The Effects of Patients' Expectations on Surgery Outcome in Total Hip and Knee
Arthroplasty: A Prognostic Factor Meta-Analysis.

Johannes A. C. Laferton, PhD

Psychologische Hochschule Berlin, Berlin, Germany, and Friedrich-Alexander-Universität
Erlangen-Nürnberg, Erlangen, Germany, and Health and Medical University Potsdam, Germany

Lara Oeltjen, MSc

Friedrich-Schiller-Universität Jena, Jena, Germany

Karolin Neubauer, PhD

VAMED Gesundheit Holding Deutschland

David D. Ebert, PhD

Vrije Universiteit Amsterdam, Amsterdam, Netherlands

&

Thomas Munder, PhD

University of Zurich, Zurich, Switzerland

Corresponding author: Johannes Laferton, Health and Medical University Potsdam,
Olympischer Weg 1, 14471 Potsdam, Germany; telephone: +49 331 74 51 13 00; fax: +49 0331
74 51 13 131; e-mail address: johannes.laferton@health-and-medical-university.de

This is an Accepted Manuscript (<https://doi.org/10.1080/17437199.2020.1854051>) that has been peer-reviewed and approved for publication in *Health Psychology Review* (<https://www.tandfonline.com/toc/rhpr20/current>) but has yet to undergo copy editing and proof correction. This manuscript may not exactly replicate the final version published by Taylor & Francis Online. It is not the copy of record.

Funding: JL was supported by the Emerging Talents Initiative of the Friedrich-Alexander-Universität Erlangen-Nürnberg

Conflict of interest: Dr. Neubauer is employed as head of innovation at VAMED Gesundheit Holding Deutschland GmbH (private German Health Care Provider running several rehabilitation hospitals and other health care facilities). Dr. Ebert has served as a consultant to/on the scientific advisory boards of Sanofi, Novartis, Minddistrict, Lantern, Schoen Kliniken, Ideamed and German health insurance companies (BARMER, Techniker Krankenkasse) and a number of federal chambers for psychotherapy. Dr. Ebert is a stakeholder of HelloBetter - GET.ON institute for health training online, which aims to implement scientific findings related to digital health interventions into routine. All other authors declare no conflict of interest.

Abstract

Patients' expectations are among the most frequently studied psychological prognostic factors in total knee and hip arthroplasty (TKA/THA). So far, however, evidence on the effect of patients' preoperative expectations on surgery outcome is inconclusive. Heterogeneity of expectation constructs and the use of psychometrically not evaluated measurement instruments have constituted major obstacles for the integration of the current literature. Using a theory-based model of expectation constructs (Laferton, Kube, Salzmänn, Auer, & Shedden-Mora, 2017), this meta-analysis set out to disentangle the conflicting results in the current literature. Systematic literature searches yielded $k = 46$ studies ($N = 10,465$) that reported associations of preoperative expectations with postoperative pain, functioning and disability, and satisfaction. Random effects meta-analysis revealed a robust small association ($r = .16$; 95% CI .13, .19) between patients' positive preoperative expectations and better postoperative outcomes. This effect did not differ between THA and TKA, different outcome categories and different follow-up periods. Studies using psychometrically evaluated expectation measures reported significantly higher effects ($r = .19$; 95% CI .16, .22). Whether this effect varies among different expectation constructs remains unclear. High-quality studies using validated, multidimensional expectation measures are needed to further understand the role of different expectation constructs in THA and TKA surgery.

Keywords: patients' expectations, placebo effect, arthroplasty, osteoarthritis, meta-analysis, joint replacement surgery

The Effects of Patients' Expectations on Surgery Outcome in Total Hip and Knee Arthroplasty: A Prognostic Factor Meta-Analysis.

Hip and knee osteoarthritis are a major source of pain, disability, and socioeconomic costs worldwide (Cross et al., 2014; Glyn-Jones et al., 2015; Salmon et al., 2016). Total hip and knee arthroplasty (THA/TKA) are the gold standard of treatment for patients suffering from severe hip or knee joint pain and disability due to osteoarthritis (Carr et al., 2012; Pivec, Johnson, Mears, & Mont, 2012; Zhang et al., 2010). They are already among the most frequently performed major surgical procedures worldwide (OECD, 2017) and are predicted to drastically increase further by 2030 (Inacio, Graves, Pratt, Roughead, & Nemes, 2017; Kurtz, Ong, Lau, & Mowat, 2007), making them a primary health care issue in the near future. Although many patients experience large improvements in pain, functioning and quality of life after surgery (Hammett et al., 2018; Judge, Cooper, Williams, Dreinhoefer, & Dieppe, 2010), 7-23% of THA and 10-34% of TKA patients do not benefit from these procedures in the way in which surgeons would predict from a medical point of view (Beswick, Wylde, Gooberman-Hill, Blom, & Dieppe, 2012; Brokelman, van Loon, & Rijnberg, 2003; Dunbar, Richardson, & Robertsson, 2013; Judge et al., 2010; Wylde, Dieppe, Hewlett, & Learmonth, 2007). Identifying additional predictors of surgery outcome might help to identify patients at risk of diminished treatment success and could potentially lead to the development of additional treatment strategies to enhance surgery outcome in THA and TKA.

Patients' expectations are among the most frequently studied psychological predictors of TKA and THA outcome, and this high level of interest is well justified from both a clinical and scientific perspective. Patients' questions about what to expect from surgery are part of daily clinical routine for surgeons, although the right way to answer such questions has often been subject to debate. There is broad scientific evidence suggesting that positive expectations are linked to better health. Important evidence-based psychological models of health behavior, such

as the social cognitive theory (Bandura, 1986; Maddux, 1999) and the common-sense model of self-regulation of health and illness (Leventhal, Meyer, & Nerenz, 1980; Petrie & Weinman, 2012) as well as the extensive literature on optimism (Carver, Scheier, & Segerstrom, 2010), have linked positive expectations to improved health. Moreover, research has identified expectations as one of the key mechanisms of the placebo effect, with positive expectations being linked to a variety of improved health outcomes in various health conditions such as pain, depression, cardiovascular diseases, Parkinson's disease, and osteoarthritis (Colloca & Barsky, 2020; Dieppe, Goldingay, & Greville-Harris, 2016; Kong et al., 2018; Petrie & Rief, 2019). Patients with positive expectations are more likely to engage in positive health and illness coping behavior (Hagger & Orbell, 2003; Nes & Segerstrom, 2006), thereby triggering a self-fulfilling prophecy. Furthermore, several neurophysiological mechanisms have been identified to mediate the beneficial effects of positive expectations on health, such as immunological responses (Segerstrom & Sephton, 2010), stress responses (Salzmann et al., 2017, 2018) and endogenous pain modulatory systems (Colloca & Barsky, 2020). While this suggests that it might be advantageous to communicate positive expectations to the patient, some authors have voiced concern that optimistic expectations might lead to worse treatment outcome (Sweeny & Andrews, 2017). For instance, patients might engage in maladaptive health behavior due to overly optimistic expectations, or expectations that turn out to be unfulfilled might lead to dissatisfaction, in turn possibly resulting in worse psychosocial outcomes and thus potentially decreased treatment compliance and health behavior.

Despite the high number of studies, evidence regarding the prognostic role of patients' expectations in the field of TKA and THA remains conflicting. While some studies reported that positive preoperative expectations are associated with better postoperative outcome (e.g. Gandhi, Davey, & Mahomed, 2009; Sullivan et al., 2011), others reported the opposite to be the case (e.g. Cross et al., 2009; Kumar, Battepathi, & Bangalore, 2015) or did not find any association at all (e.g. Mannion, Kämpfen, Munzinger, & Kramers-de Quervain, 2009). Heterogeneity and a lack

of standardization regarding the conceptualization and assessment of expectations have impeded previous systematic reviews and meta-analyses (Barlow, Clark, Dunbar, Metcalfe, & Griffin, 2016; Haanstra et al., 2012; Vissers et al., 2012) from clarifying the role of patients' expectations in TKA and THA. Multiple different aspects of patients' expectations have often been studied without clear theoretical foundation, without precise terminology and without the use of psychometrically evaluated measures (Bowling et al., 2012; van Hartingsveld et al., 2010; Zywił, Mahomed, Gandhi, Perruccio, & Mahomed, 2013).

In order to provide clear terminology and conceptual integration, Laferton and colleagues (Laferton et al., 2017) proposed an integrative model of patients' expectations in medical treatment. With the aim of achieving a unified classification of expectations related to health and treatment, this model draws on social cognitive and social learning theories (Bandura, 1986; Maddux, 1999; Schwarzer, 1994), the common sense model of illness representation (Cameron & Leventhal, 2003; Leventhal et al., 1980), the response expectancy theory (Kirsch, 1983, 1997, 2018), and research on the placebo effect (Colloca & Miller, 2011; Di Blasi, Harkness, Ernst, Georgiou, & Kleijnen, 2001). The model defines expectations as future-oriented beliefs that focus on the incidence or non-incidence of specific events or experiences. It distinguishes *probabilistic expectations*, describing patients' subjective estimation about the future, from *value expectations*, describing what a patient would like to happen. The latter term refers to a patients' desires, wishes, hopes or entitlements, which are much more driven by preference than by estimation of likelihood, and which involve a stronger affective component than probabilistic expectations (Kravitz, 1996; Kube et al., 2019; Leung, Silvius, Pimlott, Dalziel, & Drummond, 2009). Regarding probabilistic expectations, the model distinguishes four general content domains: *behavioral expectations*, about patients' illness-/treatment-related behavior (i.e. self-efficacy, personal control); *treatment expectations*, about efficacy, risks, structure and process of a treatment; *outcome expectations*, describing the expected effects of the treatment and/or behavior (i.e. symptoms, quality of life, or side effects); and *timeline expectations*, about

temporal aspects of the treatment, disease or behavior. In addition to expectations referring to a specific treatment context, the model takes into account *generalized behavioral expectations* (i.e. generalized self-efficacy) and *generalized outcome expectations* (i.e. optimism). Due to a lack of influential theories or empirical findings regarding distinct content domains of value expectations, this construct is not further differentiated within the integrative model of patients' expectations. Notably, the categorization of the integrative model of patients' expectations was corroborated in two recent systematic reviews, of expectation questionnaire items used in orthopedic surgery (Cortes, Meints, & Katz, 2019) and of generally used treatment expectation scales (Alberts et al., 2020), and in one qualitative interview study with general hospital patients (El-Haddad, Hegazi, & Hu, 2020).

Using the integrative model, a unified conceptualization of expectations could serve to disentangle the conflicting results on the effects of THA and TKA patients' expectations found in the current literature. To this aim, based on the integrative model of patients' expectations, a pre-registered meta-analysis was conducted in order to 1) assess the overall effect of patients' preoperative expectations on postoperative outcome, 2) test whether expectation effects differ between THA and TKA, 3) assess whether expectation constructs differ in terms of their association with postoperative outcome, and 4) assess whether the predictive effects of value expectations differ from the effects of probabilistic expectations.

Methods

This meta-analysis was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. The review protocol was pre-registered with PROSPERO ([CRD42017079746](https://www.crd42017079746)).

Eligibility criteria

The inclusion criteria for the selection of studies were as follows: a) empirical studies of adults (age ≥ 18) undergoing primary total knee or total hip arthroplasty; b) assessing preoperative expectations; c) assessing postoperative outcome; d) reporting an effect size for the association between preoperative expectation and postoperative outcome. Studies were excluded if e) the study type was cross-sectional, qualitative, case report, review, meta-analysis, letter or comment; f) they had a sample size smaller than 10. The classification of expectations was derived from the integrative model of patients' expectations (Laferton et al., 2017).

Search strategy

Eligible studies were identified by searching the databases EMBASE, PsycINFO, and CINAHL. Search terms included a combination of free text and controlled vocabulary of the prognostic factor (expect* OR internal-external control OR pessimis* OR fantas* OR phantas* OR self-efficacy OR self efficacy OR optimis* OR personal control OR treatment control OR belief* OR illness cognition* OR illness representation* OR catastrophiz* OR catastrophis* OR locus of control OR perceived control) and the intervention ((knee OR hip) AND (arthroplasty OR replacement)). The search strategy of controlled vocabulary was adapted for each database (see Supplement 1 for a complete list of search terms). The final search was conducted in August 2017.

Study selection

Duplicates of the identified references were removed using the reference management software Mendeley. Titles and abstracts of the remaining studies were screened against the eligibility criteria by one of two reviewers (LO and JL). In a second step, full-text methods and results sections of the remaining references were screened for eligibility by one reviewer (LO). To assess the accuracy of study selection at this stage, 10 percent of these studies were randomly

selected and screened by an independent reviewer (KN). The complete full texts of the remaining studies were independently screened by two reviewers (JL and LO) to determine final inclusion in the meta-analysis. Disagreements between reviewers were resolved through discussion among JL, LO and TM.

Data extraction

The data extraction was conducted by two independent reviewers (JL and LO), and disagreements were resolved through discussion among JL, LO and TM. Data were extracted on:

Study characteristics: year of publication, country of study setting, number of eligible participants, number of included participants, number of participants analyzed per effect size

Participant characteristics: age (*M*; range), gender (% female), body mass index (*M*; range),

Intervention characteristics: procedure (TKA, THA, both), primary cause for surgery (osteoarthritis, rheumatoid arthritis, fracture, mixed).

Prognostic factor: The operationalization (yes/no) of each of the following distinct expectation constructs was extracted: probabilistic expectations, with the subcategories of generalized outcome expectations, generalized behavioral expectations, behavioral expectations, treatment expectations, and outcome expectations. Pain catastrophizing (Vlaeyen & Linton, 2000) was added as a separate condition-specific probabilistic expectation subcategory, encompassing a mixture of behavioral, outcome and timeline expectations about pain. In addition, it was extracted whether a study assessed value expectations. Studies that reported only an aggregated combination of the aforementioned expectation constructs within their operationalization were classified as mixed. Prior to data extraction, a hierarchical list of assessment tools was created for each expectation construct, based on their psychometric quality, treatment or condition specificity, and frequency of use within the field (see Supplement 2; Laferton et al., 2017; van

Hartingsveld et al., 2010; Zywiell et al., 2013). For studies using more than one measure to operationalize one specific expectation construct, the higher-ranking measure was extracted. Furthermore, the psychometric quality of each expectation measure (at least basic psychometric evaluation vs. none) and the timing of prognostic factor assessment were extracted.

Outcome: The operationalization of each of the following three different outcome categories was extracted: pain, functioning & disability, satisfaction. Studies that reported only an aggregated combination of these outcome categories within their operationalization (i.e. Western Ontario and McMaster Universities Osteoarthritis Index sum score) were classified as mixed. Prior to data extraction, a hierarchical list of assessment tools was created for each outcome category, based on their psychometric quality, treatment or condition specificity, and frequency of use within the field (see Supplement 2; adapted from Juhl, Lund, Roos, Zhang, & Christensen; 2012). For studies using more than one measure to operationalize one specific outcome category, the higher-ranking measure was extracted. Furthermore, the psychometric quality of each outcome measure (at least basic psychometric evaluation vs. none) and timing of outcome assessment were extracted. The timing of outcome assessment was categorized according to three pre-specified periods: short-term (up to 6 weeks), medium-term (6 weeks to 8 months), and long-term (more than 8 months). If there was more than one assessment matching one outcome period, the earliest was chosen for short-term, the closest to 6 months was chosen for medium-term, and the closest to 12 months was chosen for long-term.

Effect size estimates: For each study, effect size estimates (r) were extracted for the association between every expectation construct assessed preoperatively and every available outcome category. Effect size estimates were calculated following Lipsey and Wilson (2001). If an outcome category was assessed more than once across different outcome periods, only one effect size estimate was extracted (medium-term preferred over long-term preferred over short-term). Moreover, interval data were preferred over categorical data. Standardized bivariate associations

(e.g., zero-order correlation) were prioritized over multivariate effect sizes (i.e. multiple regression coefficients), since univariate associations appeared to be more frequently reported in the literature on expectations in surgical populations (Auer et al., 2016) and the choice of covariates statistically controlled for in the models differed widely between studies.

Corresponding authors of studies reporting multivariate associations were contacted via e-mail in order to obtain bivariate associations. Contrary to the study protocol, during data extraction but prior to data analysis, it was decided to exclude studies in which results were only given through p values and p thresholds.

Risk of bias

Two independent reviewers (JL and LO) used the Quality in Prognosis Studies (QUIPS; Hayden et al., 2013) tool to assess risk of bias for each included study. Disagreements between reviewers were resolved through discussion among JL, LO and TM. QUIPS was specifically developed to determine risk of bias in studies investigating prognostic factors among six bias domains: study participation, study attrition, prognostic factor and outcome measurement, study confounding and statistical analysis. In line with the instructions (Hayden et al., 2013), the quality items of each domain were adapted for the current study (see Supplement 3). The risk of bias was rated as low, unclear or high for attrition, and low or high for prognostic factor measurement, outcome measurement, and statistical analysis. The overall study risk of bias was judged as low if all of these four risk of bias domains were judged as low. The risk of bias was not formally rated for study participation, since the vast majority of studies had no or ambiguous reporting of eligible participants and recruitment process. However, descriptive demographic and clinical characteristics can be used to judge their match to the target population (see Table 1). Moreover, the risk of bias was not rated for confounding, since univariate effect size estimates

were preferably extracted, and accounting for confounding variables was extremely heterogeneous for all multivariate effect size estimates.

Data analysis

For meta-analyses, we used a random-effects inverse-variance model with DerSimonian-Laird estimation of between-study variance. Heterogeneity was quantified using I^2 , with values of 0%, 25%, 50%, and 75% indicating no, low, medium, and high heterogeneity, respectively (Higgins, Thompson, Deeks, & Altman, 2003). The exploration of heterogeneity included the investigation of (a) outliers (i.e., defined as studies with effects whose 99% confidence interval did not overlap with the 95% confidence interval of the aggregated effect in meta-analyses; for a similar definition see (Cuijpers, 2016)), (b) small-study effects (using Egger's test), (c) risk of bias, and (d) differences in the timing of outcome measurement. In the moderator analysis, we used a conservative approach to significance testing (Knapp & Hartung, 2003). When moderator analysis included more than one estimate from one study, standard errors were adjusted to avoid biasing weights. STATA 15.0 was used for all analyses.

Results

Included Studies

A flow chart of the study selection process is depicted in Figure 1. The literature search in all three databases resulted in 4489 hits. 680 studies were removed using the deduplication function of the reference management software. The title and abstract screening of the remaining 3809 abstracts indicated a clear violation of a least one of the inclusion/exclusion criteria in 2661 articles, which were excluded accordingly. The abstracts of the remaining 1148 articles indicated a fit with the inclusion criteria or did not provide sufficient information for selection within the title or abstract, and were therefore included in the full-text methods-results screening. 901

studies were excluded during full-text methods-results screening. To determine the accuracy of study selection at this stage, 10 percent of these studies were screened by a second independent rater. We found an inter-rater agreement of 98%, with only two erroneously included studies and no erroneously excluded studies. The remaining 247 articles were examined completely and in detail by two of the authors independently. After all disagreements had been resolved through discussion, 70 studies were subjected to data extraction and study quality rating. Finally, 46 studies, including 48 individual samples and a total of 10,465 patients, fulfilled the inclusion criteria and provided sufficient data for analysis.

Figure 1. PRISMA flow chart of study selection process.

Study characteristics

Participant characteristics (age, sex, BMI; see Table 1) were relatively homogenous and within the range of general THA and TKA populations (Carr et al., 2012; Pivec et al., 2012). Of the 48 samples, 12 consisted of THA patients, 28 of TKA patients, and 8 of both TKA and THA patients. Ninety-five effect sizes were extracted from these samples, 80 of which were from univariate analysis (14 multivariate and 1 unknown). Among the 14 multivariate effect sizes, 6 controlled for measures of psychopathology, 8 for sociodemographic factors, 0 for other expectation constructs, and 11 for baseline health status. Probabilistic expectations were assessed 42 times, value expectations 4 times, and 2 operationalizations aggregated different expectation constructs (mixed). Among probabilistic expectations, generalized outcome expectations were assessed 5 times, generalized behavioral expectations 2 times, behavioral expectations 11 times, treatment expectations 3 times, outcome expectations 17 times, and pain catastrophizing 11 times. Regarding surgery outcome, pain was assessed 26 times, functioning and disability 23 times, satisfaction 11 times and mixed outcome 13 times. Surgery outcome was assessed at a median of 9-month follow-up, with the majority of studies assessing long-term follow-up.

Table 1.

Characteristics of included studies.

Study	N	Gender: % female	Age: M/ Mdn	BMI: M/ Mdn	Surgery Type	Expectation Constructs (Measure)	Outcome Constructs (Measure)	Timing Outcome Measurement
van den Akker-Scheek et al., 2007	103	72.8	63.8	27	TKA/ THA	BE (SEfROS)	MIX (WOMAC), FUN (SF-36)	6 months
Arden et al., 2011	614	60.3	68	27	THA	OE (ah)	MIX (OHS); MIX (WOMAC); Pain (WOMAC); FUN (WOMAC)	12 months
Balck et al., 2016	268	55	58.7		THA	GOE (LOT-R)		3 months
Brembo et al., 2017	212	71.3	69.3		THA	GBE (GSE)	MIX (WOMAC)	3 months
Cardoza, 2011	111	56.8	65.8		THA	GBE (GSE)	MIX (ah); FUN (ah)	6 weeks
Cross et al., 2009 (K)	78	50	70		TKA	VE (KSS)	Pain (WOMAC); FUN (WOMAC)	6 months
Cross et al., 2009 (H)	28	54	68		THA	VE (HSS)	Pain (WOMAC); FUN (WOMAC)	6 months
Dave et al., 2017	241	60.6	66.2	30.5	TKA	PC (PCS)	Pain (WOMAC)	12 months
Elman et al., 2014	56	79.7	61.1		TKA/ THA	OE (ah)	FUN (ah)	24 months
Engel et al., 2004	60	49.3	67.1		TKA	BE (ah); MIX (ah)	Pain (WOMAC); FUN (WOMAC)	6 months
Forsythe et al., 2008	48	64	69		TKA	PC (PCS)	Pain (NRS/VAS)	24 months
Gandhi, Davey et al., 2009	179						MIX (WOMAC); Pain (WOMAC); FUN (WOMAC); SAT (ah)	
Gandhi, Razak et al., 2009	9	60.1	69.5	30.5	TKA/ THA	OE (ah)		12 months
Gonzalez Saenz De Tejada et al., 2014	140	50	66.5	28.7	TKA/ THA	BE (ah)	MIX (WOMAC)	12 months
Hieber, 2011	892	59.4	68.7	29.4	TKA/ THA	OE (ah)	Pain (WOMAC); FUN (WOMAC); SAT (ah)	12 months
Hirschmann et al., 2013	53	74.1	68.6		TKA	PC (PCS)	FUN (WOMAC)	1 day
Jain, Bendich et al., 2017	104	55.8	70	29	TKA	BE (ah)	Pain (WOMAC); FUN (WOMAC)	12 months
Jain, Nguyen et al., 2017	188	46.9	64.7	28	THA	VE (HSS)	MIX (HOOS); SAT (PSS)	6 months
Judge et al., 2011	70	55.4	69.7	29.9	TKA	VE (HSS)	MIX (KOOS); MIX (WOMAC), Pain (WOMAC); FUN (WOMAC)	6 months
Kiran et al., 2015	845	56.2	65.9	27.8	THA	OE (ah)		12 months
Kumar et al., 2015	260	61.6	72	28.6	TKA	OE (ah)	MIX (OKS), SAT (ah)	12 months
	271	53.2	62.1		TKA	MIX (ah)	MIX (WOMAC)	12 months

Table 1. (continued)

Characteristics of included studies.

Study	N	Gender: % female	Age: M/ Mdn	BMI: M/ Mdn	Surgery Type	Expectation Constructs (Measure)	Outcome Constructs (Measure)	Timing Outcome Measurement
Kuroda et al., 2016	75	84	74.8		TKA	OE (KSS)	FUN (ah); SAT (KSS)	12 months
Lindberg et al., 2016	188	68.6	67.7	29.3	TKA	BE (ah)	Pain (NRS/VAS)	3 days
Lingard et al., 2006	525	57.5	69.3	29.3	TKA	OE (ah)	Pain (WOMAC); FUN (WOMAC); SAT (ah)	12 months
Lopez-Olivo et al., 2011	241	65	65		TKA	GOE (LOT- R); BE (ASES)	Pain (WOMAC); FUN (WOMAC)	6 months
Luna et al., 2017	60	61.7	67	29	TKA	PC (PCS)	Pain (NRS/VAS)	1 day
Lunn et al., 2013	92	51.5	66	29	TKA	PC (PCS)	Pain (NRS/VAS)	1 day
Mahomed et al., 2002	192	55.2	67		TKA/ THA	OE (ah); TE	Pain (WOMAC); FUN (WOMAC)	6 months
Mannion et al., 2009	112	69.6	67		TKA	OE (ah)	Pain (ah); FUN (ah), SAT (ah)	24 months
Masselin-Dubois et al., 2013	89	65	68.7		TKA	PC (PCS)	Pain (NRS/VAS)	3 months
Neuprez et al., 2016 (K)	58	60.3	68.1	28.7	TKA	OE (ah)	SAT (KSS)	12 months
Neuprez et al., 2016 (H)	80	62.5	64.4	26.7	THA	OE (ah)	SAT (HSS)	12 months
Oettingen & Mayer, 2002	51	59	65.7	27.5	THA	OE (ah)	FUN (ah)	2 weeks
van Onsem et al., 2016	112	56	65.2	29.3	TKA	OE (KSS); PC (PCS)	SAT (KSS)	3 months
Palazzo et al., 2014	123	49.6	63.5	25.8	THA	OE (ah)	SAT (ah)	12 months
Pinto et al., 2013	92	66.3	64	29.4	TKA/ THA	BE (IPQ); TE (IPQ)	Pain (NRS/VAS)	5 months
Razmjou et al., 2015	63	75	67		TKA	BE (ASES)	Pain (ah)	60 months
Roth et al., 2007	49	52	71.9	32.5	TKA	PC (PCS)	Pain (ah)	1 day
Singh et al., 2010	755	61.7	68.8		TKA	GOE (ah)	Pain (ah); FUN (ah)	24 months
Singh et al., 2016	456	57.4	67.4		THA	GOE (ah)	Pain (ah); FUN (ah)	24 months
Smith & Zautra, 2004	64	52	67.2		TKA	GOE (LOT-R)	Pain (WOMAC); FUN (WOMAC)	6 months

Table 1. (continued)

Characteristics of included studies.

Study	N	Gender: % female	Age: M/ Mdn	BMI: M/ Mdn	Surgery Type	Expectation Constructs (Measure)	Outcome Constructs (Measure)	Timing Outcome Measurement
Sullivan et al., 2011	120	60.8	67	31	TKA	OE (ah); PC (PCS)	Pain (WOMAC); FUN (WOMAC)	12 months
Trevisan et al., 2015	69	46.4	63	26	THA	BE (HLoC)	FUN (ah); SAT (KSS)	20 months
Vissers et al., 2010	44	54.5	63.5	30.8	TKA	TE (ah); OE (ah)	SAT (ah)	6 months
Wallace, 2000	31	60	67		TKA	BE (ah); OE (ah)	Pain (WOMAC); FUN (WOMAC)	6 weeks
Willens, 1994	72	65.3	66.3		TKA/ THA	OE (ah)	Pain (NRS/VAS)	1 day
Witvrouw et al., 2009	43	60.5	61		TKA	PC (PCS)	MIX (ah)	1 day
Wylde et al., 2017	168	64	70	30	TKA	BE (PSES); PC (CSQ)	Pain (WOMAC); FUN (WOMAC)	12 months

Note. TKA=total knee arthroplasty; THA=total hip arthroplasty. Constructs: BE=behavioral expectations OE=outcome expectation; GBE=generalized behavioral expectations; GOE=generalized outcome expectations; PC=pain catastrophizing; VE=value expectations; TE=treatment expectations; FUN=functioning & disability; SAT=satisfaction; MIX=mixed expectation or outcome. Scales: SEfROS=Self-Efficacy for Rehabilitation Outcome Scale; LOT-R=Life Orientation Test Revised; IPQ=Illness Perception Questionnaire or Illness Perception Questionnaire Revised or Brief Illness Perception Questionnaire; GSE=General Self-Efficacy Scale; HSS=Harris Hip Score; KSS=Knee Society Score; PCS=Pain Catastrophizing Scale; CSQ=Coping Strategies Questionnaire; ASES=Arthritis Self-Efficacy Scale; HLoC=Health Locus of Control Scale; PSES=Pain Self Efficacy Scale; WOMAC=Western Ontario and McMaster Universities Osteoarthritis Index; OHS=Oxford Hip Score; OKS=Oxford Knee Score; NRS/VAS=Numeric Rating Scale/Visual Analog Scale; HOOS= Hip Osteoarthritis Outcome Score; KOOS=Knee Osteoarthritis Outcome Score; PSS=Patient Satisfaction Scale ; ah=ad hoc measure.

Risk of bias assessment

The risk of bias rating for each included study can be seen in Supplement 4. Attrition risk of bias was rated as low for 41% of the included studies, unclear for 50% and high for 9%. Risk of bias regarding prognostic factor measurement was rated as low for 70% of the studies and high for 30%. Outcome measurement risk of bias was rated as low for 78% and high for 22%, and risk of bias regarding statistical analysis was rated as low for 74% and high for 26% of studies. Only 20% of all studies had a low risk of bias rating in all four domains.

Meta-analysis

In a first step, analyses were conducted regarding the pre-specified research questions. Across all studies and outcomes, the mean association of all types of preoperative expectations with outcomes was $r = .20$ (95% CI .15, .26), suggesting a small positive correlation between positive expectations and better surgery outcome. This effect did not seem to vary between TKA and THA ($p = .46$), different outcome categories ($p = .25$) and different types of probabilistic expectations ($p = .58$). There was a statistically significant difference between probabilistic and value expectations ($p = .03$). However, given the extreme heterogeneity of the effect size estimate for value expectations ($r = .41$; 95% CI -.11, .75; $I^2 = 95.5$) this result cannot be considered robust. Overall, for most of these analyses heterogeneity was high ($I^2 > 75\%$; see Supplement 5 for details), making it difficult to interpret the findings.

Consequently, in a second step, we explored reasons for heterogeneity. The exclusion of 15 outlying effect estimates (15.8%) from 12 studies (26.1%) reduced the number of included studies to 39 (84.8%) and heterogeneity to a small to moderate degree ($I^2 = 43.0\%$). Egger's test did not suggest possible presence of small-study effects or publication bias ($p = .047$). However, contrasting studies with sample sizes below and above the median number of participants ($Mdn = 111.5$) or above and below a sample size of $n = 200$ did not result in statistically significant differences in effect size nor did it result in reduction in heterogeneity ($I^2 > 75\%$). Differentiating

by study quality and timing of outcome measurement did not lead to substantial reductions in heterogeneity ($I^2 = 85.3\%$ and 86.9% , respectively). Therefore, outliers were excluded for all subsequent analyses. With outliers removed (see Table 2), the overall association between expectations and outcome was $r = .16$ (95% CI .13, .19), with the whole confidence interval falling into the range of small effect sizes (see Figure 2 for a forest plot).

Figure 2. Overall association (r) of pre-surgery expectations and post-surgery outcome for TKA and TKA (outliers removed).

Moderator analysis

The results of the moderator analysis after excluding outliers can be found in Table 2. All mean effect sizes of the moderator analysis with outliers included are comparable or somewhat higher compared to those after removing outliers (see Supplement 5). The prognostic effect of patients' expectations on surgery outcome did not vary between TKA and THA, different outcome categories and overall study quality. However, the effect size varied significantly according to type of probabilistic expectation and quality of expectation measure. The effect sizes of treatment ($p = .012$) and outcome expectations ($p < .001$) were significantly lower than those of the other probabilistic expectation constructs. Moreover, studies using higher-quality expectation measures reported significantly larger effect sizes than studies using lower-quality measures ($p = .001$). The difference between probabilistic versus value expectations could not be evaluated, since there was only one study with value expectations remaining after the removal of outliers. Without the removal of outliers, effect sizes for value expectations were extremely heterogeneous and not significantly different from zero (see Supplement 5). Finally, the effects within each individual probabilistic expectation category did not significantly vary between short-, medium-, and long-term outcome (see Supplement 6).

Table 2.

Subgroup analyses of the prognostic effect of patients' expectations on TKA and THA outcome.

Analyses	<i>k</i>	<i>r</i>	95% CI	<i>I</i> ²	<i>p</i>
All studies	39	.16	.13, .19	43.0%	< .001
Surgery					.69
THA	8	.17	.09, .23	58.0%	
TKA	24	.18	.14, .23	31.3%	
Type of outcome					.80
Mixed	9	.13	.09, .17	0%	
Pain	24	.15	.10, .19	33.0%	
Functioning & disability	21	.17	.12, .21	17.8%	
Satisfaction	7	.14	.08, .19	0%	
Probabilistic vs. value expectations					—
Probabilistic	38	.16	.13, .19	43.6%	
Value	1	—	—	—	
Type of probabilistic expectation					<.001
Generalized outcome expectations	5	.21	.17, .26	0%	
Generalized behavioral expectations	2	.19	.08, .29	0%	
Behavioral expectations	8	.17	.09, .24	24.1%	
Treatment expectations	3	.02	-.12, .16	3.3%	
Outcome expectations	15	.11	.07, .14	19.5%	
Pain catastrophizing	11	.25	.19, .32	0%	
Overall study quality					.17
high	8	.20	.18, .26	0%	
low	31	.15	.11, .18	46.1%	
Quality of expectation measurement					.001
high	27	.19	.16, .22	5.1%	
low	13	.11	.06, .15	39.3%	

Notes. Outliers were removed for all analyses in Table 2.

Discussion

Summary of the evidence

Data from this meta-analysis, based on $k = 46$ studies including $N = 10,465$ THA and TKA patients, indicate that there is a robust small positive association between patients' positive preoperative expectations and better patient-reported postoperative outcome. The effect was

present for both THA and TKA, different patient-reported outcome categories and different follow-up periods. There was some indication that the association with surgery outcome might vary between different probabilistic expectation constructs. Moreover, studies with higher-quality expectation measures reported stronger associations between positive preoperative expectations and improved surgery outcome than did studies using lower-quality measures. Despite the heterogeneity and limitations of the included primary studies, the effect size of the association between pre-surgery expectations and TKA and THA outcome remained quite consistent across the primary analysis, as well as the subgroup and sensitivity analysis.

The overall pooled effect in the present study suggests that patients with higher positive expectations experience better post-surgical improvements in terms of improvement in pain, functioning/disability and higher satisfaction. Moreover, the size of this effect might be of potential clinical relevance, as it matches the mean effect of pain relief achieved by first-line oral analgesic treatment recommended for patients with hip and knee osteoarthritis (Zhang et al., 2010). These results are supported by previous meta-analyses investigating expectations as a prognostic factor in related patient populations. A recent Cochrane review reported a strong association between recovery expectations and work participation outcomes in patients with low back pain (Hayden et al., 2019). Moreover, other meta-analyses investigating the prognostic effect of preoperative expectations in a broad set of surgical populations found similar associations with acute post-surgical pain (Sobol-Kwapinska, Babel, Plotek, & Stelcer, 2016) and post-surgical quality of life (Auer et al., 2016). Further support for a beneficial effect of patients' expectations on TKA and THA surgery outcome comes from experimental studies which actively manipulated patients' expectations. Several randomized controlled trials were able to show that enhancing patients' expectations leads to improved outcome in patients undergoing cardiac surgery (Laferton, Auer, Shedden-Mora, Moosdorf, & Rief, 2015b; Rief et al., 2017) and abdominal surgery (van der Meij et al., 2018), as well as improved pain outcomes in general (Peerdeman et al., 2016) and osteoarthritis pain specifically (Kong et al., 2018). In addition,

expectations are considered to be the main mechanism driving placebo effects. An accumulating body of evidence documenting substantial placebo effects in osteoarthritis (Gollub et al., 2018; Zhang, 2019) and orthopedic surgery (Jonas et al., 2015; Moseley et al., 2002) further supports the hypothesis that patients' expectations should be considered as an important variable predicting and potentially influencing outcome in THA and TKA surgery.

An additional goal of the study was to identify types of expectations with specific prognostic importance for the outcome of TKA and THA. According to the respective subgroup analysis, the probabilistic expectation constructs of generalized outcome expectations, generalized and specific behavioral expectations and pain catastrophizing showed somewhat larger effect sizes than outcome and treatment expectations. Possibly, generalized expectations might have stronger effects on long term outcomes, which are overrepresented in the current data, while specific expectations might have stronger effects on short term outcomes. However, this effect pattern was not significant within the current data. Moreover, those probabilistic expectation constructs showing larger mean effect sizes are also those with a stronger and more consistent theoretical foundation and standardized, psychometrically well-evaluated measurement tools (e.g. optimism and the Life Orientation Test; Scheier, Carver, & Bridges, 1994). This is supported by the subgroup analysis, which revealed that studies with higher-quality expectation measures report stronger positive associations than those using measures without any evidence for psychometric quality. Accordingly, in their prognostic factor meta-analysis on the association between expectations and quality of life after different types of surgery, Auer et al. (2016) found comparable differences between the effect sizes of studies using ad-hoc developed expectation measures and those using established measures. Therefore, although the respective subgroup analysis was significant, any conclusion on the differential importance of specific expectation constructs might be premature. To resolve this, it appears crucial for future studies researching the association of patients' expectations with surgery outcome to use theory-based, psychometrically sound expectation measures that allow for the direct comparison of the

independent impact of different aspects of patients' expectation on treatment outcome at different follow-up intervals. Moreover, the present meta-analysis is unable to provide additional insights into whether probabilistic and value expectations do affect TKA and THA outcome differently. Only a small number of studies have assessed value expectations, and their measurement as well as the reported effect sizes were extremely heterogeneous, meaning that no reliable comparison was possible. Again, the use of well-defined and psychometrically evaluated measures that allow for a direct comparison of the two types of expectation would help to provide further insight into this issue.

Strengths & Limitations

This meta-analysis has several strengths. The study was based on a theoretical model of patients' expectations and previous research in this field, which led to the formulation of specific a-priori hypotheses. Moreover, the model of patients' expectations provided clear search and selection criteria, which enabled an exhaustive identification of relevant literature. A further strength lies in the application of guidelines and tools specifically suggested for prognostic factor meta-analysis (Riley et al., 2019), such as the QUIPS risk of bias tool (Hayden et al., 2013). Despite these strengths, some limitations should be considered when interpreting the current results. First and foremost, the limitations of the included studies have to be taken into account. Only a small number of studies were considered to have a low risk of bias. Low study quality, differences in study design and a lack of psychometrically validated prognostic factor measures are likely to be a major source of heterogeneity. Although the overall effect was robust across different sensitivity analyses, this heterogeneity has to be considered when interpreting the generalizability of the effect and potential moderating factors. Furthermore, since adjustment for covariates was very heterogeneous within the field and among the included studies, unadjusted effect sizes were preferably extracted over adjusted effect sizes. For the same reason, risk of bias for the confounding domain was not formally rated. Therefore, one cannot rule out that the effect

found is independent of preoperative health status or other potential confounding variables.

Patients with negative preoperative expectations may be those with objectively poorer preoperative health status, putting them at increased risk for poorer treatment outcome (and vice versa for patients with positive preoperative expectations; Sweeny & Andrews, 2017). Speaking against this, the sensitivity analysis did not reveal that unadjusted effect sizes were significantly larger than adjusted effect sizes. In line with this finding, several studies indicate that pre-surgery health indicators have rather weak or inconsistent associations with patients' expectations prior to surgery (Laferton, Auer, Shedden-Mora, Moosdorf, & Rief, 2015a; Scott et al., 2012). Moreover, in a similar meta-analysis, the prognostic relationship of expectations with low back pain outcome retained its statistically and clinically significant effect after pooling only effect size estimates from adjusted analyses (Hayden et al., 2019). Hence, there is sufficient reason to believe that the current effect would remain when only using adjusted effect size estimates. As a further limitation, authors within relevant fields were not contacted to obtain unpublished studies, meaning that the current effect size might be overestimated due to publication bias. However, sensitivity analysis did not indicate a large risk of publication bias (small study effects) within the current data. Moreover, about 20% of the included studies did not investigate expectations as a primary research aim, which further mitigates the risk of publication bias regarding the current results. Although the risk of bias assessment and sensitivity analysis specifically included risk of selective reporting, due to a lack of study protocols for the majority of studies, this source of bias should still be taken into consideration when interpreting the current results.

Conclusion

Overall, the results of this meta-analysis demonstrate a robust positive association between patients' positive expectations prior to TKA and THA surgery and superior surgery outcome. This effect is further substantiated by both prognostic factor meta-analyses and experimental studies from adjacent fields. However, many of the studies which have assessed

expectations as a prognostic factor in TKA and THA to date are subject to a risk of bias. Specifically, the present meta-analysis indicates that the use of low-quality prognostic factor assessment might lead to an underestimation of the effect size. Moreover, heterogeneity in study quality and study design currently limit the ability to further elucidate specific effects of expectations on THA and TKA outcome. High-quality prognostic factor studies are warranted, which apply pre-registered study designs, assess relevant covariates and most importantly use psychometrically evaluated assessment tools that allow for differential assessment of different aspects of expectations and their effects over different follow-up intervals. The recently developed Treatment Expectation Questionnaire (Alberts et al., 2020) appears to be a promising candidate in this regard. Moreover, future research should investigate potential moderators of expectation effects in this population. While the majority of patients might benefit from optimistic expectations, they may still be detrimental to others, for instance patients with a realistically pessimistic outlook (Sweeny & Andrews, 2017). Beyond this, psychological interventions to manipulate patients' expectations have been successfully employed in patients undergoing cardiac surgery (Laferton et al., 2015b; Rief et al., 2017), abdominal surgery (van der Meij et al., 2018) and endocrine breast cancer treatment (Shedden-Mora et al., 2020). Similar experimental studies among TKA and THA patients would promise to deliver more conclusive evidence on the effects of patients' expectations and, if successful, could potentially open up a new way to further improve health outcomes within this patient population.

Acknowledgements

The authors would like to thank Julia Koß and Marie Mylord for their valuable support during the data collection process.

Data availability statement

The data and analysis code used in this manuscript are publicly available at the Open Science Framework: <https://osf.io/nsf6w/> (DOI 10.17605/OSF.IO/NSF6W)

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References of studies included in to the meta-analysis can be found in Supplement 7.