Are contextual factors associated with activities and participation after total hip arthroplasty?

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Are contextual factors associated with activities and participation after total hip arthroplasty? A systematic review

Abstract

Objectives: After total hip arthroplasty (THA), over 30% of individuals report activity limitations and participation restrictions. This systematic review aimed to determine the association between contextual factors and outcomes in the activity and participation domain after THA for hip osteoarthritis (OA).

Methods: This systematic review was developed according to the PRISMA guidelines for systematic reviews. PubMed, Web of Science, Embase and Scopus were searched until August 2022. Risk of bias was assessed with the Quality in Prognosis Studies tool (QUIPS).

Results: Twenty-nine articles were included. Eighteen had a high risk of bias, 3 had a low risk of bias, and 8 had a moderate risk of bias. Anxiety was only investigated in studies with high risk of bias but showed a consistent negative association with activities and participation after THA across multiple studies. Evidence was inconsistent regarding the associations between depression, trait anxiety, sense of coherence, big 5 personality traits, educational level, marital status, employment status, job position, expectations and social support, and the activity and participation domain. Optimism, general self-efficacy, cognitive appraisal processes, illness perception, ethnicity, and positive life events were associated with activities and participation but were only investigated in 1 study. No associations were identified across multiple studies for living or smoking status. Control beliefs, kinesiophobia, race, discharge location, level of poverty in neighbourhood, negative life events and occupational factors, were not associated with the activity and participation domain but were only investigated in 1 study.

Conclusion: Methodological quality of the included studies was low. Anxiety was the only factor consistently associated with worse outcomes in the activity and participation domain after THA but was only investigated in studies with high risk of bias. Further research is needed to confirm relationships between other contextual factors and activities and participation after THA.

Registration: PROSPERO CRD42020199070

Keywords

Osteoarthritis; Personal factors; Environmental factors; Social factors; Cognitions; Emotions

Abbreviations

ADL	Activities of Daily Living
BAI	Brief Appraisal Inventory
BDI	Beck Depression Inventory
BMI	Body Mass Index
BSI	Brief Symptom Inventory
CEQ	Credibility Expectancy Questionnaire
COPSOC-II	Copenhagen Psychosocial Questionnaire II
EPI	Eysenck Personality Inventory
EPQ	Eysenck Personality Questionnaire
EQ-5D	EuroQol 5D
ESSI	ENRICHD Social Support Instrument score
GLM	General Linear Model
GO-SSS	Groningen Orthopaedic Social Support Scale
GP	General Practitioner
GSES	General Self-Efficacy Scale
HADS	Hospital Anxiety and Depression Scale

HOOS	Hip disability and Osteoarthritis Outcome Score
HOOS-JR	Hip Disability and Osteoarthritis Outcome Score for Joint Replacement
HSS	Hospital for Special Surgery
ICF	International Classification of Functioning, Disability and Health
ILOA	Iowa Level of Assistance Scale
IPQ-R	Illness Perception Questionnaire-Revised
IQR	Inter Quartile Range;
LASSO	Least Absolute Shrinkage Selection Operator
LLDI	Late-Life Function and Disability Instrument
LMM	Linear Mixed Model
LOT-R	Life Orientation Test-Revised
MGLM	Multivariable General Linear Model
MID	Minimal Important Difference
MLOGRA	Multivariable Logistic Regression Analysis
MLRA	Multivariable Linear Regression Analysis
MVPA	Moderate-to-vigorous Physical Activity
OA	Osteoarthritis
OHS	Oxford Hip Score
OLR	Ordinal Logistic Regression
OP	Occupational Physician
OR	Odds Ratio
PCS	Physical Component summary score
PEBC	Perceived External Behavioural Control
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QOL	Quality of Life
QUIPS	Quality in Prognosis Studies tool
RLOC	Recovery Locus of Control
RMLRA	Repeated Measures Linear Regression Analysis

RTW	Return to Work
SDOH	Social Determinants of Health
SE	Standard Error
SF-36	Short Form 36-item Health Survey
SF-36 PCS	Short Form 36 Health Survey Physical Component Summary score
SMLOGRA	Stepwise Multivariable Logistic Regression Analysis
SMLR	Stepwise Multiple Linear Regression
SOC	Sense of Coherence scale
SPS	Social Provisions Scale
STAI	State-Trait Anxiety Inventory
THA	Total Hip Arthroplasty
TKA	Total Knee Arthroplasty
TSK	Tampa Scale for Kinesiophobia
TUG	Timed Up and Go
UGLM	Univariable General Linear Model
ULOGRA	Univariable Logistic Regression Analysis
ULRA	Univariable Linear Regression Analysis
WALS	Workplace Activity Limitations Scale
WHO	World Health Organisation
WOMAC	Western Ontario and McMaster Universities osteoarthritis index score
10MWT	10 Meter Walk Test

Introduction

Osteoarthritis (OA) is one of the leading causes of pain and disability worldwide [1-3]. The hip joint is clinically one of the most affected locations of OA [4]. Each year, more than 40 million prevalent cases and more than 2 million incident cases of hip OA are reported worldwide [3]. The global prevalence and incidence are expected to increase considerably in the upcoming decades

because of population aging and the increasing prevalence of risk factors such as obesity and sedentary lifestyle [1, 5]. Correspondingly, the mean rate of hip implants per 100.000 inhabitants in Organisation for Economic Co-operation and Development countries is expected to increase from 145 in 2010 to 275 in 2050 [6]. Total hip arthroplasty (THA) is a cost-effective procedure in persons with end-stage hip OA [7]. However, previous studies have reported that 8% of people are dissatisfied with the outcome [8, 9] and up to 23% report long-term pain after THA [10]. Furthermore, over 30% report activity limitations and about 25% report participation restrictions after THA [11, 12].

The International Classification of Functioning, Disability and Health (ICF) (Figure 1) describes a person's health state in domains of body functions and structures, and the domain of activity and participation [13]. The activity and participation domain can be considered as a clinically relevant outcome in individuals after THA. An important step towards the improvement of outcomes in the activity and participation domain is the identification of prognostic factors [14]. Research suggests that differences in the outcomes of THA cannot be entirely explained by prognostic factors in the domain of body functions and structures (e.g. comorbidities, radiological OA severity) or by the surgery itself [15]. The ICF framework considers an individual's functioning and disability as the result of an interaction between a health condition and contextual factors [13]. Contextual factors (i.e., personal and environmental factors) are associated with outcomes in the activity and participation domain in individuals with musculoskeletal disorders. Higher self-efficacy is associated with better activity and participation levels in individuals with chronic musculoskeletal pain [16]. Furthermore, research in individuals with knee pain suggests that environmental factors (e.g., poor access to public transportation) are associated with participation levels [17]. Contextual factors are also associated with outcomes after surgery. Anxiety, catastrophizing, depression and kinesiophobia have been identified as prognostic factors for general chronic postsurgical pain [18]. Different systematic reviews found that these personal factors are associated with pain and function after total knee arthroplasty (TKA) [19-22]. Although different prognostic factors have been found for THA and TKA [23], no conclusive evidence exists for the relationship between

contextual factors and outcomes in the activity and participation domain after THA, except for a negative association with older age, female sex and higher body mass index (BMI) [24, 25]. Therefore, the aim of this systematic review was to determine which contextual factors are associated with outcomes in the activity and participation domain after THA for hip OA.

Methods

Protocol and registration

This systematic review was developed according to the PRISMA guidelines for systematic reviews (PRISMA checklist in Supplementary Table S1) [26]. A protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO, CRD42020199070) and can be accessed online.

Eligibility criteria

Articles were eligible for inclusion in this systematic review if (1) they reported a quantitative longitudinal cohort study or an analysis of longitudinal data from a randomized controlled trial, (2) the study included adult participants (mean age > 40 years) with hip OA who underwent THA; studies investigating both THA and TKA were only included if the results were reported separately for THA (when results were not reported separately, the authors were contacted to ask if separate results were available) (3) the independent variable was a contextual factor (i.e. personal or environmental factor) (at least one factor besides age, sex or BMI), (4) the dependent variable was a self-reported or performance-based measure of the activity and participation domain, (5) the association between independent and dependent variables was determined with regression analysis (univariable and/or multivariable), (6) the article was peer-reviewed and published in English or Dutch, and (7) the article was published after 2001 (introduction of the ICF). Articles were excluded if (1) people with rheumatoid arthritis or other rheumatic diseases were included,

(2) the study investigated people with neurological, cardiovascular, systemic or psychiatric disorders that considerably influence disability, (3) the study only investigated activity characteristics (e.g., symmetry, accelerometery) through lab based kinetic and kinematic movement analysis (e.g., gait analysis), and (4) the study had no ethical approval or informed consent.

Information sources

Articles were identified by a literature search in the electronic databases PubMed, Embase, Scopus and Web of Science, until 29 August 2022. Reference lists of included articles were screened for additional articles.

Search

The search strategy was developed using terms related to 'hip osteoarthritis' and 'total hip arthroplasty', and terms related to the activity and participation domain, such as 'activities of daily living' and 'participation' (Supplementary Data S1). No terms were included for personal or environmental factors to avoid exclusion of articles not covered by these terms.

Article selection

The title screening was performed by 1 reviewer (AS). Then, titles and abstracts were screened by 2 reviewers independently (AS & JV). Finally, the full texts were screened by the same 2 reviewers independently. In each phase of the study selection process, disagreements were resolved by consensus or by the independent evaluation of a third reviewer (AT). A Kappa score was calculated after study selection.

Data collection

Data were extracted from the included studies by 1 reviewer (AS) using a standardized extraction form (Microsoft Excel), and independently evaluated by a second reviewer (JV). Disagreements were resolved by consensus or by consulting a third reviewer (AT).

Data items

The authors extracted article information (author, year, country, and journal), study characteristics (aims, design, setting, recruitment, sample size and follow-up), sample characteristics (age, sex, BMI, comorbidities, treatment, diagnosis, and time since surgery), dependent variables in the activity and participation domain, independent contextual factors (divided into personal and environmental factors), confounding factors, statistical methods, and results.

Risk of bias in individual articles

Risk of bias of the individual articles was assessed using the Quality In Prognosis Study (QUIPS) tool [27]. The QUIPS tool is recommended by the Cochrane Prognosis Methods Group for Prognosis studies [28]. The assessments were performed by 2 researchers independently (AS & JV). Disagreements were resolved by consensus or by consulting a third reviewer (AT). The QUIPS tool evaluates six domains in prognostic research: (1) study participation, (2) study attrition, (3) prognostic factor measurement, (4) outcome measurement, (5) study confounding, and (6) statistical analysis and reporting. No recommendations are available for overall risk of bias assessment with the QUIPS tool [27]. Therefore, a classification method was used, similarly to Grooten et al. [29] and Tseli et al. [30]. Articles with 2 or more domains with high risk of bias were classified as high overall risk of bias. Articles with 4 or more domains with low risk of bias, and less than two domains with high risk of bias were classified as low overall risk of bias. All articles in between were classified as having moderate risk of bias.

Summary measures

The level of statistical significance was expressed as a p-value. Measures of the association between contextual factors and outcomes in the activity and participation domain included odds ratios or coefficients (e.g. β coefficient), depending on the regression analyses.

Synthesis of results

Contextual factors were divided into personal and environmental factors and the results of the individual studies were classified as significant or non-significant. In accordance with the World Health Organisation's default approach, activities and participation were considered as one domain [13]. Measures of effect were extracted for each personal and environmental factor across different studies. The first (AS) and second author (JV) prospectively determined a classification system to provide a clear overview of the literature. Factors investigated across multiple studies were classified as consistently associated when at least two-thirds of the studies reported an association with outcomes in the activity and participation domain. If less than one-third of the studies reported an association, the factor was classified as not associated. Other factors were classified as 'inconsistent' or 'only investigated in 1 study'.

Results

Article selection

Figure 2 illustrates the study selection process in a PRISMA flow diagram [26]. Two reviewers had a 97% agreement during the screening process, resulting in a Cohen's Kappa score of .84. Reasons for exclusion in each phase of the selection process are described in figure 2. In the final phase, the full texts of 59 articles were screened. Nine were excluded because of the investigated population, because they included individuals with osteonecrosis, septic arthritis, post-traumatic

arthritis or rheumatoid arthritis, or because no separate results were available for total hip arthroplasties. One cross-sectional study and 4 conference abstracts were excluded because of the study design. Eight studies did not perform a regression analysis and were therefore excluded. Seven studies were excluded because the independent variables could not be classified as a personal or environmental factor, and 1 study was excluded because the dependent variable was not a measure of the activity and participation domain. Finally, 29 eligible studies were included in this systematic review.

Article characteristics

This systematic review included 29 articles that reported 26 longitudinal cohort studies. Most studies had a follow-up between 3 and 12 months, however, 2 reported a follow-up of 5 and 12 days [31, 32]. Twenty-two studies had a prospective design [15, 23, 31-53] and 4 had a retrospective design [54-57]. The dependent and independent variables are presented in Table 1. Twenty-four studies used a self-reported outcome measure [15, 23, 31, 33-40, 42-50, 52, 55-57], 3 studies used an outcome measure related to return to work [47, 51, 53, 54], and 2 used performance-based outcome measures [32, 41]. All included studies investigated associations between preoperative contextual factors and postoperative outcome measures. Three studies also included postoperative contextual factors in a longitudinal analysis [40, 43, 53].

Risk of bias

The results of the risk of bias assessment are described in Table 2. Eighteen studies had a high overall risk of bias [15, 23, 32-34, 36, 38, 39, 41-46, 48-50, 55], 3 had a low risk of bias [31, 37, 52] and 8 had a moderate risk of bias [35, 40, 47, 51, 53, 54, 56, 57]. Across the different risk of bias domains, high risk of bias was mainly found for the domains ‘study attrition’ and ‘study confounding’. Study attrition refers to the risk of a different relationship between the prognostic factor and the outcome measure in participants lost to follow-up. Problems within this domain were

low response rate (<80%), no reporting of attempts to collect information for participants lost to follow-up or reasons for loss to follow-up, and no information on potential differences between completing and non-completing participants. In the study confounding domain, confounders were not clearly defined, not measured validly and reliably, or not appropriately accounted for in the statistical analysis.

Synthesis of results

This systematic review aimed to identify contextual factors associated with outcomes in the activity and participation domain after THA for hip OA. Results of the contextual factors investigated in the individual studies and across the different studies are presented in Tables 1 and 3. Seventeen personal and 10 environmental factors were investigated in the included studies. A summary of the associations of investigated personal and environmental factors with the activity and participation domain is presented in Table 4.

Personal factors

Cognitions and emotions

Six studies investigated the association between *anxiety* and an outcome in the activity and participation domain after THA [15, 23, 33, 34, 42, 49]. Anxiety, measured with the Hospital Anxiety and Depression Scale (HADS), the Brief Symptom Inventory (BSI), or the anxiety/depression dimension of the EuroQol 5D (EQ-5D) was negatively associated with the activity and participation domain in 4 out of 5 studies [15, 23, 33, 42, 49]. However, when measured with the State-Trait Anxiety Inventory (STAI-X1), state anxiety was not associated with self-reported outcome in the activity and participation domain [34].

Contradictory results were found for *depression* in 9 studies [15, 23, 32-34, 40, 42, 49, 57]. Three studies found an association between depression, measured with the HADS or the EQ-5D anxiety/depression dimension, and the activity and participation domain [15, 42, 49]. However, 6 studies found no association between depression measured with the Beck Depression Inventory (BDI), the HADS, the BSI, or reported by a physician, and self-reported or performance-based outcomes in the activity and participation domain [23, 32-34, 40]. It should be mentioned that the study with the performance-based outcome measure had a follow-up of only 12 days [32].

One study found no association in the univariate analysis between *kinesiophobia* and short-term postoperative outcomes in the activity and participation domain, measured with the Iowa Level of Assistance (ILOA) scale [31]. However, the follow-up duration was only 5 days.

Sniderman et al. [50] investigated the association between *cognitive processes underlying quality-of-life (QOL) appraisal*, measured with the Brief Appraisal Inventory (BAI), and outcomes in the activity and participation domain after THA. Negative cognitive appraisal processes, such as frequent concerns about accomplishing new goals at work and comparing oneself to others whose health does not limit them, were associated with worse outcomes after THA. However, trying not to complain about one's health, problem solving, thoughts about interpersonal relationships and independence, being focused on family-related goals and being motivated to help others in their community were associated with better outcomes in the activity and participation domain.

Balck et al. [52] investigated the influence of cognitive and emotional illness representations, measured with the Illness Perception Questionnaire-Revised (IPQ-R), on postoperative Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores. Individuals who preoperatively attributed few symptoms to the hip OA, presumed a shorter timeline of the disease, experienced mild consequences, and had high personal and treatment control, had better WOMAC scores 3 months after THA. A higher emotional representation (i.e., more anxiety, depression etc.) was associated with worse WOMAC scores 3 months after THA. Cognitive and

emotional illness representations had no influence on the activity and participation domain 6 months after THA.

Four studies found inconsistent results for the association between *preoperative expectations* and outcome after THA in the activity and participation domain [39, 44, 48, 54]. Better general and specific outcome expectations, and a greater number of expectations were associated with better outcomes in the activity and participation domain [39, 48]. Expectations for return to work and pain relief were not associated with the activity and participation domain [44, 54].

Personality traits

Results were inconsistent for *anxiety as a trait* [32, 34], *sense of coherence* [23, 34] and *the big 5 personality traits* [34, 46], which were investigated in 2 studies. Anxiety as a trait was associated with self-reported [34], but not with performance-based outcome measures [32] in the activity and participation domain. However, the latter study had a follow-up of only 12 days [32]. Sense of coherence was associated with postoperative SF-36 PCS [34], but not with postoperative WOMAC scores [23]. Among the big 5 personality traits, only neuroticism was associated with the activity and participation domain in 1 of 2 studies [34]. Other personality traits were only investigated in 1 study. *Dispositional optimism* [35] and general *self-efficacy* [37] were associated with self-reported outcome measures in the activity and participation domain. *Control beliefs* were not associated with postoperative activity and participation [43].

Social factors

Results from 13 studies were inconsistent for the association between *educational level* and the activity and participation domain [32, 33, 36-38, 40, 44, 45, 47, 50, 54, 56]. Six studies found that educational level was associated with the activity and participation domain [37, 38, 44, 47, 54, 56]. However, 3 of these 6 studies only found an association in a univariate analysis [37, 44, 54].

Moreover, 7 studies found no association between educational level and self-reported or performance-based outcome in the activity and participation domain [32, 33, 36, 40, 45, 48, 50]. However, the study with the performance-based outcome measure had a follow-up of only 12 days [32].

Results were inconsistent for the association between *employment status* and outcome in the activity and participation domain [33, 38, 41, 45, 50, 56]. No association was found in 4 of 6 studies [33, 38, 41, 45]. One study found an increased risk of non-response on the WOMAC in individuals with a disability pension compared to individuals in full time employment [56]. Sniderman et al. [50] retained employment status (currently working) as a predictor in a final machine-learning model. Three studies investigated the association between *job position* and the activity and participation domain [51, 54, 56]. Employees and self-employed individuals had a reduced risk of poor outcome compared to labour workers [56]. In contrast, self-employment was associated with partial or no return to work [54]. Self-employment was not significantly associated with the time to return to work [51].

Other personal factors

No association was found between race and change in Hip Disability and Osteoarthritis Outcome Score for Joint Replacement (HOOS-JR) in a study by Delanois et al. [57]. Furthermore, there was no association between *smoking status* and postoperative activity and participation in 3 studies [36, 50, 55].

Environmental factors

Marital status [33, 44, 45, 50, 56] and *living status* [37, 43, 49, 56] were investigated in 5 and 4 studies, respectively. One of these studies found that being a widow or living alone was associated with an increased risk of non-response on the WOMAC [56]. Another study found that being

married was associated with a better outcome in the activity and participation domain [50]. *Other* factors relating to living environment, such as discharge location and level of poverty in the neighbourhood, were only investigated in one study and were not associated with the activity and participation domain [45, 49]. The number of *positive life events*, but not *negative life events,* after THA was associated in 1 study with a change in frequency of engaging in life activities [40]. Results for the association between *social support* and outcome in activities and participation were inconsistent across 5 studies [23, 37, 42, 44, 53]. Two of 4 studies found an association between reliable alliance and social support, and WOMAC scores after THA [23, 58]. One study found no association between preoperative social support from home, work, or healthcare, on postoperative return to work [53]. However, perceived social support from the supervisor at work 3 months after THA was found to be associated with full return to work 6 months after THA [53]. Finally, one study found a negative association between Hispanic *ethnicity* and outcome in the activity and participation domain [45].

Three studies investigated the association between *occupational factors* and outcome after THA in the activity and participation domain [47, 51, 54]. Preoperative absenteeism from work because of hip pain was associated with partial or no return to work [54]. Preoperative working hours, preoperative work adaptations (e.g., change in tasks, changes in working hours), type of work and preoperative workers' compensation were not associated with return to work [54]. Jobs of low or unclassifiable physical demand and jobs in business, finance, administration, health, science or arts were associated with earlier return to work after THA [47]. However, physical demand and job sector were not associated with workplace activity limitations [47]. Physical tasks and a combination of both physical and mental tasks was associated with a longer time to return to work, whereas higher quality of leadership was associated with a shorter time to return to work [51]. Finally, no associations were found between social determinants of health and HOOS-JR change scores after THA [57].

Discussion

The results of this systematic review suggest that contextual factors may help to explain outcomes after THA. However, because of the heterogeneity and high risk of bias of the included studies, further research is needed to draw stronger conclusions.

Three contextual factors were investigated in more than 1 study and showed consistent results. Smoking status and living status were systematically not associated with the activity and participation domain after THA [36, 37, 43, 49, 50, 56]. Anxiety measured with the HADS, the BSI or the EQ-5D anxiety/depression dimension, was consistently associated with self-reported outcomes in the activity and participation domain [15, 23, 33, 42, 49, 55]. Anxiety is highly prevalent among individuals with hip OA [59] and was already found to be associated with higher levels of pain and disability [60]. This systematic review specifically highlighted the influence of anxiety on outcomes in the activity and participation domain after THA. However, anxiety was only investigated in studies with high risk of bias, and no association was found when the STAI was used to measure state anxiety [34]. This may be explained by the content of the anxiety questionnaires. The state anxiety part of the STAI asks about anxiety symptoms at the time the questionnaire is completed, while the HADS and the BSI ask about anxiety symptoms in the past week(s).

No definitive conclusions could be drawn regarding the prognostic value of depression [15, 23, 32-34, 40, 42, 49, 57], sense of coherence [23, 34], educational level [32, 33, 36-38, 40, 44, 45, 47, 54, 56], expectations [39, 44, 48, 54], job position [54, 56], the big 5 personality traits [34, 46], employment status [33, 38, 41, 45, 56], trait anxiety [32, 34], social support [23, 37, 42, 44, 53], and marital status [33, 44, 45, 56]. Results for these contextual factors were inconsistent across the included studies. This may be explained by the high heterogeneity within the studies. Measurement methods of candidate prognostic factors, outcome measures in the activity and participation domain, and statistical analyses varied widely across the studies. Furthermore, the follow-up across the included studies ranged from 5 days to 2 years after THA. This may be

important because the prognostic value can differ depending on the time period over which the outcome is predicted [14].

Further research is needed to confirm results for contextual factors that were only investigated in 1 study. General self-efficacy and illness perceptions were the only personal factors associated with the activity and participation domain in a study with low risk of bias [37, 52]. This is consistent with the results on the prognostic value of self-efficacy for outcome after TKA [61] and in individuals with chronic musculoskeletal pain [16]. However, kinesiophobia was not found to be associated with the activity and participation domain after THA [31]. This is surprising, as kinesiophobia is identified as an important prognostic factor for outcome after TKA [62]. However, kinesiophobia was only investigated in a study with a short follow-up (5 days), and the outcome measure used assesses the level of assistance needed for only 5 activities [31]. Furthermore, kinesiophobia was measured with the Tampa Scale for Kinesiophobia (TSK), which has been criticized for limited construct validity and missing important components of the fear-avoidance model [63]. Finally, optimism [35] and the number of positive life events during follow-up after THA [40] were positively associated with the activity and participation domain after THA in a study with moderate risk of bias. The other contextual factors were only investigated in 1 study with high risk of bias.

The influence of environmental factors on outcomes in the activity and participation domain after THA was generally understudied. Living status, marital status and social support were the only factors investigated in more than 1 study. Although results were inconsistent, social support was the only environmental factor associated with better outcomes in the activity and participation domain in a study with low risk of bias [37].

Limitations

This systematic review has some limitations regarding bias in the included studies. Most studies (n=18) had a high risk of bias, with problems mainly in the domains of 'study attrition' and 'study confounding.' This might have had an important influence on the associations reported in the included studies. Studies with a high risk of bias in the 'study attrition' domain have a high risk that a different relationship between the prognostic factor and the outcome measure exists in participants lost to follow-up. Associations reported in studies with high risk of bias in the 'study confounding' domain should also be interpreted with caution because the result of a regression analysis is highly dependent on the number and type of independent variables and confounders included in the final model. This has important implications on the results of this systematic review. Although anxiety was consistently reported across multiple studies to have a negative association with the activity and participation domain, it was only investigated in studies with a high risk of bias. Only general self-efficacy, illness perceptions, and social support were associated with activity and participation in a low risk of bias study [37, 52].

Apart from the methodological limitations and heterogeneity of the included studies, there might be a limitation related to the search process of this systematic review. Because the risk for hip OA increases considerably after the age of 40 years, and because this systematic review focused on individuals with hip OA undergoing THA, an average lower age limit of 40 years was used to include studies [64, 65]. The results of this systematic review therefore only apply to individuals who underwent THA for degenerative hip OA and not to those who underwent THA for other conditions, such as avascular necrosis or posttraumatic OA. Furthermore, most articles did not provide information regarding the influence of comorbid conditions, which are common in individuals with hip OA, on participants' activities and participation level. Consequently, the role of these comorbid conditions in the prognosis after THA is unclear. Future studies should provide clear information on these comorbid conditions in individuals with hip OA.

Middle-aged adults and older adults are likely to have different risk factors for THA and prognosis after THA. Another limitation of this systematic review is that it was not possible to stratify by age

because the included studies did not report any information on subgroups by age. However, 24 of 25 studies did include age as a confounder in the statistical analyses, and therefore the reported associations between contextual factors and the activity and participation levels after THA can be considered independent from the age of the participants. Finally, it is remarkable that important constructs such as pain catastrophizing were not investigated. Nevertheless, a study in individuals with hip dysplasia, osteonecrosis, septic arthritis and post-traumatic arthritis found that pain catastrophizing predicted worse self-reported outcomes in the activities and participation domain [66].

Implications for future research and clinical practice

Future research should include anxiety as a confounder, along with other established prognostic factors such as age, sex and BMI. Current problems in the domains of study attrition and study confounding should be considered to improve prognostic research quality. Future studies should also independently replicate findings on contextual factors that were only investigated in 1 study. The prognostic value of these contextual factors should be confirmed over established prognostic factors [14]. Furthermore, the prognostic value of important constructs such as pain catastrophizing should be explored in future research. Finally, future studies should establish the causal relationship between contextual prognostic factors and outcomes in the activity and participation domain in randomized controlled trials.

For clinical practice, this review highlights the impact of anxiety in persons with hip OA on outcomes in activities and participation after THA. Assessment of anxiety is essential in individuals with hip OA waiting for THA. This contextual prognostic factor can enable healthcare providers to identify individuals with hip OA at risk of poor outcome following THA and consequently inform management strategies and address expectations.

Conclusions

Despite the fact that prognosis after THA for hip OA has already been extensively researched in the scientific literature, the methodological quality of available articles appears to be very low. Eighteen studies had a high risk of bias, which might have had an important influence on the associations reported in the included articles. Most contextual factors included in this systematic review were only investigated in 1 study or showed inconsistent results across multiple studies. Anxiety was the only factor consistently associated with worse outcomes in the activity and participation domain 3 to 12 months after THA. Smoking and living status showed no association with activities and participation 3 to 12 months after THA. Further research is needed to confirm results on personality traits (e.g., optimism, control beliefs and general self-efficacy), cognitive appraisal processes, illness perceptions, kinesiophobia, race, ethnicity, discharge location, level of poverty in the neighbourhood, positive/negative life events, occupational factors, and social determinants of health.

Other information

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Competing interest statement

Conflicts of interest: none.

Figures

Figure 1. International Classification of Functioning, Disability and Health (ICF) [13]

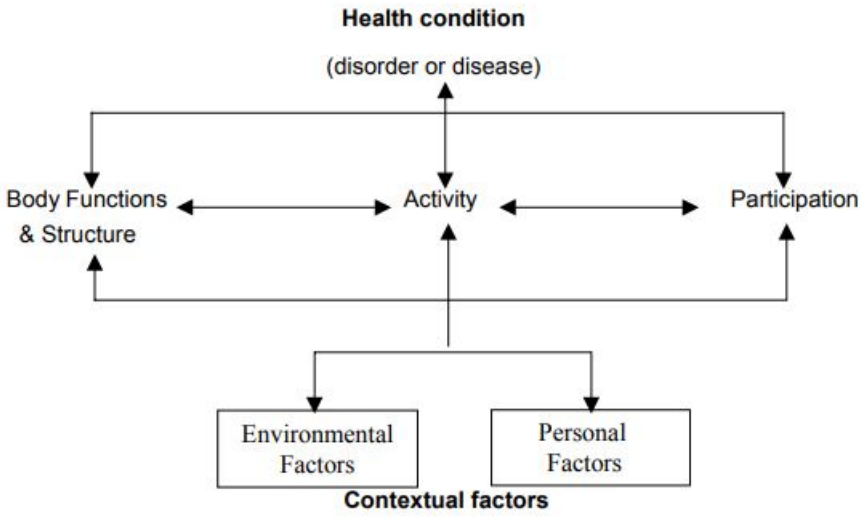

Figure 2. PRISMA 2009 Flow Diagram [26]

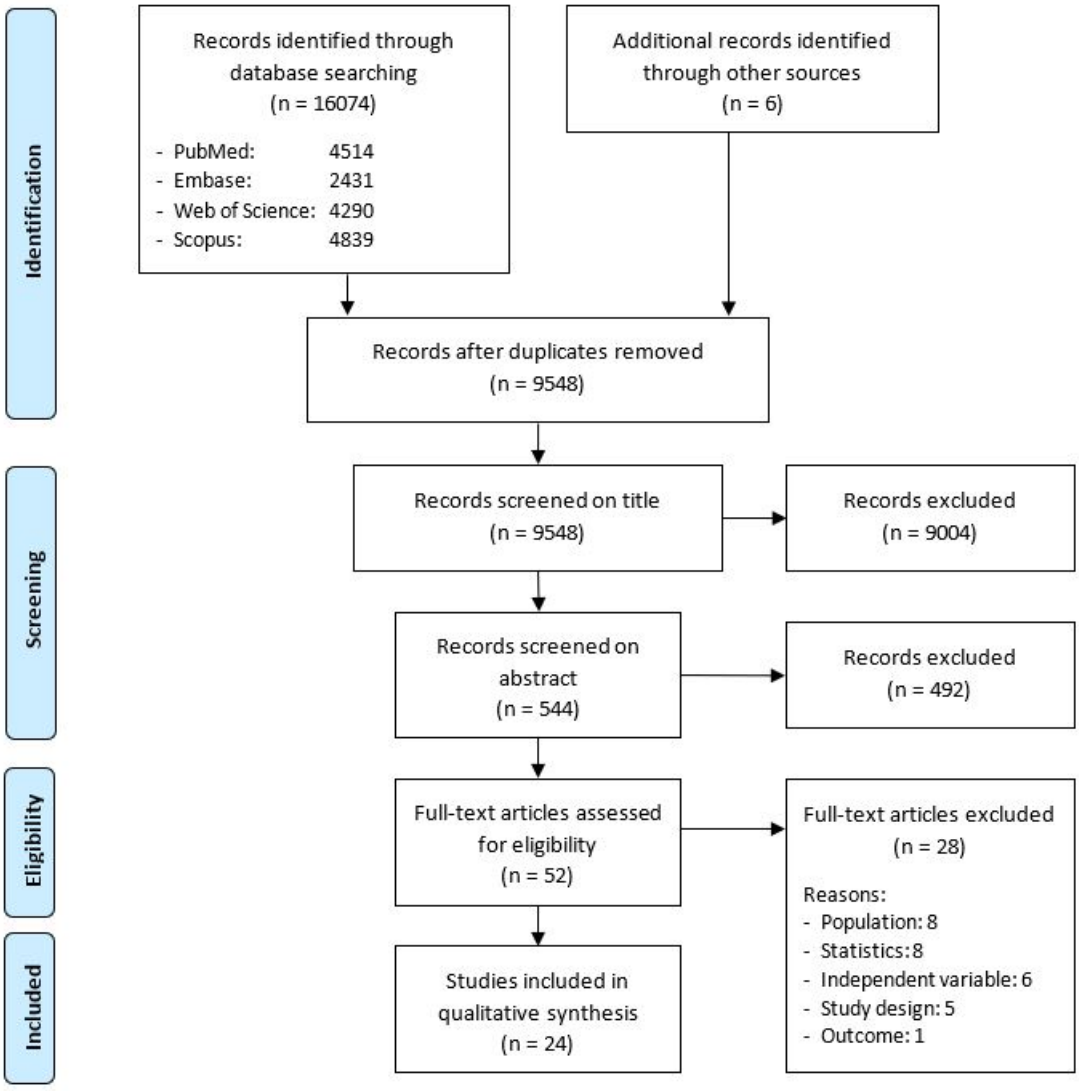

Table 1. Results of individual studies.

Author	Follow-up	n	Age*	Independent variables		Dependent variables	Results
				Personal factors	Environmental factors		
Badura-Brzoza et al. [34]	6m	102	Median: 61	Anxiety (STAI), depression (BDI), sense of coherence (SOC-29), neuroticism and extroversion (EPI)	/	SF-36 PCS	S: trait anxiety, neuroticism, sense of coherence NS: extroversion, depression and state anxiety
Badura-Brzoza et al. [33]	6m	184	59 (SD not reported)	Anxiety (HADS), depression (HADS), educational level	Marital status, employment status	SF-36 PCS	NS: anxiety, depression, educational level, marital and employment status
Balck et al. [35]	6m	317	58.7 (12.5)	Optimism (LOT-R), interaction age and optimism	/	WOMAC total and function	S: optimism, interaction age and optimism
Balck et al. [52]	6m	317	58.7 (12.5)	Cognitive and emotional illness representations (IPQ-R)	/	WOMAC total and subscales	S: cognitive and emotional illness representations (3m)
Braaksma et al. [36]	>3m	79	70 (9.5)	Educational level, smoking status	/	HOOS-PS (Δ)	NS: educational level, smoking status
Brembo et al. [37]	3m	223	69.3 (9.8)	Educational level, self-efficacy (GSES)	Living status, social support (SPS)	WOMAC total score	**Univariable** S: educational level, self-efficacy, SPS total, reliable alliance, social integration, reassurance of worth NS: living alone **Multivariable** S: self-efficacy, reliable alliance
Delanois et al. [57]	12m	136	72.8 (7.9)	Race, depression	Social Determinants of Health (SDOH)	HOOS-JR (Δ)	NS: Race, depression, SDOH
Duivenvoorden et al. [15]	12m	268	67.9 (9.6)	Anxiety and depression (HADS)	/	HOOS	S: anxiety and depression
Judge et al. [38]	12m	908	65.7 (10.9)	Employment status, educational level	/	WOMAC total score	S: educational level NS: employment status
Judge et al. [39]	12m	908	65.7 (10.9)	Pre-operative expectations (number)	/	WOMAC total score	S: Number of expectations
Kamp et al. [51]	12m	100	Median: 56	Self-employment	Company size, working hours, contractual hours, type of job and tasks, physical and psychosocial (COPSOQ-II) working conditions, work adjustments, living status	Time to RTW	**Univariable:** S: company size, type of task, physical and psychosocial working conditions **Multivariable:** S: type of task, psychosocial working conditions
Kamp et al. [53]	6m	77	Median: 56 IQR: 52-60	/	Social support from home (GO-SSS), work and occupational healthcare	RTW	**Univariable:** S: support from OP (preoperative), support from supervisor and GP (3m) **Multivariable:** S: Support from supervisor (3m)
Leichtenberg et al. [54]	12m	67	56 (6.6)	Educational level, preoperative expectations over return to work, self-employed or salaried	Preoperative working hours, absenteeism from work, work adaptations, type of work, and workers' compensation	RTW (complete, partial or no RTW)	S: Educational level, self-employment, preoperative absenteeism from work NS: expectations over RTW, working hours, work adaptations, type of work, workers' compensation
Lindner et al. [23]	3m	44	67.4 (10.3)	Anxiety (BSI), depression (BSI), sense of coherence (SOC-13)	Social support (Perceived Social Support Questionnaire)	WOMAC total and subscales	S: anxiety and social support NS: depression, sense of coherence
MacKay et al. [40]	12m	376	64.0 (12.08)	Depression (HADS), educational level	Positive/negative life events (Life Experiences Survey)	LLDI-frequency subscale	S: number of positive life events NS: educational level, depression, number of negative life events
Matsunaga-Myoji et al. [41]	12m	153	61.4 (8.1)	Employment status	/	MVPA/week, number of steps/day	NS: Employment status
McHugh et al. [42]	12m	206	66.3 (10.4)	Anxiety and depression (HADS)	Involvement in decision for THA, Social support (ESSI)	SF-36 total physical function	S: Anxiety and depression NS: Social support and involvement in decision for THA
Morri et al. [31]	5 days	284	59.9 (10.5)	Kinesiophobia (TSK)	/	ILOA scale	**Univariable:** NS: Kinesiophobia
Negrini et al. [32]	12 days	40	63.3 (7.5)	Educational level, trait anxiety (STAI-X), mood (BDI)	/	10MWT and TUG	NS: Educational level, trait anxiety and mood

Okoro et al. [43]	12m	35	65.80 (9.51)	Control beliefs (RLOC and PEBC)	Living status	OHS and WOMAC-PF	NS: living status, control beliefs
Peters et al. [55]	12m	22.357	Not reported	Smoking status	/	HOOS-PS and OHS	NS: smoking status
Quintana et al. [44]	6m, 24m	788	69.34 (8.54)	Educational level, expectations on pain relief	Marital status, social support (questionnaire not defined)	WOMAC and SF-36 domains	NS: educational level, marital status, social support, expectations on pain relief
Ramaesh et al. [46]	12m	184	67.1	Personality (extroversion – neuroticism) (EPQ)	/	OHS	NS: Personality (extroversion – neuroticism)
Rubenstein et al. [45]	12m	271	65.6 (8.3)	Educational level, employment status	Marital status, level of poverty in neighbourhood, ethnicity	HOOS(-JR)	**Univariable:** S: employment status (HOOS-JR) NS: ethnicity, educational level, marital status, level of poverty **Multivariable:** S: Ethnicity (HOOS) NS: educational level, employment status, marital status, level of poverty
Sankar et al. [47]	12m	190	56.1 (9.9)	Educational level	Job sector, physical demands at work	RTW	S: Educational level, job sector, physical demands (earlier RTW)
Schäfer et al. [56]	6m	1007	60.9 (12.7)	Educational level, employment status, professional education	Job position, marital status, living status	WOMAC (<20 change score)	S: marital status, living status, employment status, educational level, job position NS: professional education
Sniderman et al. [50]	3m	160	66.7 (9.7)	Educational level, employment status, smoking status, cognitive appraisal processes (BAI)	Marital status	HOOS (19 items)	Not effective: smoking status, educational level Retained predictors: marital status, employment status, cognitive appraisal processes (BAI)
Tilbury et al. [48]	12m	148	67.2 (9.5)	General and specific outcome expectations (CEQ and HSS expectation surveys), educational level, treatment credibility (CEQ)	/	HOOS ADL subscale	S: patients' general and specific outcome expectations NS: educational level, treatment credibility
Vogl et al. [49]	6m	321	67.7 (10.1)	Anxiety/depression (EQ-5D question)	Living status, discharge location (home/inpatient)	WOMAC	S: EQ-5D anxiety/depression NS: living status, discharge location

*reported as mean (SD) unless otherwise stated; ADL=activities of daily living; BAI=Brief Appraisal Inventory; BDI=Beck Depression Inventory; BSI=Brief Symptom Inventory; CEQ=Credibility Expectancy Questionnaire; COPSOC-II=Copenhagen Psychosocial Questionnaire II; EPI=Eysenck Personality Inventory; EPQ=Eysenck Personality Questionnaire; ESSI=ENRICHD Social Support Instrument score; EQ-5D=EuroQol 5D; GO-SSS=Groningen Orthopaedic Social Support Scale (GO-SSS); GP=general practitioner; GSES=General Self-Efficacy Scale; HADS=Hospital Anxiety and Depression Scale; HOOS=Hip Disability and Osteoarthritis Outcome Score; HSS=Hospital for Special Surgery; ILOA=Iowa Level of Assistance Scale; IPQ-R=Illness Perception Questionnaire-Revised; IQR=inter quartile range; LLDI=Late Life Disability Index; LOT-R=Life Orientation Test – Revised; MVPA=Moderate-to-Vigorous Physical Activity; OHS=Oxford Hip Score; OP=occupational physician; n=sample size; NS=not significant; PCS=Physical Component Score; PEBC=Perceived External Behavioural Control; RLOC=Recovery Locus Of Control; RTW=Return To Work; S=significant; SF-36=Short Form 36-item Health Survey; SOC=Sense of Coherence scale; SPS=Social Provisions Scale; STAI=State-Trait Anxiety Inventory; TSK=Tampa Scale for Kinesiophobia; TUG=Timed Up and Go; WOMAC=Western Ontario and McMaster Universities Osteoarthritis Index; 10MWT=10 Meter Walk Test)

Table 2. Risk of bias in studies (QUIPS tool).

Author	Study participation	Study attrition	Prognostic factor measurement	Outcome measurement	Study confounding	Statistical analysis and reporting	Total
Badura-Brzoza et al. [34]	*Moderate*	*High*	*Moderate*	*Low*	*High*	*Moderate*	***High***
Badura-Brzoza et al. [33]	*Low*	*High*	*Low*	*Low*	*High*	*High*	***High***
Balck et al. [35]	*Low*	*High*	*Low*	*Low*	*Moderate*	*Moderate*	***Moderate***
Balck et al. [52]	*Low*	*High*	*Low*	*Low*	*Moderate*	*Low*	***Low***
Braaksma et al. [36]	*Moderate*	*High*	*Low*	*Low*	*High*	*Low*	***High***
Brembo et al. [37]	*Moderate*	*Low*	*Low*	*Low*	*High*	*Low*	***Low***
Delanois et al. [57]	*Low*	*High*	*Moderate*	*Low*	*Moderate*	*Moderate*	***Moderate***

Duivenvoorden et al. [15]	*Low*	*High*	*Moderate*	*Low*	*High*	*Moderate*	***High***
Judge et al. [38]	*Low*	*High*	*Moderate*	*Low*	*High*	*Low*	***High***
Judge et al. [39]	*Low*	*High*	*Moderate*	*Low*	*High*	*Low*	***High***
Kamp et al. [51]	*Low*	*High*	*Moderate*	*Moderate*	*Moderate*	*Low*	***Moderate***
Kamp et al. [53]	*Low*	*High*	*Moderate*	*Moderate*	*Low*	*Moderate*	***Moderate***
Leichtenberg et al. [54]	*Low*	*NA*	*NA*	*Low*	*High*	*Low*	***Moderate***
Lindner et al. [23]	*Moderate*	*High*	*Low*	*Low*	*High*	*Moderate*	***High***
MacKay et al. [40]	*Moderate*	*High*	*Low*	*Low*	*Moderate*	*Moderate*	***Moderate***
Matsunaga-Myoji et al. [41]	*Low*	*High*	*Moderate*	*Low*	*High*	*Moderate*	***High***
McHugh et al. [42]	*Moderate*	*High*	*Low*	*Moderate*	*High*	*Moderate*	***High***
Morri et al. [31]	*Low*	*High*	*Low*	*Low*	*Moderate*	*Low*	***Low***
Negrini et al. [32]	*High*	*High*	*High*	*Low*	*High*	*Low*	***High***
Okoro et al. [43]	*Moderate*	*High*	*Low*	*Low*	*High*	*Moderate*	***High***
Peters et al. [55]	*Moderate*	*NA*	*NA*	*Low*	*High*	*Moderate*	***High***
Quintana et al. [44]	*Moderate*	*Moderate*	*High*	*Low*	*High*	*Low*	***High***
Ramaesh et al. [46]	*Low*	*High*	*High*	*Moderate*	*Moderate*	*Moderate*	***High***
Rubenstein et al. [45]	*Low*	*High*	*Low*	*Low*	*High*	*Low*	***High***
Sankar et al. [47]	*Low*	*High*	*Moderate*	*Low*	*Moderate*	*Low*	***Moderate***
Schäfer et al. [56]	*Moderate*	*NA*	*NA*	*Low*	*Moderate*	*Low*	***Moderate***
Sniderman et al. [50]	*Moderate*	*High*	*Low*	*Low*	*High*	*Low*	***High***
Tilbury et al. [48]	*Moderate*	*High*	*Moderate*	*Low*	*High*	*Low*	***High***
Vogl et al. [49]	*Low*	*High*	*Low*	*Low*	*High*	*Low*	***High***

NA=not applicable

Table 3. Synthesis of results.

Personal factors	Outcome variable	Analysis	Results
COGNITIONS AND EMOTIONS			
Anxiety [15, 23, 32, 33, 42, 49]			
HADS - Anxiety [15, 33, 42]	HOOS-ADL [15]	MLRA	β=-9.5 (-15.1; -4.0)
	HOOS-sport [15]	MLRA	β=-9.1 (-17.7; -0.4)
	SF-36 PCS [42]	LMM	β=0.28 (0.02; 0.54), p=0.034 (6m) β=0.38 (0.12; 0.64), p=0.004 (12m)
	SF-36 PCS [33]	SMLOGRA	NS
BSI - Anxiety [23]	WOMAC function	MLRA	β =1.89; SE=0.51; β=0.48; t=3.69; p=0.001
	WOMAC total	MLRA	β =14.06; SE=3.91; β=0.47; t=3.60; p=0.001
STAI-X1 - anxiety as a state [34]	SF-36 PCS	SMLR	NS
EQ-5D anxiety/depression [49]	WOMAC	MLRA	β= -4.454, SE = 1.598, p<0.01
Depression [15, 23, 32-34, 40, 42, 57]			
HADS - Depression [15, 33, 40, 42]	HOOS-ADL [15]	MLRA	β=-10.2 (-15.3; -5.1)
	HOOS-sport [15]	MLRA	NS, β=-4.7 (-12.5; 3.2)
	SF-36 PCS [42]	LMM	β=-0.56 (-0.56; -0.16), p=0.001 (6m) β=-0.65 (-0.98; -0.31), p<0.001 (12m)
	SF-36 PCS [33]	SMLOGRA	NS
	LLDI (frequency) [40]	MLRA	NS (p=0.06)
BSI - Depression [23]	WOMAC	MLRA	NS
BDI [32, 34]	10MWT and TUG [32]	MLRA	NS
	SF-36 PCS [34]	SMLR	NS (β=0.061)
EQ-5D anxiety/depression [49]	WOMAC	MLRA	β= -4.454, SE = 1.598, p<0.01
Depression [57]	HOOS-JR (change score)	MLRA	NS (Estimate=2.57 (-1.12; 6.27), SE=1.89, p=0.17)
Kinesiophobia [31]			
TSK	ILOA	GLM	Univariate analysis: NS (p=0.556), not included in multivariate analysis
Cognitive Appraisal [50]			

Frequent thoughts about…			
- Achieving a calmer, more peaceful or healthier lifestyle	HOOS (19 items)	Machine learning (LASSO)	β=0.00
- Impressions and assumptions others have because of your health			β=0.16
- How you compare to others whose health does not limit them			β=-0.26
- Increasing your volunteer work			β=0.22
- Growing spiritually			β=0.00
- Resolving problems in living situation			β=0.12
- Spending more time with family			β=0.12
- Trying not to complain to others			β=0.13
- Increasing your travel for leisure/visiting			β=0.02
- Accomplishing new goals at work			β=-0.34
Cognitive and emotional illness representations [52]			
Cognitive illness representation schemas	WOMAC total	SMLR	β=5.128 (p=0.01), Eta^2=0.04 (3m) β=2.468 (p=0.18), Eta^2=0.01 (6m)
	WOMAC ADL	SMLR	β=5.701 (p=0.01), Eta^2=0.04 (3m) β=2.344 (p=0.23), Eta^2=0.01 (6m)
Emotional representation	WOMAC total	SMLR	β=-0.45 (p=0.046), Eta^2=0.02 (3m) β=-0.385 (p=0.08), Eta^2=0.01 (6m)
	WOMAC ADL	SMLR	β=-0.425 (p=0.07), Eta^2=0.01 (3m) β=-0.312 (p=0.17), Eta^2=0.01 (6m)
Expectations [39, 44, 48, 54]			
Number of preoperative expectations [39]	WOMAC (OMERACT/OARSI criteria)	ULOGRA	OR=1.36 (1.07; 1.73), p=0.013
		MLOGRA	adj. OR=1.34 (1.01; 1.78), p=0.04
	WOMAC total (MID)	ULOGRA	OR=1.27 (1.10; 1.47), p=0.001
		MLOGRA	NS (p=0.086)
	WOMAC function (MID)	ULOGRA	OR=1.25 (1.16; 1.35), p<0.001
		MLOGRA	adj. OR=1.20 (1.09; 1.32), p<0.001
Expectations over RTW [54]	RTW	ULOGRA	NS (p=1.000)
Expectation on pain relief [44]	WOMAC function	UGLM	NS (p=0.90)
	SF-36 Physical Function	UGLM	NS (p=0.44)
	SF-36 Role Physical	UGLM	NS (p=0.89)
CEQ expectancy [48]	HOOS ADL	MLRA	β=1.23 (0.17; 2.29), p=0.023
CEQ credibility [48]	HOOS ADL	MLRA	Not included in final model
HSS expectations survey (function) [48]	HOOS ADL	MLRA	β=0.732 (0.014; 1.449), p=0.014
PERSONALITY TRAITS			
Optimism [35]			
LOT-R [35]	WOMAC total	GLMR	Optimism: β= 4.58 (p<0.01), partial Eta^2=0.39 (3m) β= 2.10 (p<0.01), partial Eta^2=0.14 (6m) Age x optimism: β=-0.06 (p<0.01), partial Eta^2=0.22 (3m) β=-0.03 (p<0.01), partial Eta^2=0.11 (6m)
	WOMAC ADL	GLMR	Optimism: β= 4.64 (p<0.01), partial Eta^2=0.39 (3m) β= 2.04 (p<0.01), partial Eta^2=0.13 (6m) Age x optimism: β=-0.06 (p<0.01), partial Eta^2=0.22 (3m) β=-0.03 (p<0.01), partial Eta^2=0.10 (6m)
Trait anxiety [34]			
STAI-X2 [34]	SF-36 PCS	SMLR	β=0.345, p=0.04
STAI-X [32]	10MWT and TUG	MLRA	NS
Self-efficacy [37]			
GSES [37]	WOMAC total	ULRA	β=-0.52 (-0.93; -0.11), SE=0.21, p=0.01, R^2=0.03
		MLRA	β=-0.44 (-0.87; -0.02), SE=0.22, p=0.04
Sense of coherence [23, 34]			
SOC-13 [23]	WOMAC	MLRA	NS
SOC-29 [34]	SF-36 PCS	SMLR	β=-0.06, p=0.04
Control beliefs [43]			
RLOC [43]	Reduced WOMAC PF	MLRA	NS
	OHS	MLRA	NS (p=0.754)
PEBC [43]	Reduced WOMAC PF	MLRA	NS
	OHS	MLRA	NS
Big five personality traits [34, 46]			
Neuroticism-extroversion (EPQ) [46]	OHS	MLRA	NS
Extroversion (EPI) [34]	SF-36 PCS	SMLR	NS (β=-0.413)
Neuroticism (EPI) [34]	SF-36 PCS	SMLR	β=-0.731, p=0.005
SOCIAL FACTORS			
Educational level [32, 33, 36-38, 40, 44, 45, 47, 54, 56]			
Levels not specified [33]	SF-36 PCS	SMLOGRA	NS
Elementary, high school, college [36]	HOOS-PS (change score)	MLRA	NS (p=0.380)
Primary, secondary, university (<4y), university (≥4y) [37]	WOMAC total	ULRA	β=-5.30 (-9.85; -0.74), SE=2.31, p=0.02, R^2=0.02
		MLRA	NS
Postgraduate, university, college or equivalent, none (reference) [38]	WOMAC (return to normal)	ULOGRA	Postgraduate OR=4.0 (1.3;12.0), university OR=2.7 (1.5; 4.9), college OR=2.0 (1.4; 2.8) (p<0.001)

		MLOGRA	Postgraduate OR=2.6 (0.8; 8.7), university OR=2.9 (1.4; 5.9), college OR=2.1 (1.3; 3.4) (p<0.001)
	WOMAC (OMERACT/OARSI criteria)	ULOGRA	Postgraduate OR=2.7 (0.6; 12.1), university OR=8.4 (2.0; 35.3), college OR=1.6 (1.0; 2.6) (p=0.001)
		MLOGRA	Postgraduate OR=3.7 (0.5; 29.8), university OR=14.4 (1.8; 117.8), college OR=1.7 (0.9; 3.3) (p=0.002)
	WOMAC (MID)	ULOGRA	Postgraduate OR=1.6 (0.6; 4.0), university OR=1.8 (1.0; 3.2), college OR=1.2 (0.8; 1.7) (p=0.039)
		MLOGRA	NS (p=0.08)
Low, medium, high [54]	RTW	ULOGRA	p=0.006
		MLOGRA	NS
Years of education [32]	10MWT and TUG	MLRA	NS
Primary, secondary, graduate [44]	WOMAC function	UGLM	p<0.001
	SF-36 Physical Function	UGLM	NS (p =0.26)
	SF-36 Role Physical	UGLM	NS (p =0.75)
High school or less, some college, college graduate [45]	HOOS	ULRA	NS (p=0.61)
		MLRA	College graduate (reference), high school or less NS (p=0.86), some college NS (p=0.81)
	HOOS (MID)	MLOGRA	College graduate (reference), high school or less NS (p=0.06); some college NS (p=0.51)
	HOOS-JR	ULRA	NS (p=0.61)
		MLRA	College graduate (reference), high school or less NS (p=0.36); some college NS (p=0.29)
	HOOS-JR (MID)	MLOGRA	College graduate (reference), high school or less NS (p=0.47); some college NS (p=0.44)
More than high school [40, 47]	Time of RTW [47]	OLR	OR=2.0 (1.3; 3.2)
	LLDI (frequency) [40]	MLRA	NS (p=0.93, β=0.09 (-1.96, 2.13))
8, 9 or 12 years of school [56]	WOMAC (<20 change score)	LOGRA	8 years (reference); 9 years: NS; 12 years: adj. OR=0.49 (0.27; 0.89)
Professional education [56]	WOMAC (<20 change score)	LOGRA	NS
High or low [48]	HOOS ADL	MLRA	Not included in final model
Less than college degree, college degree, advanced degree [50]	HOOS (19 items)	Machine learning (LASSO)	Not an effective predictor in model
Employment status [33, 38, 41, 45, 56]			
Working [33]	SF-36 PCS	SMLOGRA	NS
Employed, retired, retired early, other [38]	WOMAC (return to normal)	ULOGRA	NS
		MLOGRA	NS
	WOMAC (OMERACT/OARSI criteria)	ULOGRA	NS
		MLOGRA	NS
	WOMAC (MID)	ULOGRA	NS
		MLOGRA	NS
Employed [41]	MVPA (minutes per week)	MLM	NS (p=0.878)
	Number of steps per day	MLM	NS (p=0.380)
Working, not working, retired [45]	HOOS	ULRA	NS (p=0.34)
		MLRA	not working NS (p=0.11); retired NS (p=0.34)
	HOOS (MID)	MLOGRA	not working NS (p=0.23); retired NS (p=0.30)
	HOOS-JR	ULRA	p=0.003
		MLRA	not working NS (p=0.37); retired NS (p=0.18)
	HOOS-JR (MID)	MLOGRA	not working NS (p=0.63); retired NS (p=0.70)
Fulltime, part time, unemployed, retired, disability pension [56]	WOMAC (<20 change score)	MLRA	Full time (reference); part time NS; Unemployed NS; Retired NS; Disability pension adj. OR=5.81 (2.33; 14.46), crude OR=2.56 (1.17; 5.57)
Currently working [50]	HOOS (19 items)	Machine-learning (LASSO)	β=0.17
Job position [54, 56]			
Self-employment [54]	RTW	ULOGRA	p=0.009
		MLOGRA	OR = 7.63 (1.5; 39.8)
Salaried (reference self-employed) [51]	Time to RTW	ULRA	NS
Worker, employee, civil servant, self-employed, other [56]	WOMAC (<20 change score)	MLRA	Worker (reference); civil servant, others NS; employee: adj. OR=0.55 (0.33;0.90); crude OR=0.62 (0.40; 0.95); self-employed: adj. OR=0.41 (0.18;0.94)
OTHER PERSONAL FACTORS			
Race [57]			
Non-white	HOOS-JR (change score)	MLRA	NS (Estimate=1.39 (-3.17; 5.94), SE=2.32, p=0.55)
Smoking status [36, 50, 55]			
Smoking/not smoking [36, 50, 55]	HOOS-PS (change score) [36]	MLRA	NS (p=0.330)
	HOOS-PS (change score) [55]	MLRA	NS (p=0.74 (3m), p=0.56 (12m))
	OHS (change score) [55]	MLRA	NS (p=1.00 (3m), p=0.41 (12m))
	HOOS (19 items) [50]	Machine-learning (LASSO)	Not an effective predictor in model

Environmental factors	Outcome variable	Analysis	Results
Marital status [33, 44, 45, 56]			
Levels not specified [33]	SF-36 PCS	MLOGRA	NS
Married, divorced, widow, single [44]	WOMAC function	UGLM	NS (p=0.24)
	SF-36 Physical Function	UGLM	NS (p=0.18)
	SF-36 Role Physical	UGLM	NS (p=0.22)
Married, previously married, single [45]	HOOS	ULRA	NS (p=0.12)
		MLRA	NS (p=0.81)
	HOOS (MID)	MLOGRA	NS (p=0.23)
	HOOS-JR	ULRA	NS (p=0.49)
		MLRA	NS (p=0.14)
	HOOS-JR (MID)	MLOGRA	NS (p=0.41)
Single, married, divorced, widow [56]	WOMAC (<20 change score)	MLRA	Widowed: adj. OR = 4.30 (1.45; 12.71); Single, married and divorced NS
Married (or living with a partner) [50]	HOOS (19 items)	Machine-learning (LASSO)	β=0.14
Level of poverty in neighbourhood [45]			
Family poverty in ZIP	HOOS	ULRA	NS (p=0.51)
		MLRA	NS (p=0.74)
	HOOS (MID)	MLOGRA	NS (p=0.99)
	HOOS-JR	ULRA	NS (p=0.32)
		MLRA	NS (p=0.97)
	HOOS-JR (MID)	MLOGRA	NS (p=0.27)
Living status [37, 43, 49, 56]			
Living alone [37, 56]	WOMAC total	ULRA	NS (p=0.11) [37]
	WOMAC (<20 change score)	MLOGRA	Adj. OR = 1.70 (1.02; 2.85) [56]
Alone or with partner [43]	Reduced WOMAC PF	MLRA	NS
	OHS	MLRA	NS
Family compared to alone[49]	WOMAC (change score)	MLRA	NS
Discharge location [49]			
Home or inpatient rehabilitation [49]	WOMAC (change score)	MLRA	NS
Social support [23, 37, 42, 44, 53]			
SPS – total [37]	WOMAC total	ULRA	β=-0.26 (-0.52; -0.003), SE=0.13, p=0.05, R^2=0.02
SPS – reliable alliance [37]	WOMAC total	ULRA	β=-2.13 (-3.48; -0.78), SE=0.69, p=0.002, R^2=0.04
		MLRA	β=-1.40 (-2.81; 0.01), SE=0.71, p=0.05
SPS – social integration [37]	WOMAC total	ULRA	β=-1.26 (-2.54; 0.02), SE=0.65, p=0.05, R^2=0.02
SPS - reassurance of worth [37]	WOMAC total	ULRA	β=-1.41 (-2.63; -0.19), SE=0.62, p=0.02, R^2=0.02
Perceived Social Support Questionnaire [23]	WOMAC function	MLRA	β=-0.72; SE=0.35; β=-0.27; t=-2.08; p=0.044
	WOMAC total	MLRA	β=-5.38; SE=2.64; β=-0.27; t=-2.04; p=0.048
ESSI [42]	SF-36 PCS	LMM	NS (p=0.360 (6m), p=0.335(12m))
Questionnaire not specified [44]	WOMAC function	UGLM	NS (p=0.41)
	SF-36 Physical Function	UGLM	NS (p=0.13)
	SF-36 Role Physical	UGLM	p=0.008
GO-SSS [53]	RTW	ULOGRA	Preoperative: NS (OR=1.03 (0.88; 1.20), p=0.76) 3m postoperative: NS (OR=1.09 (0.93; 1.27), p=0.29)
Support from co-workers [53]	RTW	ULOGRA	Preoperative: NS (OR=2.04 (0.35; 11.90), p=0.43) 3m postoperative: NS (OR=3.13 (0.55; 17.80), p=0.20)
Support from supervisor [53]	RTW	ULOGRA	Preoperative: NS (OR=2.79 (0.55; 14.07), p=0.21) 3m postoperative: OR=1.90 (1.12; 21.53), p=0.04
		MLOGRA	3m postoperative: OR=1.90 (1.12; 21.53), p=0.04
Support from occupational physician [53]	RTW	ULOGRA	Preoperative: OR=3.33 (0.81; 13.69), p=0.10 3m postoperative: NS (OR=1.85 (0.51; 6.81), p=0.35)
Support from general practitioner [53]	RTW	ULOGRA	Preoperative: NS (OR=1.15 (0.34; 3.90), p=0.83) 3m postoperative: OR=3.24 (0.77; 13.61), p=0.11
Support from other caregivers [53]	RTW	ULOGRA	Preoperative: NS (OR=0.67 (0.19; 2.33), p=0.53) 3m postoperative: NS (OR=0.65 (0.18; 2.39), p=0.52)
Number of positive and negative life events [40]			
Life Experiences survey (LES) - positive life events	LLDI (frequency subscale)	MLRA	β= 1.27 (0.53; 2.00), p=0.00 (unadjusted) β= 1.24 (0.49; 1.99), p=0.00 (adjusted)
LES – negative life events	LLDI (frequency subscale)	MLRA	NS (unadjusted: p=0.47, adjusted: p=0.33)
Occupational factors [47, 54]			
Preoperative working hours [54]	RTW	ULOGRA	NS (p=0.230)
Company size [51]	Time to RTW	ULRA	0-9 employees: β=-35.0 (p=0.081) 10-99 employees: NS (p=0.95)
Contractual hours [51]	Time to RTW	ULRA	NS (p=0.27)
Working hours [51]	Time to RTW	ULRA	NS (p=0.55)
Job type [51]	Time to RTW	ULRA	NS: executive (p=0.54), administrative (p=0.59), advisory (p=0.65), management (p=0.58)
		MLRA	NS
Tasks (reference: mental) [51]	Time to RTW	ULRA	Physical: β=57.5 (p=0.008) Both: β=54.0 (p=0.003)
		MLRA	Physical: β=52.1 (p=0.01) Both: β=54.0 (p=0.00)

Physical working conditions [51]	Time to RTW	ULRA	**Work demands:** standing NS (p=0.36), sitting β=-23.7 (p=0.10), walking NS (p=0.39), kneeling/squatting β=67.9 (p=0.00) **Difficulties**: standing NS (p=0.57), sitting NS (p=0.24), moving > 5kg NS (p=0.45), moving >20kg NS (p=0.77), using power with arm/hand NS (p=0.77), using vibrating/tamping work tools NS (p=0.71), driving NS (p=0.65), working in uncomfortable position β=-37.4 (p=0.05), lengthy work in same position β=0.35 (p=0.02)
		MLRA	Work demands walking NS, work demands kneeling/squatting NS, difficulty sitting NS, difficulty working in uncomfortable position NS
Psychosocial work conditions (COPSOC-II) [51]	Time to RTW	ULRA	Quantitative demands β=6.7 (p=0.11), tempo work pace β=6.2 (p=0.18), emotional demands NS (p=0.50), influence at work NS (p=0.48), possibilities for development β=-10.0 (p=0.05), meaning of work NS (p=0.49), commitment to workplace NS (p=0.61), predictability NS (p=0.21), recognition NS (p=0.85), role clarity NS (p=0.90), quality of leadership β=-8.5 (p=0.08), social support of supervisor NS (p=0.31), social support of colleagues NS (p=0.63)
		MLRA	Influence at work NS, possibilities for development NS, recognition NS, tempo work pace NS, quality leadership β=-14.1 (p=0.00)
Work adjustments [51]	Time to RTW	ULRA	NS
Preoperative absenteeism from work [54]	RTW	ULOGRA	p=0.002
		MLOGRA	OR=8.62 (1.9; 39.0)
Preoperative work adaptations [54]	RTW	ULOGRA	NS (p=0.100)
Type of work [54]	RTW	ULOGRA	NS (p=0.672)
Preoperative compensation [54]	RTW	ULOGRA	NS (p=0.302)
Job sector [47]	RTW	OLR	Business, finance, administration: OR=2.0 (0.4; 9.3); Health, science, arts: OR = 1.6 (0.4; 6.5); Sales and service: OR = 1.4 (0.3; 6.4)
	WALS	MLRA	Factor included as confounder
Physical demand [47]	RTW	OLR	High (reference); Low: OR = 2.9 (1.1; 7.6); Unclassified: OR = 4.3 (1.3; 14.1)
	WALS	MLRA	Factor included as confounder
Ethnicity [45]			
White, Black, Hispanic, Asian, Native American, Other [45]	HOOS	ULRA	NS (p=0.82)
		MLRA	Hispanic β=-61.97 (p=0.01); NS: Black (p=0.45); Other (p=0.38)
	HOOS (MID)	MLOGRA	NS (Black: p=0.81; Hispanic: p=0.70; Other: p=0.74)
	HOOS-JR	ULRA	Not calculable
		MLRA	NS (Black: p=0.83; Hispanic: p=0.17; Other; p=0.10)
	HOOS-JR (MID)	MLOGRA	NS (Black: p=0.28; Hispanic: p=0.70; Other: p=0.77)
Social Determinants of Health (SDOH) [57]			
Socioeconomic status	HOOS-JR (change score)	MLRA	NS (Estimate=0.98 (-9.43; 11.39), SE=5.31, p=0.85)
Household Composition and Disability			NS (Estimate=-4.49 (-13.12; 4.14), SE=4.40, p=0.31)
Minority Status and Language			NS (Estimate=1.16 (-7.04; 9.36), SE=4.18, p=0.78)
Housing and Transportation			NS (Estimate=-6.00 (-13.08; 1.08), SE=3.61, p=0.10)
Tobacco Stores			NS (Estimate=-0.31 (-1.85; 1.22), SE=0.78, p=0.69)
Food desert			NS (Estimate=7.16 (-5.74; 20.06), SE=6.58, p=0.28)

Confidence intervals are provided in parentheses for odds ratios and β coefficients.

adj.=adjusted; BAI=brief appraisal inventory; BDI=Beck Depression Inventory; BSI=Brief Symptom Inventory; CEQ=Credibility Expectancy Questionnaire; COPSOC-II=Copenhagen Psychosocial Questionnaire II; EPI=Eysenck Personality Inventory; EPQ=Eysenck Personality Questionnaire; EQ-5D=EuroQol 5D; ESSI=ENRICHD Social Support Instrument score; GLM=general linear model; GSES=General Self-Efficacy Scale; HADS=Hospital Anxiety and Depression Scale; HOOS=Hip disability and Osteoarthritis Outcome Score; HSS=Hospital for Special Surgery; LASSO=least absolute shrinkage selection operator; LLDI=Late-Life Function and Disability Instrument; LMM=linear mixed model; LOT-R=Life Orientation Test-Revised; MGLM=multivariable general linear model; MID=Minimal Important Difference; MLOGRA=multivariable logistic regression analysis; MLRA=multivariable linear regression analysis; MVPA=Moderate-to-vigorous Physical Activity; OHS=Oxford Hip Score; OLR=ordinal logistic regression; OR=Odds Ratio; PCS=physical component summary score; PEBC=Perceived External Behavioural Control; RLOC=Recovery Locus Of Control; RMLRA=repeated measures linear regression analysis; RTW=Return To Work; SE=Standard Error; SF-36=Short Form 36-item Health Survey; SMLOGRA=stepwise multivariable logistic regression analysis; SMLR=stepwise multiple linear regression; SOC=Sense Of Coherence scale; SPS=Social Provisions Scale; STAI-X=State-Trait Anxiety Inventory; TUG=Timed Up and Go; UGLM=univariable general linear model; ULOGRA=univariable logistic

regression analysis; ULRA=univariable linear regression analysis; WALS=Workplace Activity Limitations Scale; WOMAC=Western Ontario and McMaster Universities osteoarthritis index score; 10MWT=10 Meter Walk Test

Table 4. Summary of evidence for investigated personal and environmental factors.

Personal prognostic factors				
Association	*No association*	*Inconsistent*	*Only investigated in one study*	
			Association	*No association*
Anxiety (-) [15, 23, 33, 34, 42, 49]	Smoking status [36, 55]	Depression [15, 23, 32-34, 40, 42, 49, 57]	Self-efficacy (+) [37]	Control beliefs [43]
		Sense of coherence [23, 34]	Optimism (+) [35]	Kinesiophobia [31]
		Educational level [32, 33, 36-38, 40, 44, 45, 47, 54, 56]	Cognitive appraisal processes (+/-) [50]	Race (non-white) [57]
		Big Five personality traits [34, 46]	Cognitive and emotional illness representations [52]	
		Expectations [39, 44, 48, 54]		
		Job position [54, 56]		
		Employment status [33, 38, 41, 45, 51, 56]		
		Trait Anxiety (-) [32, 34]		
Environmental prognostic factors				
Association	*No association*	*Inconsistent*	*Only investigated in one study*	
			Association	*No association*
	Living status [37, 43, 49, 56]	Social support [23, 37, 42, 44, 53]	Positive life events [40] (+)	Occupational factors [47, 51, 54]
		Marital status [33, 44, 45, 56]	Ethnicity (Hispanic) (-) [45]	Negative life events [40]
				Discharge location [49]
				Level of poverty in neighbourhood [45]
				Social Determinants of Health (SDOH) [57]

(-) negative association; (+) positive association

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