk as far as possible in 6 minutes in other studies. The distance covered in 6 minutes ranged from 134 m (SE=7.9) 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 by Troosters et al 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 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, and another study measured the time needed for 5 repetitive chair-rise movements. 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 period longer than 6 months. Only 1 study measured stair climbing capacity. 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=4.3–17.2) at 6 months postsurgery. Measured with capacity tests, the recovery of physical functioning generally increased after surgery.

Actual Daily Activity in the 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). 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 hours 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.

In the study measuring daily activity in the home, 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% of 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 reference values, patients scored relatively low on perceived daily functioning, but relatively high on functional capacity to perform activities (ie, what patients can actually 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 reference 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.

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 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 also was reported in a review by Montin et al, who also found that self-reported physical functioning improved after surgery.

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...
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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 among 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 (eg, age, sex, body mass index) on the recovery of physical functioning after THA.

Walking speed was measured with different gait analysis devices, which could have 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 with 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 by 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 patients’ home situation. 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 homes 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

“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

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 “Method” 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 \(.001\)?

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 | Individuals Who Gave Consent Representative | Outcome Measures Accurate | Appropriate Statistics | Data Dredging | Total |
|------------------------|-----------------------|---------------------------------|----------------------------------|---------------------------------|---------------------------------|---------------------------------|-------------------------------|-----------------------------|-----------------------------------|-----------------------------------------------|--------------------------|-------------------------|--------------|-------|
| Ajemian et al.,45 2004 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 1                             | 0                           | 0                                  | 1                              | 1                        | 10           | 1     |
| Bachrach-Lindström et al.,30 2008 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 1                             | 1                           | 1                                  | 1                              | 1                        | 1             | 9     |
| Bennett et al.,26 2006 | 1                     | 1                               | 1                                | 1                               | 0                               | 0                               | 0                             | 0                           | 0                                  | 1                              | 1                        | 1             | 8     |
| Berge et al.,26 2004  | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 1                             | 0                           | 0                                  | 1                              | 1                        | 1             | 9     |
| Boardman et al.,31 2000 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 0                             | 0                           | 1                                  | 1                              | 1                        | 1             | 8     |
| Brown et al.,36 1980  | 1                     | 1                               | 1                                | 0                               | 1                               | 0                               | 0                             | 0                           | 0                                  | 1                              | 1                        | 1             | 6     |
| Busija et al.,32 2008 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 0                             | 0                           | 0                                  | 1                              | 1                        | 1             | 7     |
| Chiu et al.,33 2000   | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 1                             | 1                           | 0                                  | 1                              | 1                        | 1             | 9     |
| Chiu et al.,34 2001   | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 0                             | 1                           | 0                                  | 1                              | 1                        | 1             | 8     |
| Dawson et al.,35 1996 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 0                             | 0                           | 1                                  | 1                              | 1                        | 1             | 7     |
| Dawson et al.,36 1996 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 0                             | 1                           | 0                                  | 1                              | 1                        | 1             | 8     |
| Dorr et al.,37 2007   | 1                     | 1                               | 1                                | 0                               | 0                               | 1                               | 0                             | 1                           | 0                                  | 1                              | 1                        | 1             | 9     |
| Fitzpatrick et al.,38 2000 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 0                             | 1                           | 0                                  | 1                              | 1                        | 1             | 8     |
| Fortin et al.,39 1999 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 1                             | 0                           | 0                                  | 1                              | 1                        | 1             | 8     |
| de Groot et al.,39 2008 | 1                    | 1                               | 1                                | 0                               | 1                               | 1                               | 0                             | 1                           | 0                                  | 1                              | 1                        | 1             | 10    |
| Huber et al.,39 2006  | 1                     | 1                               | 1                                | 1                               | 0                               | 1                               | 0                             | 1                           | 0                                  | 1                              | 1                        | 1             | 9     |
| Laupacis et al.,40 1993 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 0                             | 0                           | 1                                  | 1                              | 1                        | 1             | 8     |
| Laupacis et al.,41 2002 | 0                    | 1                               | 0                                | 1                               | 1                               | 0                               | 1                             | 0                           | 0                                  | 1                              | 0                        | 1             | 7     |
| Leuchte et al.,42 2007 | 0                     | 1                               | 0                                | 1                               | 1                               | 0                               | 1                             | 0                           | 0                                  | 1                              | 1                        | 1             | 8     |
| Lindemann et al.,43 2006 | 1                     | 1                               | 1                                | 0                               | 1                               | 1                               | 0                             | 1                           | 0                                  | 1                              | 1                        | 1             | 10    |
| McBeath et al.,44 1980 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 0                             | 0                           | 0                                  | 1                              | 0                        | 1             | 6     |
| Roos et al.,45 2006   | 1                     | 1                               | 1                                | 0                               | 1                               | 1                               | 0                             | 1                           | 0                                  | 1                              | 1                        | 1             | 9     |
| Salmon et al.,46 2001 | 1                     | 1                               | 0                                | 0                               | 0                               | 0                               | 0                             | 0                           | 1                                  | 1                              | 1                        | 1             | 6     |
| Shadrer et al.,47 2009 | 1                     | 1                               | 1                                | 1                               | 0                               | 0                               | 0                             | 0                           | 0                                  | 1                              | 1                        | 1             | 6     |
| Stauffler et al.,48 1974 | 1                     | 1                               | 0                                | 1                               | 1                               | 0                               | 0                             | 0                           | 0                                  | 1                              | 0                        | 1             | 8     |
| Unver et al.,49 2004  | 0                     | 1                               | 0                                | 1                               | 1                               | 1                               | 1                             | 0                           | 0                                  | 1                              | 1                        | 1             | 9     |
| van den Akker-Scheek et al.,50 2007 | 1                     | 1                               | 1                                | 0                               | 1                               | 1                               | 0                             | 0                           | 0                                  | 1                              | 1                        | 1             | 9     |
| van den Akker-Scheek et al.,51 2008 | 1                     | 1                               | 1                                | 0                               | 1                               | 1                               | 0                             | 0                           | 0                                  | 1                              | 1                        | 1             | 9     |
| Vendittoli et al.,52 2006 | 1                     | 1                               | 1                                | 1                               | 0                               | 0                               | 0                             | 0                           | 0                                  | 1                              | 1                        | 1             | 9     |
| Wall et al.,53 1980   | 0                     | 1                               | 0                                | 1                               | 1                               | 1                               | 0                             | 0                           | 0                                  | 1                              | 0                        | 1             | 5     |
Appendix 4.
Forest Plots

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.