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SYSTEMATIC REVIEW

# The influence of perioperative interventions targeting psychological distress on clinical outcome after total knee arthroplasty

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## Abstract

Our aim was to assess the effect of perioperative interventions targeting psychological distress on clinical outcome after total knee arthroplasty (TKA). We searched studies on the effect of perioperative interventions focused on psychological distress used in conjunction with TKA on pain, function, and quality of life (QoL) on PubMed, Embase.com, PsycINFO/OVID, CENTRAL, the Cochrane Database of Systematic Reviews, Scopus, and Web of Science. We included 40 studies (22 RCTs, ten cohort studies, and eight quasi-experimental studies) with a total of 3846 patients. We graded the quality of evidence as low for pain and function and as moderate for QoL. Patients receiving music, education, cognitive behavioural therapy, guided imagery, pain coping skills training, Reiki, occupational therapy with self-monitoring, and biofeedback-assisted progressive muscles relaxing training had lower pain scores or declined opioid prescriptions after TKA. Pain coping skills training, audio recording-guided imagery scripts, video promoting self-confidence, psychological therapies by video, Reiki, music, occupational therapy with self-monitoring, education, and psychotherapy improved postoperative functional outcome. Education through an app improved QoL after TKA. The studies in our systematic review show that perioperative interventions targeting psychological distress for patients receiving TKA seem to have a positive effect on postoperative pain, function, and QoL. RCTs with strict methodological safeguards are still needed to determine if perioperative interventions focused on psychological distress should be used in conjunction with TKA. These studies should also assess which type of intervention will be most effective in improving patient-reported outcome measures and declining opioid prescriptions.

**Keywords** Total knee arthroplasty · Psychological distress · Pain · Function · Quality of life

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## Introduction

Total knee arthroplasty (TKA) is the treatment of choice for medically operable patients with end-stage osteoarthritis (OA) of the knee joint if non-surgical therapies fail to obtain adequate pain relief and functional improvement [1]. TKA proved to be a cost-effective procedure with excellent postoperative implant-related outcomes, such as radiographic appearance and implant features [2]. Nevertheless, a significant number of patients report pain (8.0–26.5%) on long-term follow-up after TKA [3] and as many as 11–19% of the patients are not satisfied with their procedure [4, 5]. Persistent pain after TKA is commonly treated with opioids after surgery [6]. Currently, increasing misuse and addiction to opioids are a rapidly evolving public health issue [7]. Improving pain scores after surgery by understanding factors influencing postoperative pain may help prevent further expansion of this opioid crisis [7].

Unfavourable outcome after TKA is related to age, gender, level of education, pre-operative function and pain [8], comorbidities [9], social support [9], Body Mass Index (BMI) [10], and surgical factors [11–13]. Preoperative psychological factors such as mental health status, symptoms of anxiety and depression, and poor coping skills have also been examined [13–15]. Systematic reviews [16–18] and meta-analyses [19, 20] on this subject reported that psychological distress might affect the postoperative outcome (pain and function) after TKA. Perioperative interventions targeting these psychological factors may improve clinical outcome after surgery. Previous studies have examined the effect of interventions influencing psychological factors to improve postoperative clinical outcome after TKA [21–24]. We found three previous systematic reviews on psychological interventions in conjunction to orthopaedic surgeries [25–27]. The systematic review of Bay et al. [25] did not support the effectiveness of psychological interventions in improving patient-reported joint outcomes after TKA as the interventions explored by studies were found to be ineffective at the latest follow-up. The results of Szeverenyi et al. [26] and Tong et al. [27] indicated that psychological interventions might improve postoperative outcome of orthopaedic surgery. These previous reviews included several types of orthopaedic procedures (among which TKA, total hip arthroplasty (THA) and spinal procedures) and did not focus on TKA. Besides, the most up-to-date search was performed in January 2018 [27].

To our knowledge, focused systematic reviews of studies on TKA patients with wide search and inclusion criteria investigating the effect of interventions targeting psychological distress on patient-reported outcome measures pain, function and/or quality of life (QoL) after surgery have not yet been reported. The aim of our systematic review was to assess the effect of perioperative interventions focused on psychological distress on pain, function and QoL after primary TKA for OA of the knee.

## Methods

### Search strategy and study selection

We registered our review protocol at PROSPERO international prospective register of systematic reviews (<https://www.crd.york.ac.uk/PROSPERO/>) with reference number CRD42016052466 ([https://www.crd.york.ac.uk/prospero/display\\_record.php?ID=CRD42016052466](https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42016052466)). We performed this systematic review according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement criteria [28].

We performed the literature search according to the guidance of Gasparyan et al. [29]. A professional medical librarian (CdH) identified therapeutic studies (published articles and abstracts of major conferences) exploring the influence of any type of perioperative (before TKA, during surgery, or during postoperative rehabilitation) interventions targeting psychological distress on postoperative outcome (pain, function, and/or QoL) after TKA by searching PubMed, Embase.com, PsycINFO/OVID, CENTRAL, the Cochrane Database of Systematic Reviews, Scopus and Web of Science from inception up to May 26, 2020.

The following terms, including synonyms and closely related words, were used as index terms or free-text words: ‘total knee arthroplasty’ and ‘psychological intervention’. Full search strategies for all the databases are available in Supplementary Appendix 1. Duplicate articles were excluded.

Selection of articles was limited to adults > 18 years who had undergone a primary total knee replacement for osteoarthritis of the knee. We included different study designs (RCTs, cohorts, quasi-experimental studies) investigating the effect of any intervention targeting psychological distress on postoperative pain, function and/or QoL. Minimum duration of follow-up was not an inclusion criterion with the aim to create a complete overview of all studies that have investigated the effect of perioperative interventions focused on psychological distress on pain, function and/or QoL. Perioperative interventions influencing psychological factors of patients had to be clearly defined. Full-text availability was required. There were no restrictions with respect to language, age, or publication source of the paper.

Exclusion criteria were studies not meeting domain, determinant, or outcome, case reports, descriptive studies (in which there was no control group), non-primary literature studies (letter to the editor, reviews, thesis, expert opinions) and articles with no separated results of patients after TKA and total hip arthroplasty (THA) or other types of surgery if various surgical procedures were analysed.

### Main outcome variables

Two authors (JS & GO) independently screened articles for title and abstract and thereafter full text if the abstract potentially met the inclusion criteria. Subsequently, the authors (JS & GO) individually extracted information regarding study design, baseline patient characteristics, baseline clinical findings, follow-up, number of patients initially included in the study, the number of patients available for follow-up and data regarding the primary outcomes of the systematic review. When there was disagreement with respect to data extraction, a third author (AH or RP) could make the final decision.

## Quality assessment

We assessed the risk of bias of the included studies using Cochrane Collaboration's tool for assessing the risk of bias [30]. Using this tool, two authors (JS & GO) independently scored six types of bias (selection bias, performance bias, detection bias, attrition bias, reporting bias, and other types of bias) as low, high, or unclear on potential risk of bias [30].

We used the Grading of Recommendation, Assessment, Development, and Evaluation (GRADE) approach to qualify the overall level of evidence of outcome measures pain, function and/or QoL (<https://www.gradeworkinggroup.org/>). Using the GRADEpro software (McMaster University, 2015, available from [www.grade-pro.org](http://www.grade-pro.org)), we graded the quality of evidence as high, moderate, low, or very low [31].

## Data analysis

We arranged the studies according to the type of perioperative intervention (music, education, psychotherapy, and remaining) and collected data of the effect of perioperative interventions targeting psychological distress on post-operative clinical outcome measures pain, function, and QoL. Initially, our intention was to pool data to perform a meta-analysis.

## Results

The search strategy and article selection of articles published from 1964 to 26 May 2020 are shown in the flowchart (Fig. 1). Out of 7835 articles remaining after deduplication,

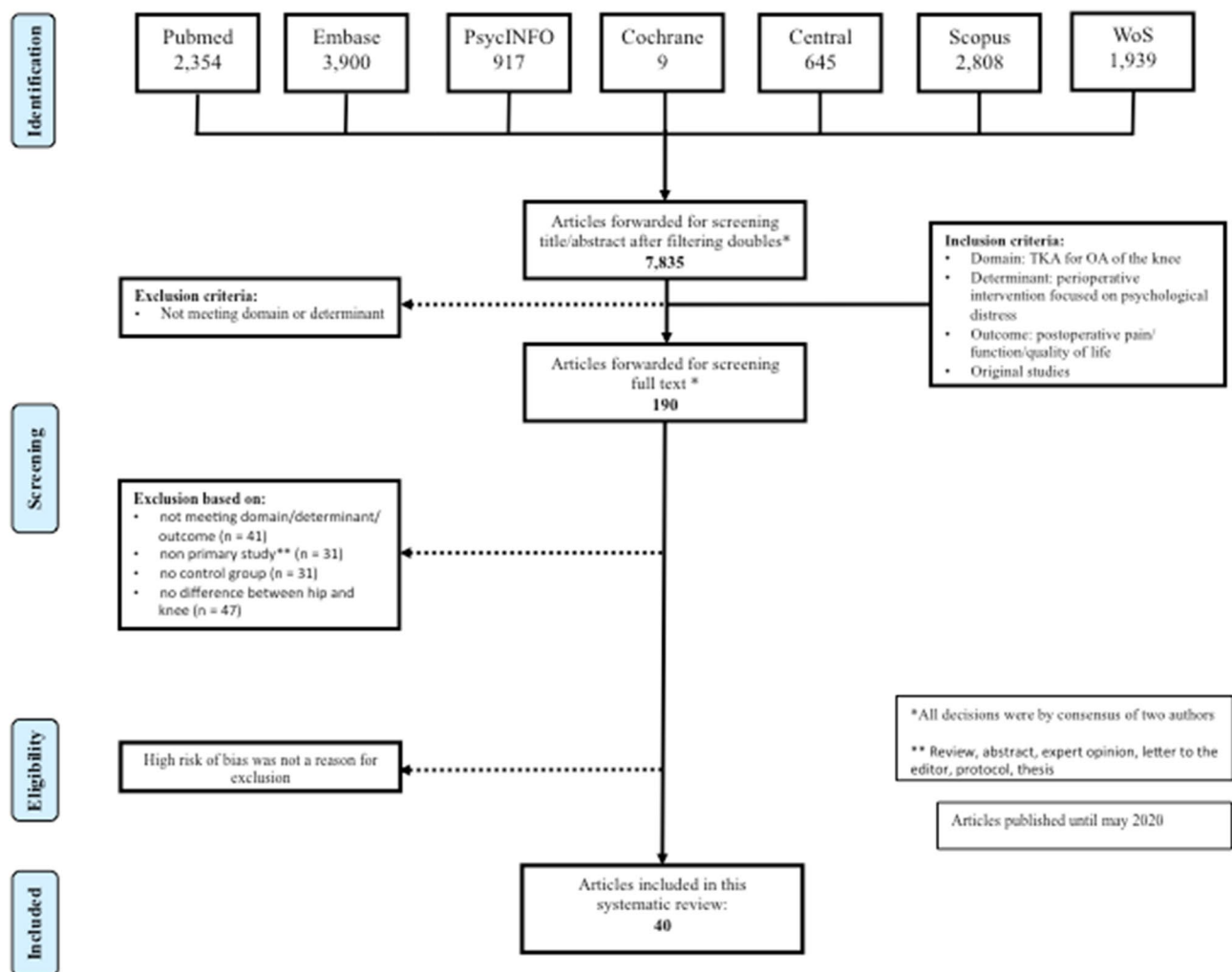


Fig. 1 Search strategy and article selection

we included 40 studies of which 22 RCTs (one randomised controlled pilot study), 10 cohort studies, and 8 quasi-experimental studies with a total number of 3846 patients.

## Interventions

A description of the interventions in the experimental and the control groups and the time at which the interventions were applied are presented in Table 1.

### Music

Nine studies examined the effect of perioperative listening to music on postoperative outcome. Eight of these studies [32–34, 36–40] assessed the effect of music on pain and three [35, 36, 40] on function. Music was offered at different time points and different types of music were provided.

### Education

The effect of education on postoperative outcome was investigated in fifteen studies in which the time of education varied from 12 weeks before surgery to 3 months after surgery (Table 1).

### Psychotherapy

Psychological therapies provided with direct support from a professional were examined by eight studies. The patients in the RCTs of Jacobson et al. [61] and Russo et al. [64], who also received psychological therapy, received their psychological intervention by audio recordings, or watching a video instead of direct contact with a health care professional.

### Other/remaining interventions

Four remaining interventions (Reiki, biofeedback relaxing training and enhanced reality analgesia, self-monitoring using a diary), applied to six studies, could not be allocated to the music, educational, or psychological therapy intervention groups and were, therefore, classified as remaining interventions (Table 1).

### Outcomes

Outcome measures pain, function, and/or QoL were assessed in 22 RCTs (one randomised controlled pilot study), 10 cohort studies, and 8 quasi-experimental studies. Mean age of the patients ranged from 61.7 to 74.1 years and duration of follow-up ranged between 60 min and 2 years. Due to the heterogeneity of the type of studies, interventions, outcome

measures and follow-up there was no possibility to pool data to perform a meta-analysis.

## Pain

34 studies examined the influence of a perioperative intervention targeting psychological distress on clinical outcome pain after the TKA. Many different scoring systems were used to score postoperative pain and eight studies assessed pain medication use as an outcome measure for pain (Table 2).

As shown in Table 2, patients in the intervention groups had significant better postoperative pain scores or declined prescriptions of opioids in 20 studies. Therapies applied in these studies were music during surgery [40] or after surgery [33, 36, 38, 39], education [41, 49, 51–53, 55], cognitive behavioural therapy [57, 58], guided imagery [61], pain coping skills training [62], Reiki therapy [66, 70], occupational therapy in combination with self-monitoring using a diary [68], weight-bearing biofeedback training [67] and biofeedback-assisted progressive muscle relaxing training [71]. The remaining 14 studies did not show a significant effect on any of the pain-related outcome measures or pain medication use at the latest follow-up when using a perioperative intervention focused on psychological distress in conjunction to TKA.

## Function

A total of 29 studies examined the effect of an intervention targeting psychological distress on function after the TKA (Table 3).

As shown in Table 3, function was significantly improved by perioperative interventions in 18 studies. Pain coping skills training [62], audiorecording guided imagery scripts [61], video promoting self-confidence and psychological support [64], music [35, 36], occupational therapy in combination with self-monitoring using a diary [68], various types of education [41, 43, 45, 47, 51–53], weight-bearing biofeedback training [67], and psychological therapies (behavioural change intervention [60] and cognitive behavioural therapy [57–59]) positively affected any, but not all, of the functional outcome measures after TKA. In the most recent study by Riddle et al. [63], patients receiving pain coping skills training did not have significantly better scores on WOMAC function and the short physical performance battery. Other types of education [42, 44, 48–50, 55], music during physiotherapy [38], enhanced reality analgesia [69], cognitive behavioural therapy delivered by physiotherapists [56], and psychological support from a professional psychologist [23] did also not affect any of the functional outcome measures after TKA.

**Table 1** Overview of included studies

| Type of intervention | Study                             | Description of intervention                                                                                                                                                 | When was the intervention applied?                                                                          |
|----------------------|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Music                | Allred [32]<br>Prospective cohort | I: Easy-listening music with headphones for 20 min<br>C: 20-min quiet rest period                                                                                           | Before and after their first ambulation at the first postoperative day                                      |
|                      | Aris [33] RCT                     | I: Additional relaxing music therapy during recovery (<60 beats per minute)<br>C: Usual care                                                                                | During recovery                                                                                             |
|                      | Chen [34] RCT                     | I: Five compositions of 30 min soothing piano and Chinese violin music (60–80 beats per minute)<br>C: No music                                                              | Ward before surgery, in the waiting area of the surgical room and twice during postoperative recovery       |
|                      | Hsu [35] Prospective cohort       | I: Slow relaxing music with slow tempo, low tone and soft melody<br>C: No music, required to rest in bed                                                                    | Once a day at the 10 a.m. continuous passive motion (CPM) session on the first and second postoperative day |
|                      | Hsu [36] Single-group QES         | I: Music for 10 min before receiving CPM until the end of the CPM session<br>C: Rest in bed for 10 min before CPM began                                                     | During CPM the first and second days after surgery                                                          |
|                      | Keshmiri [37] RCT                 | I1: Isolation of noise by soundproof headphones in conjunction to disposable earplugs<br>I2: Music of patients' choice with headphones<br>C: No isolation of noise or music | During surgery, after the effect of sedative (Propofol) was applied                                         |
|                      | Leonard [38] RCT                  | I: Co-treatment session that used live music to support exercise<br>C: Physiotherapy without music                                                                          | Postsurgery, after admission to the inpatient rehabilitation unit                                           |
|                      | Santhna [39] QES                  | I: Music for five days post-operatively and analgesics<br>C: No music, only pharmacological intervention                                                                    | 5 days postoperatively                                                                                      |
|                      | Simcock [40] RCT                  | I: Music of patients' choice with headphones<br>C: White noise emanating from the headphones                                                                                | During surgery, after a spinal-epidural anaesthesia and sedation with propofol                              |
|                      | Atabaki [41] RCT                  | I: Educational intervention presented as a combination of lecture, group discussion, individual education, questions and answers<br>C: Usual care                           | Four perioperative stages (one day before surgery, 24 h and 48 h later, upon discharge from the hospital)   |
| Education            | Aytekin [42] Prospective cohort   | I: Education (about OA, joint protection, home safety, and TKA) and home-based exercise<br>C: No additional training program, usual care                                    | During 12 weeks before the operation                                                                        |
|                      | Chen [43] QES                     | I: Cognitive-behavioural educational intervention (pamphlet, CD and oral instructions)<br>C Routine care and usual instructions delivered orally                            | Before surgery after hospitalisation and 1 days postsurgery                                                 |
|                      | Huang [44] RCT                    | I: 40-min preoperative home rehabilitation education program by a physiotherapist<br>C: No education program                                                                | 2–4 weeks prior to admission                                                                                |
|                      | Huang [45] RCT                    | I: Traditional education, telephone education and mobile education<br>C: Traditional face-to-face and telephone education                                                   | Following surgery                                                                                           |



**Table 1** (continued)

| Type of intervention             | Study | Description of intervention                                                                                                                                             | When was the intervention applied?                                                                                                                     |
|----------------------------------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lee [46] RCPS                    |       | I1: Psychoeducation on CPSP and prerecorded hypnotic intervention using audiotapes                                                                                      | One delivered before and another delivered at least 24 h after surgery                                                                                 |
|                                  |       | I2: Psychoeducation on CPSP and diaphragmatic breathing relaxation exercise                                                                                             |                                                                                                                                                        |
| Lin [47] QES                     |       | C: Usual care                                                                                                                                                           | Preadmission preoperative                                                                                                                              |
|                                  |       | I: One-to-one less than 30 min preadmission preoperative teaching*                                                                                                      |                                                                                                                                                        |
| Louw [48] CCTWAA                 |       | C: Postadmission preoperative teaching and no video                                                                                                                     | Before surgery                                                                                                                                         |
|                                  |       | I: Education program and an additional 30-min group pain neuroscience education session                                                                                 |                                                                                                                                                        |
| Mallerschek [49] RCT             |       | C: Only education program                                                                                                                                               | 3–6 days after TKA                                                                                                                                     |
|                                  |       | I: Additional pain psychoeducation over at least 45 min                                                                                                                 |                                                                                                                                                        |
| Moulton [50] Prospective cohort  |       | C: Usual care                                                                                                                                                           | Preoperative for 2 h                                                                                                                                   |
|                                  |       | I: Joint school by members of a multidisciplinary group explaining the process of the surgery                                                                           |                                                                                                                                                        |
| Piva [51] RCT                    |       | C: No joint school                                                                                                                                                      | During 3 months postoperative: 2 lectures during the first postoperative week and mini-sessions of physical activity promotion in the subsequent weeks |
|                                  |       | I: Interactive education to promote physical activity and healthy eating                                                                                                |                                                                                                                                                        |
| Reslan [52] QES                  |       | C: No education                                                                                                                                                         | Prior to surgery                                                                                                                                       |
|                                  |       | I: One to one intervention (30–40 min) including education and exercise training by a nurse                                                                             |                                                                                                                                                        |
| Timmers [53] RCT                 |       | C: Standard hospital care                                                                                                                                               | During the 28-day period after discharge                                                                                                               |
|                                  |       | I: Day-to-day postoperative care information related to topics such as pain, physiotherapy exercises, wound care, and daily self-care activities through an application |                                                                                                                                                        |
| Wilson [54] RCT                  |       | C: Only weekly, basic information                                                                                                                                       | Teaching session and booklet within 4 weeks prior to surgery<br>Phone call during a week before surgery                                                |
|                                  |       | I: Usual teaching and preoperative educational intervention**                                                                                                           |                                                                                                                                                        |
| Yajnik [55] Retrospective cohort |       | C: Usual teaching                                                                                                                                                       | Prior to peripheral nerve block placement on the day of surgery, at the time of ward admission by the bedside nurse and once daily during rounds       |
|                                  |       | I: Pain management educational card***                                                                                                                                  |                                                                                                                                                        |
|                                  |       | C: Before implementation of pain management educational card                                                                                                            |                                                                                                                                                        |
|                                  |       | I: Pain management educational card***                                                                                                                                  |                                                                                                                                                        |

**Table 1** (continued)

| Type of intervention | Study                             | Description of intervention                                                                                                                                      | When was the intervention applied?                                                                             |
|----------------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Psychotherapy        | Birch [56] RCT                    | I: CBT based pain education of approximately 45 min delivered by 2 physiotherapists<br>C: Usual care                                                             | 3 sessions preoperatively and 4 sessions postoperatively (2 weeks before surgery until 3 months after surgery) |
|                      | Cai [57] RCT                      | I: CBT<br>C: No CBT                                                                                                                                              | After TKA                                                                                                      |
|                      | Cai [58] RCT                      | I: Individually tailored CBT by a physiotherapist and a psychologist<br>C: No CBT                                                                                | During 4 weeks after surgery                                                                                   |
|                      | Das Nair [59] RCT                 | I: 10 sessions of CBT during hour-long sessions by one or two psychologists<br>C: No CBT                                                                         | During waiting time for surgery                                                                                |
|                      | Harnirattisai [60] QES            | I: 25-min sessions of nurse-patient interaction and discussion****<br>C: No behavioural change intervention                                                      | At the fourth postoperative day and two weeks after surgery                                                    |
|                      | Jacobson [61] RCT                 | I: 19- to 21- minute audio recordings of guided imagery\$ scripts designed for TKA patients<br>C: Commercially available 17- to 21-min audio recordings          | Every day for two weeks before surgery and three weeks after surgery                                           |
|                      | Riddle [62] QES                   | I: Intervention delivered by trained psychologists#<br>C: No intervention                                                                                        | During 8 weekly sessions from approximately one month prior to surgery to one month after surgery              |
|                      | Riddle [63] RCT                   | I1: Eight 50-min sessions of 1-on-1 pain coping skills training<br>I2: Eight 50-min sessions of 1-on-1 arthritis education by registered nurses<br>C: Usual care | Approximately 2 weeks preoperatively to approximately 6 weeks postoperatively                                  |
|                      | Russo [64] RCT                    | I: Video according to the Videoinsight Methods^ principles<br>C: No video                                                                                        | Three times a week during the first 3 months after surgery                                                     |
|                      | Tristaino [23] Prospective cohort | I: Four psychologist-patient sessions of 30 min focusing on defining the psychological themes and concepts on which to focus the activity<br>C: Standard of care | One before surgery, two during postoperative hospital stay and one during rehabilitation                       |



Table 1 (continued)

| Type of intervention | Study                         | Description of intervention                                                                                                                                                                                                             | When was the intervention applied?                                                                                                                                |
|----------------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Remaining            | Baldwin [66] RCT              | I1: Three or four 30-min Reiki treatments provided by three expert Reiki professionals<br>I2: Standard of care and three or four sham Reiki session delivered by non-trained people<br>C: Standard of care and sessions of “quiet time” | During the hospital stay                                                                                                                                          |
|                      | Christiansen [67] RCT         | I: Standard of care rehabilitation plus weight bearing biofeedback training<br>C: Standard of care rehabilitation alone                                                                                                                 | On the morning before surgery (20 min) and after admission to the post anaesthesia care unit (30 min) and 20 min at the first, second and third postoperative day |
|                      | Hiraga [68] NRCT              | I: Occupational therapy & self-monitoring using a diary<br>C: Occupational therapy only                                                                                                                                                 | From 1 to 2 weeks postoperatively                                                                                                                                 |
|                      | Koo [69] RCT                  | I: Enhanced reality analgesia<br>C: No enhanced reality analgesia                                                                                                                                                                       | Shortly after physiotherapy for 5 times a week, for 2 weeks<br>Shortly after physiotherapy for 5 times a week, for 1 week                                         |
|                      | Notte [70] Prospective cohort | I: Weight bearing (WB) biofeedback-assisted progressive muscle relaxation training sessions using a Nintendo Wii fit Plus game and associated Wii balance board<br>C: Standard of care                                                  | Twice weekly at home for 6 weeks after surgery                                                                                                                    |
|                      | Wang [71] QES                 | I: CPM therapy and 30-min biofeedback relaxation training<br>C: Only CPM therapy                                                                                                                                                        | One day before surgery and twice a day on the five first postoperative days, concurrent with CPM therapy                                                          |

I: intervention group, C: control group, RCT randomised controlled trial, CPM continuous passive motion, QES quasi-experimental study, OA osteoarthritis, TKA total knee arthroplasty, CD compact disk, RCT randomized controlled pilot study, CPSP chronic postsurgical pain, CCTWAA controlled clinical trial with alternating allocation, CBT cognitive behavioural therapy, NRCT non-randomised controlled trial

\*Preoperative education about care pathway, knee surgery, pain management, expected discharge goals and in-patient and out-patient arthroplasty rehabilitation by an educational nurse and a booklet

\*\*Preadmission preoperative teaching with an instruction booklet during a preoperative outpatient clinic visit. Upon admission to the hospital, they were presented with an educational videotape

\*\*\*A booklet containing symptom management after TKA, an individual teaching session, and a follow-up support call by the principal investigator

\*\*\*\*25-Min sessions of nurse-patient interaction and discussion regarding specific exercises and physical activity, self-monitoring, goal setting, family support and encouragement, and information prompting

§Guided imagery is a widely used mind-body intervention by the generation of self- or practitioner-guided positive sensory and affective mental images to promote health changes in the body, reducing anxiety and stress, and evoking psychological and physiologic relaxation [61]

#Intervention addressed to the recovery of physical function, the concerns during the recovery period and strategies for coping with pain after the operation delivered by trained therapists

^The video was established to produce positive and therapeutic insight, according to the Videoinsight Methods principles [65]

**Table 2** The influence of perioperative interventions targeting psychological distress on pain after the TKA

| Type of intervention | Study         | Nr TKA | Females (%) | Age mean $\pm$ SD  | Follow-up          | Outcome score (pain)                                                | I score $\pm$ SD                            | C score $\pm$ SD   | Statistically significance at latest follow-up                |
|----------------------|---------------|--------|-------------|--------------------|--------------------|---------------------------------------------------------------------|---------------------------------------------|--------------------|---------------------------------------------------------------|
| Music                | Allred 2010   | T      | 56          | 63.9 (64-84)*      | 6 hours            | VAS                                                                 | 41.2 $\pm$ 25.8                             | 45.1 $\pm$ 31.2    | $P = 0.337$                                                   |
|                      |               | I      | 28          |                    |                    | MPQ                                                                 | 15.9 $\pm$ 10.6                             | 14.9 $\pm$ 12.3    | $P = \text{na}$ , no statistical analysis between groups      |
|                      |               | C      | 28          |                    |                    | Opioid use (morphine or dilauidid)                                  | na                                          | na                 | $P = 0.388$ and $P = 0.152$ (regarding which oral medication) |
|                      | Aris 2019     | T      | 56          |                    | 60 minutes         | VAS                                                                 | 0 (24.39)**                                 | 1.5 (32.61)**      | $P = 0.045$                                                   |
|                      |               | I      | 28          | 63.71 $\pm$ 11.005 |                    |                                                                     |                                             |                    |                                                               |
|                      |               | C      | 28          | 64.50 $\pm$ 8.851  |                    |                                                                     |                                             |                    |                                                               |
|                      | Chen 2015     | T      | 30          | 68 (53-85)*        | Postoperative days | VAS (recovery)                                                      | 3.22 $\pm$ 0.22***                          | 3.00 $\pm$ 0.25*** | $P = 0.50$                                                    |
|                      |               | I      | 15          |                    |                    | VAS (ward)                                                          | 3.07 $\pm$ 0.26***                          | 2.87 $\pm$ 0.18*** | $P = 0.53$                                                    |
|                      |               | C      | 15          |                    |                    | Opioid use (parental morphine, meperidine, fentanyl in PO recovery) | 7.39 $\pm$ 2.66                             | 6.86 $\pm$ 2.29    | $P = 0.57$                                                    |
|                      |               |        |             |                    |                    | Opioid use (parental morphine, meperidine, fentanyl in the ward)    | 12.04 $\pm$ 14.43                           | 12.90 $\pm$ 8.05   | $P = 0.89$                                                    |
| Hsu 2019             | T             | 49     | 34 (69.4)   | 73.9 $\pm$ 7.5     | 2 days             | NRS                                                                 | 0.06 $\pm$ 0.24                             | 2.14 $\pm$ 1.10    | $P < 0.01$                                                    |
|                      |               | I      | 49          |                    |                    |                                                                     |                                             |                    |                                                               |
|                      |               | C      | 49          |                    |                    |                                                                     |                                             |                    |                                                               |
|                      | Keshmiri 2014 | T      | 83          | 68.7 $\pm$ 0.96    | 2-7 days           | VAS (day 1-3)                                                       | 1.33 $\pm$ 0.11 (I1) & 1.44 $\pm$ 0.13 (I2) | 1.49 $\pm$ 0.13    | $P = 0.718$                                                   |
|                      |               | I1     | 28          |                    |                    | VAS (day 4-7)                                                       | 0.9 $\pm$ 0.15 (I1) & 0.81 $\pm$ 0.13 (I2)  | 1.23 $\pm$ 0.19    | $P = 0.330$                                                   |
|                      |               | I2     | 27          |                    |                    | VAS (day 17)                                                        | 1.09 $\pm$ 0.12 (I1) & 1.08 $\pm$ 0.11 (I2) | 1.34 $\pm$ 0.14    | $P = 0.435$                                                   |
|                      |               | C      | 28          |                    |                    | Days of pain catheter duration (type of pain medication na)         | 3.43 $\pm$ 0.11 (I1) & 3.48 $\pm$ 0.12 (I2) | 3.36 $\pm$ 0.19    | $P = 0.452$                                                   |
|                      |               |        |             |                    |                    |                                                                     |                                             |                    |                                                               |
|                      |               |        |             |                    |                    |                                                                     |                                             |                    |                                                               |
|                      |               |        |             |                    |                    |                                                                     |                                             |                    |                                                               |

Table 2 (continued)

| Type of intervention | Study        | Nr TKA | Females (%)    | Age mean $\pm$ SD  | Follow-up          | Outcome score (pain)          | I score $\pm$ SD  | C score $\pm$ SD | Statistically significance at latest follow-up |
|----------------------|--------------|--------|----------------|--------------------|--------------------|-------------------------------|-------------------|------------------|------------------------------------------------|
| Education            | Leonard 2019 | T      | 32             |                    | Postoperative days | NRS                           | 5.44 $\pm$ 3.2    | 5.56 $\pm$ 2.52  | "No significant difference"                    |
|                      |              | I      | 16             | 67.9 (45-87)*      |                    | Observational coding for pain | 3.06 $\pm$ 3.13   | 2.31 $\pm$ 2.36  | P = 0.02                                       |
|                      |              | C      | 16             | 67.6 (53-80)*      |                    |                               |                   |                  |                                                |
|                      | Santhna 2015 | T      | 40             | 63.80 $\pm$ 5.64   | 5 (days)           | PRI                           | 11.78^            | 29.23^           | P = 0.00                                       |
|                      |              | I      | 20             | 64.90 $\pm$ 6.94   |                    |                               |                   |                  |                                                |
|                      |              | C      | 20             |                    |                    | VAS                           | 14.20^            | 26.80^           | P = 0.00                                       |
|                      |              |        |                |                    | PPI                | 15.00^                        | 26.00^            | P = 0.001        |                                                |
|                      |              |        |                |                    | Paracetamol        | 16000mg^^                     | 17000 mg^^        | P > 0.05         |                                                |
|                      |              |        |                |                    | Celecoxib          | 600 mg^^                      | 1600 mg^^         | P > 0.05         |                                                |
|                      |              |        |                |                    | Tramadol           | 125 mg^^                      | 225 mg^^          | P > 0.05         |                                                |
| Education            | Simcock 2008 | T      | 30             |                    | 24 hours           | VAS (3 hours PO)              | 3.87 $\pm$ 3.44   | 1.47 $\pm$ 1.39  | P = 0.01                                       |
|                      |              | I      | 15             | 67.3 $\pm$ 9.1     |                    | VAS (6 hours PO)              | 5.26 $\pm$ 3.04   | 3.38 $\pm$ 2.48  | P = 0.075                                      |
|                      |              | C      | 15             |                    |                    | VAS (24 hours PO)             | 4.03 $\pm$ 2.89   | 2.41 $\pm$ 1.67  | P = 0.04                                       |
|                      | Atabaki 2019 | T      | 56             | 65.39 $\pm$ 5.08   | 6 (weeks)          | WOMAC                         | 40.47 $\pm$ 10.47 | 57.29 $\pm$ 7.51 | P = 0.001                                      |
|                      |              | I      | 48             | 63.83 $\pm$ 5.14   |                    |                               |                   |                  |                                                |
|                      |              | C      | 48             |                    |                    |                               |                   |                  |                                                |
|                      | Aytekin 2019 | T      | 44             |                    | 6 months           | VASpr                         | 0.4 $\pm$ 0.9     | 0.8 $\pm$ 1.1    | "no significant difference between groups"     |
|                      |              | I      | 23             | 67.8 $\pm$ 6.3     |                    | VASpa                         | 1.5 $\pm$ 1.5     | 2.3 $\pm$ 2.3    | "no significant difference between groups"     |
|                      |              | C      | 21             | 69.7 $\pm$ 6.4     |                    | KOOSpain                      | 87.9 $\pm$ 15.4   | 92.7 $\pm$ 8.3   | "no significant difference between groups"     |
|                      | Chen 2014    | T      | 92             | 69.26 $\pm$ 9.025  | 5 days             | NRS (worst pain)              | 4.89 $\pm$ 2.82   | 5.57 $\pm$ 2.84  | P = 0.308                                      |
|                      | I            | 42     |                | NRS (average pain) |                    | 2.38 $\pm$ 1.97               | 2.43 $\pm$ 2.03   | P = 0.916        |                                                |
|                      | C            | 50     |                | NRS (current pain) |                    | 2.46 $\pm$ 2.31               | 2.57 $\pm$ 2.26   | P = 0.836        |                                                |
| Huang 2011           | T            | 242    | 70.2 $\pm$ 7.3 | 5 days             | VAS                | 2.4 $\pm$ 0.7                 | 2.5 $\pm$ 0.6     | P = 0.686        |                                                |
|                      | I            | 125    |                |                    |                    |                               |                   |                  |                                                |
|                      | C            | 117    |                |                    |                    |                               |                   |                  |                                                |

Table 2 (continued)

| Type of intervention | Study            | Nr TKA | Females (%) | Age mean $\pm$ SD | Follow-up       | Outcome score (pain)                                     | I score $\pm$ SD                            | C score $\pm$ SD               | Statistically significance at latest follow-up                                |
|----------------------|------------------|--------|-------------|-------------------|-----------------|----------------------------------------------------------|---------------------------------------------|--------------------------------|-------------------------------------------------------------------------------|
| Louv 2019            | T                | 103    |             |                   | 6 (months)      | NRS                                                      | na                                          | na                             | $P = 0.386$                                                                   |
|                      |                  | 49     | 32 (65.3%)  | 74.1 $\pm$ 9.5    |                 | Morfine                                                  | 2601.62 $\pm$ 1103.90                       | 2734.02 $\pm$ 1324.60          | $P = 0.635$                                                                   |
|                      |                  | 54     | 23 (51.9)   | 69.6 $\pm$ 10.6   |                 |                                                          |                                             |                                |                                                                               |
|                      | Malletschek 2019 | 75     | 47 (62.7)   | 59-78*            | 3 months        | KOOSpain                                                 | na                                          | na                             | $P = 0.01$                                                                    |
|                      |                  | 37     |             |                   |                 |                                                          |                                             |                                |                                                                               |
|                      |                  | 38     |             |                   |                 |                                                          |                                             |                                |                                                                               |
| Lee 2019             | T                | 24     |             |                   | 6 months        | NRS                                                      | 1.40 $\pm$ 0.89 (I1) & 1.73 $\pm$ 1.40 (I2) | 2.23 $\pm$ 1.41                | HYP vs. control: $P = 0.134$ and $P = 0.038$ (when controlled for covariates) |
|                      | I1               | 8      | 7 (87.5)    | 65.63 $\pm$ 9.27  |                 |                                                          |                                             |                                | MET vs. Control: $PP = 0.975$                                                 |
|                      | I2               | 8      | 7 (87.5)    | 56.25 $\pm$ 11.22 |                 |                                                          |                                             |                                |                                                                               |
|                      | C                | 8      | 8 (100)     | 67.88 $\pm$ 10.38 |                 |                                                          |                                             |                                |                                                                               |
| Moulton 2017         | T                | 563    | na          | 70.1 $\pm$ na     | 2 years         | OKS (6 months PO)                                        | 28.71 $\pm$ na                              | 31.60 $\pm$ na                 | $P = 0.251$                                                                   |
|                      | I                | 503    |             |                   |                 | OKS (2 years PO)                                         | 30.17 $\pm$ na                              | 33.26 $\pm$ na                 | $P = 0.440$                                                                   |
| Piva 2017            | T                | 44     |             |                   | 6 months        | WOMAC pain                                               | min 1.7 (95% CI -3.0,-4.0) ^^^              | min 0.3 (95% CI -1.5, 1.0) ^^^ | $P = 0.035$                                                                   |
|                      | I                | 22     | 31 (70.5)   | 68.1 $\pm$ 7.5    |                 |                                                          |                                             |                                |                                                                               |
|                      | C                | 22     |             | 68.3 $\pm$ 5.5    |                 |                                                          |                                             |                                |                                                                               |
|                      | T                | 60     |             | na                | 4 weeks         | HSSpain                                                  | 22.83 $\pm$ 4.78                            | 19.18 $\pm$ 5.14               | $PP = 0.001$                                                                  |
| Reslan 2018          | I                | 30     | 19 (63.6)   |                   |                 |                                                          |                                             |                                |                                                                               |
|                      | C                | 30     | 17 (56.7)   |                   |                 |                                                          |                                             |                                |                                                                               |
| Timmers 2019         | T                | 213    |             |                   | 4 weeks         | NRS at rest                                              | 3.45^                                       | 4.59^                          | $PP = 0.001$                                                                  |
|                      | I                | 114    | 74 (64.9)   | 64.74 $\pm$ 7.57  | after discharge | NRS activity                                             | 3.99^                                       | 5.08^                          | $P < 0.001$                                                                   |
|                      | C                | 99     | 60 (60.6)   | 65.63 $\pm$ 7.90  |                 | NRS at night                                             | 4.18^                                       | 5.21^                          | $P = 0.003$                                                                   |
|                      | T                | 143    | 89 (62.6)   |                   | 3 days          | BPI-I                                                    | 24.4 $\pm$ 14.4                             | 22.4 $\pm$ 15.1                | $PP = 0.45$                                                                   |
| Wilson 2016          | I                | 73     |             | 67 $\pm$ 8        |                 | NRS (rest)                                               | 2.8 $\pm$ 2.5                               | 2.8 $\pm$ 2.7                  | $P = 0.70$                                                                    |
|                      | C                | 70     |             | 66 $\pm$ 8        |                 | NRS (moving)                                             | 5.4 $\pm$ 3.0                               | 6.1 $\pm$ 2.5                  | $P = 0.20$                                                                    |
|                      |                  |        |             |                   |                 | NRS worst pain last 24 hours)                            | 7.0 $\pm$ 2.4                               | 7.0 $\pm$ 2.3                  | $P = 0.87$                                                                    |
|                      |                  |        |             |                   |                 | Opioid use (morphine, hydromorphone, oxycodone, codeine) | 40 (45)^**                                  | 40 (42)^**                     | "no difference between groups in daily 24-hours opioid administration"        |

Table 2 (continued)

| Type of intervention | Study       | Nr TKA | Females (%) | Age mean $\pm$ SD | Follow-up | Outcome score (pain)                                 | I score $\pm$ SD | C score $\pm$ SD | Statistically significance at latest follow-up                                                       |
|----------------------|-------------|--------|-------------|-------------------|-----------|------------------------------------------------------|------------------|------------------|------------------------------------------------------------------------------------------------------|
| Psychotherapy        | Yajnik 2018 | T      | 40          | 68 (46-80)*       | 2 days    | Opioid use (morphine, MME PO day 1 and 2)            | 38 (1-117)*      | 72 (32-285)*     | $P = 0.001$                                                                                          |
|                      |             | I      | 20          |                   |           | Minimum pain (patients' verbal rating 0-10) 1 day PO | 0 (0-3)*         | 0 (0-6)*         | $P = 0.151$                                                                                          |
|                      |             | C      | 20          |                   |           | Maximum pain (patients' verbal rating 0-10) 1 day PO | 4 (2-9)*         | 8 (1-10)*        | $P = 0.114$                                                                                          |
|                      | Birch 2019  | T      | 60          |                   | 1 (year)  | VAS activity                                         | 12 (5-18)^^      | 9 (3-15)^^       | $P = NS$                                                                                             |
|                      |             | I      | 31          | 66 $\pm$ 9        |           | VAS rest                                             | 7 (1-12)^^       | 6 (1-12)^^       | $P = NS$                                                                                             |
|                      | Cai 2017    | T      | 108         | 66 $\pm$ 10       | 6 months  | KSS                                                  | 82.61 $\pm$ 6.38 | 73.30 $\pm$ 8.45 | $P < 0.01$                                                                                           |
|                      |             | I      | 54          | 62.42 $\pm$ 6.59  |           |                                                      |                  |                  |                                                                                                      |
|                      | Cai 2018    | C      | 54          | 63.94 $\pm$ 6.58  |           |                                                      |                  |                  |                                                                                                      |
|                      |             | T      | 100         | 62 (55.9)         | 6 months  | NRS                                                  | 5.63 $\pm$ 0.73  | 6.27 $\pm$ 0.86  | time effects: $P < .001$ ;<br>group effects: $P = 0.003$ ;<br>group-by-time interaction: $P = 0.080$ |
|                      |             | I      | 50          | 65.26 $\pm$ 8.30  |           |                                                      |                  |                  |                                                                                                      |
|                      |             | C      | 50          | 66.18 $\pm$ 7.04  |           |                                                      |                  |                  |                                                                                                      |

**Table 2** (continued)

| Type of intervention | Study | Nr TKA | Females (%) | Age mean $\pm$ SD | Follow-up | Outcome score (pain)                                             | I score $\pm$ SD                                           | C score $\pm$ SD         | Statistically significance at latest follow-up |
|----------------------|-------|--------|-------------|-------------------|-----------|------------------------------------------------------------------|------------------------------------------------------------|--------------------------|------------------------------------------------|
| Das Nair 2018        | T     | 50     | 23 (46)     |                   |           | WOMAC pain                                                       | 6.5 $\pm$ 3.6                                              | 7.5 $\pm$ 2.3            | $P = 0.40$                                     |
|                      | I     | 25     |             | 65.7 $\pm$ 8.6    |           | ICOAP constant pain (item 1-5)                                   | 6.4 $\pm$ 4.4                                              | 6.2 $\pm$ 3.2            | $P = 0.99$                                     |
|                      | C     | 25     |             | 66.7 $\pm$ 9.9    |           | ICOAP constant pain (item 1, 3, 4, 5)                            | 4.8 $\pm$ 3.7                                              | 5.1 $\pm$ 3.0            | $P = 0.82$                                     |
| Jacobson 2016        | T     | 58     | 51 (62.2)   |                   |           | ICOAP constant pain (converted rasch score item 1, 3, 4, 5)      | 5.5 $\pm$ 4.1                                              | 6.0 $\pm$ 3.2            | $P = 0.75$                                     |
|                      | I     | 29     |             |                   |           | ICOAP intermittent pain (item 6-11)                              | 8.5 $\pm$ 5.6                                              | 10.2 $\pm$ 4.5           | $P = 0.43$                                     |
|                      | C     | 29     |             |                   |           | ICOAP intermittent pain (item 6, 7, 10, 11)                      | 5.7 $\pm$ 3.8                                              | 7.1 $\pm$ 3.3            | $P = 0.33$                                     |
|                      |       |        |             |                   |           | ICOAP intermittent pain (converted rasch score item 6, 7, 10 11) | 5.5 $\pm$ 3.4                                              | 6.7 $\pm$ 3.0            | $P = 0.34$                                     |
| Riddle 2011          | T     | 63     | 45 (71.4)   |                   | 6 months  | WOMAC pain                                                       | 2.7 $\pm$ 3.1                                              | 3.5 $\pm$ 3.3            | $P < 0.001$                                    |
|                      | I     | 18     |             | 65 (41-81)*       |           | VAS daily pain                                                   | na                                                         | na                       | $P$ not available at 6 months postoperatively  |
|                      | C     | 45     |             |                   |           |                                                                  | 6.0 $\pm$ 4.1                                              | 8.6 $\pm$ 3.7            | $P = 0.017$                                    |
| Riddle 2019          | T     | 402    |             |                   | 2 months  | WOMAC pain                                                       |                                                            |                          |                                                |
|                      | I     | 18     |             | 63.8 $\pm$ 11.5   |           |                                                                  |                                                            |                          |                                                |
|                      | C     | 45     |             | 60.8 $\pm$ 9.9    |           |                                                                  |                                                            |                          |                                                |
| Tristaino 2015       | T     | 130    | 94 (72.3)   |                   | 12 months | WOMAC pain                                                       | 3.3 (95% CI 2.5, 4.2) (I1) & 3.0 (95% CI 2.1, 3.8) (I2)^^^ | 2.9 (95% CI 2.0, 3.8)^^^ | $P = 0.60$                                     |
|                      | I     | 135    | 85 (63.0)   | 62.6 $\pm$ 7.9    |           |                                                                  |                                                            |                          |                                                |
|                      | C     | 137    | 88 (64.2)   | 64.2 $\pm$ 8.5    |           | NRS                                                              | 1.8 (95% CI 1.2, 2.4) (I1) & 2.0 (95% CI 1.3, 2.6) (I2) ^^ | 1.7 (95% CI 1.1, 2.2) ^^ | $P = na$                                       |
|                      | T     | 64     | 44 (62.0)   | 62.7 $\pm$ 7.7    |           |                                                                  |                                                            |                          |                                                |
|                      | I     | 33     |             | 64.2 $\pm$ 8.6    | 4 months  | SF-36 bodily pain                                                | 70.1 $\pm$ 21.5                                            | 67.8 $\pm$ 26.8          | $P = 0.715$                                    |
|                      | C     | 31     |             | 66.1 $\pm$ 6.6    |           |                                                                  |                                                            |                          |                                                |

Table 2 (continued)

| Type of intervention | Study        | Nr TKA | Females (%) | Age mean $\pm$ SD | Follow-up | Outcome score (pain)                                                    | I score $\pm$ SD | C score $\pm$ SD | Statistically significance at latest follow-up                                                                                                      |
|----------------------|--------------|--------|-------------|-------------------|-----------|-------------------------------------------------------------------------|------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| Remaining            | Baldwin 2017 | T      | na          | na                | 72 hours  | VAS                                                                     | na               | na               | "Reiki significant pain reduction ( $P = 0.003$ ), Sham Reiki and SOC no significant reduction"<br>$P = na$ , not mentioned in significant results) |
|                      |              | I1     | 25          |                   |           | Opioid use (oxycontin, oxycodone, morphine)                             | na               | na               |                                                                                                                                                     |
|                      |              | I2     | 12          |                   |           |                                                                         |                  |                  |                                                                                                                                                     |
|                      |              | C      | 19          |                   |           |                                                                         |                  |                  |                                                                                                                                                     |
|                      | Hiraga 2019  | T      | 41          |                   |           | NRS rest                                                                | 1.3 $\pm$ 0.4    | 1.2 $\pm$ 0.4    | $P = 0.965$                                                                                                                                         |
|                      |              | I      | 20          |                   |           | NRS walk                                                                | 1.3 $\pm$ 0.2    | 3.2 $\pm$ 0.6    | $P = 0.017$                                                                                                                                         |
|                      |              | C      | 21          |                   |           |                                                                         |                  |                  |                                                                                                                                                     |
|                      | Koo 2018     | T      | 120         |                   |           | VAS                                                                     | na (figure)      | na (figure)      | "No significance was found in VAS analyses between the groups"                                                                                      |
|                      |              | I      | 60          |                   |           |                                                                         |                  |                  |                                                                                                                                                     |
|                      |              | C      | 60          |                   |           |                                                                         |                  |                  |                                                                                                                                                     |
|                      | Notte 2016   | T      | 43          |                   |           | NRS                                                                     | na               | na               | $P = 0.000$ (1, 2, 3 days PO)                                                                                                                       |
|                      |              | I      | 23          |                   |           | Opioid use (type of opioid na)                                          | na               | na               | $P = 0.92$                                                                                                                                          |
|                      |              | C      | 20          |                   |           |                                                                         |                  |                  |                                                                                                                                                     |
|                      | Wang 2015    | T      | 66          |                   |           | NRS                                                                     | 3.36 $\pm$ 1.47  | 4.23 $\pm$ 1.67  | $P < 0.001$                                                                                                                                         |
|                      |              | I      | 33          |                   |           | Opioid use (pethidine PO day 5)                                         | 1 (3.2)          | 0 (0.0)          | $P = 0.49$                                                                                                                                          |
|                      |              | C      | 33          |                   |           | PMU (Acetaminophen or COX-2 inhibitor + pethidine or tramadol PO day 5) | 24 (77.4)        | 21 (63.6)        | $P = 0.27$                                                                                                                                          |

Nr number; TKA total knee arthroplasty; SD standard deviation; I intervention group; C control group; T total study group; VAS visual analog scale; P value; MPQ short form McGill pain questionnaire; na: not available; PO postoperative; NRS numeric rating score; PRI Pain Rating intensity; PPI Present Pain Intensity; mg milligram; WOMAC Western Ontario and McMaster universities osteoarthritis index; VASpr visual analog scale pain resting; VASpa visual analog scale pain activity; KOOSPain pain subscale of the knee injury and osteoarthritis outcome score; HYP hypnotic intervention; MET minimal-effect treatment; OKS Oxford knee score; 95% CI 95% confidence interval; HSS hospital for special surgery; BPI-I Brief Pain Inventory interference; MME Morphine Milligram Equivalents; NS not significant; KSS knee society score; ICOAP Intermittent and Constant Osteoarthritis Pain scale; SF-36 Short Form-36; SOC stand of care; PMU pain medication use; COX-2 cyclooxygenase-2

Instead of mean and SD: \*median (range), \*\*median and mean rank, \*\*\*mean and standard error, ^mean rank only, ^^median only, ^^mean estimate with the 95% CI in parentheses, ^^median (interquartile range) instead of mean and SD



**Table 3** The influence of perioperative interventions targeting psychological distress on function after the TKA

| Type of intervention | Study        | Nr TKA | Females (%) | Age mean $\pm$ SD | Follow-up          | Outcome score (function)                       | I score $\pm$ SD  | C score $\pm$ SD  | Statistically significance at latest follow-up |
|----------------------|--------------|--------|-------------|-------------------|--------------------|------------------------------------------------|-------------------|-------------------|------------------------------------------------|
| Music                | Hsu [35]     | T      | 91          | 67 (73.6)         | 2 days             | CPM angles 1 day PO                            | 24.29 $\pm$ 5.00  | 12.98 $\pm$ 4.43  | $P < 0.01$                                     |
|                      |              | I      | 49          | 73.9 $\pm$ 7.5    |                    | CPM angles 2 days PO                           | 21.22 $\pm$ 2.98  | 16.07 $\pm$ 4.49  | $P < 0.01$                                     |
|                      |              | C      | 42          | 71.33 $\pm$ 8.45  |                    | Active knee flexion ROM 2 days PO              | 106.22 $\pm$ 6.17 | 95.00 $\pm$ 6.80  | $P < 0.01$                                     |
|                      | Hsu [36]     | T      | 49          |                   | 2 days             | Increased degree of knee flexion during CPM    | 21.22 $\pm$ 2.98  | 10.02 $\pm$ 3.03  | $P < 0.01$                                     |
|                      |              | I      | 49          | 34 (69.4)         |                    |                                                |                   |                   |                                                |
|                      |              | C      | 49          | 34 (69.4)         |                    |                                                |                   |                   |                                                |
|                      | Leonard [38] | T      | 32          |                   | Postoperative days | Observational coding for pedalling adherence   | 7.81 $\pm$ 0.40   | 7.44 $\pm$ 1.21   | "No significant difference"                    |
|                      |              | I      | 16          | 11 (68.8)         |                    |                                                |                   |                   |                                                |
|                      |              | C      | 16          | 12 (75)           |                    |                                                |                   |                   |                                                |
|                      |              | T      | 96          |                   |                    |                                                |                   |                   |                                                |
| Education            | Atabaki [41] | T      | 48          | 46 (95.8)         | 6 weeks            | WOMAC stiffness                                | 19.53 $\pm$ 12.34 | 41.66 $\pm$ 10.09 | $P = 0.001$                                    |
|                      |              | I      | 48          | 65.39 $\pm$ 5.08  |                    | WOMAC performance difficulty                   | 43.48 $\pm$ 7.96  | 55.82 $\pm$ 4.30  | $P = 0.001$                                    |
|                      |              | C      | 48          | 63.83 $\pm$ 5.14  |                    |                                                |                   |                   |                                                |
|                      | Aytekin [42] | T      | 44          |                   | 6 months           | KOOS total                                     | 82.2 $\pm$ 16.1   | 85.5 $\pm$ 9.5    | "No significant difference between groups"     |
|                      |              | I      | 23          | 18 (78.3)         |                    | KOOS daily living activities                   | 87.2 $\pm$ 18.3   | 91.1 $\pm$ 9.2    | "No significant difference between groups"     |
|                      |              | C      | 21          | 18 (85.7)         |                    | KOOS sports                                    | 52.8 $\pm$ 24.4   | 56.1 $\pm$ 13.1   | "No significant difference between groups"     |
|                      | Chen [43]    | T      | 92          | 63 (68.5)         | 5 days             | Overall rating of nine physical function items | 12.38 $\pm$ 2.806 | 12.05 $\pm$ 3.682 | $P = 0.625$                                    |
|                      |              | I      | 42          |                   |                    | Ankle pumping                                  | 1.55 $\pm$ 0.39   | 1.54 $\pm$ 0.44   | $P = 0.927$                                    |
|                      |              | C      | 50          |                   |                    | Quadriceps setting                             | 0.17 $\pm$ 0.39   | 0.23 $\pm$ 0.43   | $P = 0.518$                                    |
|                      |              |        |             |                   |                    | Knee flexion/extension                         | 0.44 $\pm$ 0.53   | 0.69 $\pm$ 0.66   | $P = 0.062$                                    |
| Huang 2011           |              | T      | 242         | 174 (71.6)        | 5 days             | Straight-leg raises                            | 1.22 $\pm$ 2.58   | 0.64 $\pm$ 0.56   | $P = 0.000$                                    |
|                      |              | I      | 125         | 70.2 $\pm$ 7.3    |                    | MPOAL                                          | 3.71 $\pm$ 0.622  | 3.08 $\pm$ 1.090  | $P = 0.004$                                    |
|                      |              | C      | 117         |                   |                    | Ability to walk during discharge               | 85.7 $\pm$ na     | 81.2 $\pm$ na     | $P = 0.343$                                    |
|                      |              |        |             |                   |                    | ROM                                            | 76 $\pm$ 22       | 74 $\pm$ 20       | $P = 0.582$                                    |
|                      |              |        |             |                   |                    |                                                |                   |                   |                                                |

Table 3 (continued)

| Type of intervention | Study             | Nr TKA | Females (%) | Age mean $\pm$ SD | Follow-up | Outcome score (function)      | I score $\pm$ SD  | C score $\pm$ SD  | Statistically significance at latest follow-up        |
|----------------------|-------------------|--------|-------------|-------------------|-----------|-------------------------------|-------------------|-------------------|-------------------------------------------------------|
| Huang [45]           | T                 | 150    | 102 (68.0)  |                   | 3 months  | ROM ITT                       | 110.6 $\pm$ 6.68  | 105.00 $\pm$ 8.82 | $P < 0.001$                                           |
|                      |                   | I      | 75          | 62.42 $\pm$ 6.59  |           | ROM PP                        | 110.0 $\pm$ 6.33  | 103.26 $\pm$ 7.57 | $P < 0.001$                                           |
|                      |                   | C      | 75          | 63.94 $\pm$ 6.58  |           |                               |                   |                   |                                                       |
|                      | Lin [47]          | T      | 60          | 31 (51.7)         |           | EPC                           | 14.93 $\pm$ na    | 8.87 $\pm$ na     | $P < 0.05$                                            |
|                      |                   | I      | 30          | 68.6 $\pm$ na     |           | Knee flexion                  | 77.84 $\pm$ na    | 70.16 $\pm$ na    | $P = 0.013$                                           |
|                      |                   | C      | 30          |                   |           | Ambulation ability            | na                | na                | "The differences between groups were not significant" |
| Louw [48]            | T                 | 101    |             |                   | 6 months  | WOMAC                         | na                | na                | $P = 0.222$                                           |
|                      |                   | I      | 49          | 32 (65.3)         |           |                               |                   |                   |                                                       |
|                      |                   | C      | 54          | 23 (51.9)         |           |                               |                   |                   |                                                       |
|                      | Mallettschek 2019 | T      | 75          | 47 (62.7)         | 3 months  | KSS                           | na                | na                | $P = 0.08$                                            |
|                      |                   | I      | 37          | 59 – 78**         |           |                               |                   |                   |                                                       |
|                      |                   | C      | 38          |                   |           |                               |                   |                   |                                                       |
| Moulton [50]         | T                 | 563    | na          | 70.1 $\pm$ na     | 2 years   | OKS (6 months PO)             | 28.71 $\pm$ na    | 31.60 $\pm$ na    | $P = 0.251$<br>(6 months)                             |
|                      |                   | I      | 503         |                   |           |                               |                   |                   |                                                       |
|                      |                   | C      | 60          |                   |           |                               |                   |                   |                                                       |
|                      | Piva [51]         | T      | 44          | 31 (70.5)         | 6 months  | OKS (2 years PO)              | 30.17 $\pm$ na    | 33.26 $\pm$ na    | $P = 0.440$<br>(2 years)                              |
|                      |                   | I      | 22          |                   |           | SF-36 PF                      | 76.7 $\pm$ 16.1   | 70.3 $\pm$ 24.2   | $P = 0.017$                                           |
|                      |                   | C      | 22          |                   |           | Single-leg stance test        | 16.1 $\pm$ 9.6    | 17.4 $\pm$ 9.8    | $P = 0.037$                                           |
| Reslan [52]          | T                 | 60     |             |                   |           | WOMAC PF                      | 11.8 $\pm$ 6.7    | 12.8 $\pm$ 10.8   | $P = 0.558$                                           |
|                      |                   | I      | 30          |                   |           | Stair-climb                   | 14.3 $\pm$ 4.1    | 15.6 $\pm$ 7.4    | $P = 0.054$                                           |
|                      |                   | C      | 30          |                   |           | Chair-stand                   | 12.2 $\pm$ 2.8    | 13.7 $\pm$ 7.5    | $P = 0.149$                                           |
|                      |                   |        |             |                   |           | 6-Min walk                    | 472.6 $\pm$ 86.5  | 518.0 $\pm$ 103.3 | $P = 0.638$                                           |
|                      |                   |        |             |                   |           | Gait speed                    | 1.14 $\pm$ 0.16   | 1.18 $\pm$ 0.24   | $P = 0.790$                                           |
|                      |                   |        |             |                   |           | Daily activity                | 152.5 $\pm$ 93.3  | 174.9 $\pm$ 126.1 | $P = 0.279$                                           |
|                      |                   |        |             |                   | 4 weeks   | HSSfunction                   | 15.73 $\pm$ 3.49  | 13.92 $\pm$ 3.35  | $P = 0.026$                                           |
|                      |                   |        |             |                   |           | HSSrom                        | 17.04 $\pm$ 2.55  | 16.53 $\pm$ 4.20  | $P = NS$                                              |
|                      |                   |        |             |                   |           | HSSquadriceps muscle strength | 9.13 $\pm$ 3.81   | 8.47 $\pm$ 2.93   | $P = NS$                                              |
|                      |                   |        |             |                   |           | HSSflexion deformity          | 10.02 $\pm$ 1.21  | 8.47 $\pm$ 1.93   | $P = 0.007$                                           |
|                      |                   |        |             |                   |           | HSSinstability                | 9.89 $\pm$ 3.41   | 8.27 $\pm$ 2.89   | $P = 0.049$                                           |
|                      |                   |        |             |                   |           | LEFS                          | 60.35 $\pm$ 11.22 | 53.83 $\pm$ 12.98 | $P = 0.048$                                           |

Table 3 (continued)

| Type of intervention | Study              | Nr TKA | Females (%) | Age mean $\pm$ SD | Follow-up       | Outcome score (function)                     | I score $\pm$ SD          | C score $\pm$ SD          | Statistically significance at latest follow-up                                                           |
|----------------------|--------------------|--------|-------------|-------------------|-----------------|----------------------------------------------|---------------------------|---------------------------|----------------------------------------------------------------------------------------------------------|
| Psycho-herapy        | Timmers [53]       | T      | 213         |                   | 4 weeks         | KOOS                                         | 37.61 $\pm$ 10.17         | 43.08 $\pm$ 12.96         | $P < 0.001$                                                                                              |
|                      |                    | I      | 114         | 64.74 (7.57)      | after discharge | Ability to perform physiotherapy             | 7.50***                   | 6.88***                   | $P = 0.03$                                                                                               |
|                      |                    | C      | 99          | 65.63 (7.90)      |                 | Ability to perform self-care activities      | 8.32***                   | 7.64***                   | $P = 0.004$                                                                                              |
|                      | Yajnik 2018        | T      | 40          | 68 (46–80)*       | 2 days          | Maximum ambulation 1 day PO                  | 20 (0–59)^                | 12 (0–30)^                | $P = 0.069$ (POD 1)                                                                                      |
|                      |                    | I      | 20          |                   |                 | Maximum ambulation 2 days PO                 | 46 (6–67)^                | 38 (0–61)^                | $P = 0.141$ (POD 2)                                                                                      |
|                      |                    | C      | 20          |                   |                 |                                              |                           |                           |                                                                                                          |
|                      | Birch 2019         | T      | 60          |                   | 1 year          | OKS                                          | 33 (29, 27)^              | 37 (33, 41)^              | $P = NS$                                                                                                 |
|                      |                    | I      | 31          | 66 (9)            |                 | 6-Min walk                                   | 441 (402, 480)^           | 406 (367, 446)^           | $P = NS$                                                                                                 |
|                      |                    | C      | 29          | 66 (10)           |                 | Sit to stand                                 | 12 (11, 14)^              | 11 (95% CI 10, 13)^       | $P = NS$                                                                                                 |
|                      | Cai [57]           | T      | 108         |                   | 6 months        | KSS                                          | 82.61 $\pm$ 6.38          | 73.30 $\pm$ 8.45          | $P < 0.01$                                                                                               |
|                      |                    | I      | 54          | 62.42 $\pm$ 6.59  |                 | First time out of bed (hours)                | 22.13 $\pm$ 4.18          | 36.41 $\pm$ 7.31          | $P = < 0.001$                                                                                            |
|                      |                    | C      | 54          | 63.94 $\pm$ 6.58  |                 |                                              |                           |                           |                                                                                                          |
|                      | Cai [58]           | T      | 100         | 62 (55.9)         | 6 months        | HSS function                                 | 80.68 $\pm$ 8.02          | 68.98 $\pm$ 8.64          | $P < 0.001$ (time interaction), $P < 0.001$ (group interaction), $P = 0.003$ (group-by-time interaction) |
|                      |                    | I      | 50          | 65.26 $\pm$ 8.30  |                 |                                              |                           |                           |                                                                                                          |
|                      |                    | C      | 50          | 66.18 $\pm$ 7.04  |                 |                                              |                           |                           |                                                                                                          |
|                      | Das Nair [59]      | T      | 50          |                   | 6 months        | WOMAC function                               | 20.9 $\pm$ 12.7           | 32.0 $\pm$ 4.8            | $P = 0.009$                                                                                              |
|                      |                    | I      | 25          | 65.7 $\pm$ 8.6    |                 | WOMAC stiffness                              | 3.2 $\pm$ 1.9             | 4.2 $\pm$ 0.9             | $P = 0.11$                                                                                               |
|                      |                    | C      | 25          | 66.7 $\pm$ 9.9    |                 |                                              |                           |                           |                                                                                                          |
|                      | Harnirattisai [60] | T      | 63          | 67.88 (60–85)*    | 6 weeks         | PTT total                                    | 8.86 $\pm$ 1.89           | 6.43 $\pm$ 1.66           | $P = na$                                                                                                 |
|                      |                    | I      | 42          |                   |                 | PPT standing balance                         | $\Delta$ 2.00 $\pm$ 1.22^ | $\Delta$ 1.09 $\pm$ 1.22^ | $P = 0.016$                                                                                              |
|                      |                    | C      | 21          |                   |                 | PPT walking speed                            | $\Delta$ 1.55 $\pm$ 1.02^ | $\Delta$ 0.76 $\pm$ 0.83^ | $P = 0.004$                                                                                              |
|                      |                    | T      |             |                   |                 | PPT chair-stand                              | $\Delta$ 2.36 $\pm$ 1.05^ | $\Delta$ 1.33 $\pm$ 1.02^ | $P < 0.001$                                                                                              |
|                      |                    | I      |             |                   |                 | ADL and daily requirements exercise activity | na                        | na                        | "There were no significant differences in ADL participation"                                             |
|                      |                    | C      |             |                   |                 |                                              |                           |                           |                                                                                                          |
|                      |                    | T      |             |                   |                 |                                              |                           |                           |                                                                                                          |
|                      |                    | I      |             |                   |                 |                                              |                           |                           |                                                                                                          |
|                      |                    | C      |             |                   |                 |                                              |                           |                           |                                                                                                          |

**Table 3** (continued)

| Type of intervention | Study | Nr TKA | Females (%) | Age mean $\pm$ SD | Follow-up | Outcome score (function)                   | I score $\pm$ SD                                 | C score $\pm$ SD         | Statistically significance at latest follow-up                                                                               |
|----------------------|-------|--------|-------------|-------------------|-----------|--------------------------------------------|--------------------------------------------------|--------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Jacobson [61]        | T     | 58     | 51 (62.2)   | 65 (41–81)*       | 6 months  | SF-36 physical                             | 50.4 $\pm$ 6.0                                   | 47.3 $\pm$ 7.5           | $P = na$                                                                                                                     |
|                      | I     | 29     |             |                   |           | WOMAC stiffness                            | 1.9 $\pm$ 1.4                                    | 2.1 $\pm$ 1.9            | $P = na$                                                                                                                     |
|                      | C     | 29     |             |                   |           | WOMAC function                             | 7.2 $\pm$ 7.1                                    | 10.2 $\pm$ 10.5          | $P = na$                                                                                                                     |
| Riddle [62]          | T     | 63     | 45 (71.4)   |                   | 2 months  | Gait velocity                              | na                                               | na                       | $P = 0.0154$                                                                                                                 |
|                      | I     | 18     |             | 63.8 $\pm$ 11.5   |           | Timed walk in seconds                      | 7.4 $\pm$ 2.2                                    | 8.5 $\pm$ 2.3            | (group-by-imaging ability interaction)<br>$P = na$                                                                           |
|                      | C     | 45     |             | 60.8 $\pm$ 9.9    |           | WOMAC disability                           | 18.3 $\pm$ 12.2                                  | 24.1 $\pm$ 10.9          | $P = 0.023$ (for differences among discharge scores for the 2 groups after adjusting for baseline differences)<br>$P > 0.05$ |
| Riddle [63]          | T     | 402    |             |                   | 12 months | WOMAC function                             | 11.7 (8.6, 14.9) (I1) & 12.2 (9.0, 15.4) (I2)^^^ | 10.5 (7.4, 13.6)^^^      | $P > 0.05$                                                                                                                   |
|                      | I1    | 130    | 94 (72.3)   | 62.6 $\pm$ 7.9    |           | SPPB                                       | 8.0 (7.2, 8.7) (I1) & 8.4 (7.6, 9.1) (I2)^^^     | 8.6 (95% CI 7.8, 9.4)^^^ | $P > 0.05$                                                                                                                   |
|                      | I2    | 135    | 85 (63.0)   | 64.2 $\pm$ 8.5    |           |                                            |                                                  |                          |                                                                                                                              |
| Russo 2016           | C     | 137    | 88 (64.2)   | 62.7 $\pm$ 7.7    |           |                                            |                                                  |                          |                                                                                                                              |
|                      | T     | 110    | na          | 69.1 $\pm$ na     | 3 months  | SF-36 physical                             | 45.6 $\pm$ 8.3                                   | 46.2 $\pm$ 9.9           | $P > 0.01$                                                                                                                   |
|                      | I     | 55     |             |                   |           | KSS                                        | 87.8 $\pm$ 9.6                                   | 78.3 $\pm$ 8.2           | $P = < 0.005$                                                                                                                |
| Tristaino 2015       | C     | 55     |             |                   |           | WOMAC                                      | 79.9 $\pm$ 13.0                                  | 69.7 $\pm$ 9.5           | $P = < 0.005$                                                                                                                |
|                      |       |        |             |                   |           | VAS functional score                       | 2.8 $\pm$ 1.6                                    | 4.0 $\pm$ 1.5            | $P = < 0.005$                                                                                                                |
|                      | T     | 44     | 44 (62.0)   |                   | 4 months  | SF-36 PCS                                  | 49.5 $\pm$ 6.6                                   | 50.9 $\pm$ 9.8           | $P = 0.5114$                                                                                                                 |
| Tristaino 2015       | I     | 33     |             | 64.2 $\pm$ 8.6    |           | Days until physiotherapy objective reached | 8.1 $\pm$ 2.4                                    | 8.8 $\pm$ 2.3            | $P = 0.2424$                                                                                                                 |
|                      | C     | 31     |             | 66.1 $\pm$ 6.6    |           |                                            |                                                  |                          |                                                                                                                              |

Table 3 (continued)

| Type of intervention | Study             | Nr TKA      | Females (%)     | Age mean $\pm$ SD    | Follow-up | Outcome score (function)                                                                                                                                                                                                                     | I score $\pm$ SD                                                                                                                                   | C score $\pm$ SD                                                                                                                | Statistically significance at latest follow-up                                                                                         |
|----------------------|-------------------|-------------|-----------------|----------------------|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Remaining            | Christiansen 2015 | T<br>I<br>C | 26<br>13<br>13  | 13 (50)              | 26 weeks  | FTSST<br>Hip moment (Nm/kg) during FTSST<br>Knee moment (Nm/kg) during FTSST<br>Ankle moment (Nm/kg) during FTSST<br>Walking speed (m/s)<br>Hip moment during walking<br>Knee extension moment during walking<br>Ankle moment during walking | 9.5 $\pm$ 2.4<br>0.65 $\pm$ 0.24<br>1.03 $\pm$ 0.22<br>0.17 $\pm$ 0.16<br>1.29 $\pm$ 0.25<br>0.28 $\pm$ 0.19<br>0.61 $\pm$ 0.25<br>0.09 $\pm$ 0.29 | 9.6 $\pm$ 1.6<br>0.63 $\pm$ 0.20<br>0.97 $\pm$ 0.11<br>0.24 $\pm$ 0.14<br>1.24 $\pm$ 0.13<br>0.36 $\pm$ 0.22<br>0.42 $\pm$ 0.44 | <i>P</i> = 0.21<br><i>P</i> = 0.686<br><i>P</i> = 0.434<br><i>P</i> = 0.227<br><i>P</i> = 0.68<br><i>P</i> = 0.160<br><i>P</i> = 0.008 |
|                      | Hiraga [68]       | T<br>I<br>C | 41<br>20<br>21  | 16 (80)<br>19 (90.4) | 4 weeks   | Daily step count<br>Psychical activity time                                                                                                                                                                                                  | 3580.5 $\pm$ 1545.2<br>1741.4 $\pm$ 551.3                                                                                                          | 2088.4 $\pm$ 2008.3<br>731.8 $\pm$ 321.1                                                                                        | <i>P</i> = 0.041<br><i>P</i> = 0.000                                                                                                   |
|                      | Koo [69]          | T<br>I<br>C | 120<br>60<br>60 | 17 (28.3)            | 5 weeks   | WOMAC<br>Graded ambulation distance                                                                                                                                                                                                          | 14.59 $\pm$ 9.14<br>na                                                                                                                             | 10.86 $\pm$ 10.84<br>na                                                                                                         | <i>P</i> = 0.398<br><i>P</i> = na                                                                                                      |
|                      |                   |             |                 |                      |           | 6-Min walk test<br>Timed-stand test                                                                                                                                                                                                          | 407.00 $\pm$ 83.62<br>19.29 $\pm$ 2.80                                                                                                             | 353.35 $\pm$ 82.35<br>19.00 $\pm$ 6.16                                                                                          | <i>P</i> = 0.163<br><i>P</i> = 0.967                                                                                                   |

Nr Number, TKA total knee arthroplasty, SD standard deviation, I intervention group, C control group, T total study group, CPM continuous passive motion, PO postoperative, P *P* value, ROM range of motion, WOMAC Western Ontario and McMaster Universities osteoarthritis index, KOOS Knee Injury and Osteoarthritis Outcome Score, MPOAL muscle power of the affected leg, ITT intention to treat, PP per protocol, na not available, EPC exercises performance checklist, KSS Knee Society Score, OKS Oxford knee score, SF-36 PF Short Form-36 physical functioning, HSS hospital for special surgery knee score, NS not significant, LEFS lower extremity functional scale, POD postoperative day, PPT physical performance test, ADL activities of daily living, SPFB short physical performance battery, VAS visual analog scale, PCS physical component scale, FTSST five-time sit-to-stand test, Nm/kg Newtonmeter/kilogram, m/s metre per second

\*Mean (range)

\*\*Range only

\*\*\*Mean only

^Median (10th–90th percentiles)

^^Mean estimate with the 95% CI parentheses

^^^Mean change score baseline—6 weeks postoperative

## QoL

Two recent studies [49, 53] examined the effect a perioperative intervention on QoL (Table 4). Patients receiving postoperative day-to-day education through an app seemed to report significantly better QoL compared to patients who received usual care [53]. Additional psychoeducation did not significantly improve QoL [49].

## Quality assessment

Figure 2 shows our risk of bias assessment of the included studies. Figure 3 represents our judgement about each risk of bias item presented as percentages across all studies. The most prevalent shortcomings regarding the risk of bias were inadequate blinding participants and/or personnel during the study (performance bias) and “other types of bias”. Bias due to inadequate generation of a randomisation sequence or inadequate allocation concealment prior to assignment (selection bias) also caused high scores on the risk of bias (Fig. 3).

The overall level of evidence of the studies using the GRADE approach was qualified as low for pain and for function and as moderate for QoL. Serious uncertainty in the assessment of the risk of bias, inconsistency, and indirectness were the main reasons for downgrading the overall level of evidence (Table 5).

## Discussion

In this systematic review, we give an overview of studies that assessed the effect of perioperative interventions targeting psychological distress on pain, function, and QoL applied to patients undergoing TKA for primary OA of the knee. Perioperative music [33, 36, 38–40], education [41, 49, 51–53, 55], cognitive behavioural therapy [57, 58], pain coping skills training [62], guided imagery [61], perioperative Reiki therapy [66, 70], occupational therapy in combination with self-monitoring using a diary [68], and biofeedback-assisted progressive muscle relaxing training [71] seem to improve postoperative pain or to decline opioid prescriptions after TKA. For function, pain coping skills training [62], audio-recording guided imagery scripts [61], video promoting self-confidence and psychological support [64], music [35, 36], occupational therapy in combination with self-monitoring using a diary [68], various types of education [41, 43, 45, 47, 51–53], weight-bearing biofeedback training [67], psychological therapies (behavioural change intervention [60] and cognitive behavioural therapy [57–59]) seem to significantly improve at least one postoperative functional outcome measure. Day-to-day education after TKA using an app might improve postoperative QoL.

**Table 4** The influence of perioperative interventions targeting psychological distress on QoL after the TKA

| Type of intervention | Study             | Nr TKA | Females (%) | Age mean $\pm$ SD                    | Follow-up               | Outcome score (QoL) | I score $\pm$ SD I score $\pm$ SD | C score $\pm$ SD | Statistically significance at latest follow-up |
|----------------------|-------------------|--------|-------------|--------------------------------------|-------------------------|---------------------|-----------------------------------|------------------|------------------------------------------------|
| Education            | Malletscheck 2019 | T      | 75          | 59–78*                               | 3 months                | KOOS QoL            | na                                | na               | P = NS                                         |
|                      |                   | I      | 37          |                                      |                         |                     |                                   |                  |                                                |
|                      |                   | C      | 38          |                                      |                         |                     |                                   |                  |                                                |
|                      | Timmers 2019      | T      | 213         | 64.74 $\pm$ 7.57<br>65.63 $\pm$ 7.90 | 4 weeks after discharge | EQ-5D               | 0.76 $\pm$ 0.16                   | 0.67 $\pm$ 0.25  | P < 0.001                                      |
|                      |                   | I      | 114         |                                      |                         |                     |                                   |                  |                                                |
|                      |                   | C      | 99          |                                      |                         |                     |                                   |                  |                                                |

Nr Number, TKA total knee arthroplasty, SD standard deviation, QoL quality of life, I intervention group, C control group, T total study group, KOOS Knee Injury and Osteoarthritis Outcome Score, na not available, P P value, NS not significant, EQ-5D EuroQOL Five-Dimensional Questionnaire

Instead of mean and SD

\*Range

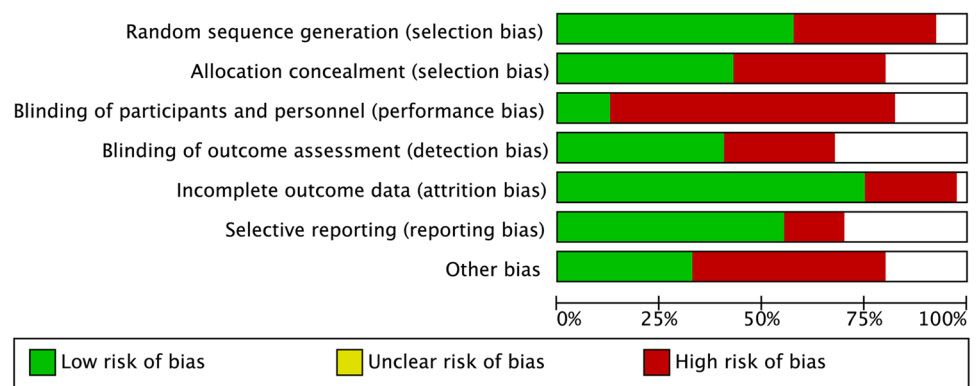
**Fig. 2** Risk of bias summary. Authors' judgements about each risk of bias item for each included study. Green: low risk of bias. Red: high risk of bias. No fill: unclear risk of bias

|                    | Random sequence generation (selection bias) | Allocation concealment (selection bias) | Blinding of participants and personnel (performance bias) | Blinding of outcome assessment (detection bias) | Incomplete outcome data (attrition bias) | Selective reporting (reporting bias) | Other bias |
|--------------------|---------------------------------------------|-----------------------------------------|-----------------------------------------------------------|-------------------------------------------------|------------------------------------------|--------------------------------------|------------|
| Allred 2010        | +                                           | +                                       | -                                                         |                                                 | +                                        |                                      | -          |
| Aris 2019          | +                                           |                                         | -                                                         |                                                 | +                                        | +                                    | +          |
| Atabaki 2019       |                                             |                                         | -                                                         | +                                               | +                                        | +                                    | +          |
| Aytekin 2019       |                                             | -                                       | -                                                         | -                                               | -                                        | +                                    | +          |
| Baldwin 2017       | +                                           | +                                       | +                                                         |                                                 | -                                        | -                                    | +          |
| Birch 2019         | +                                           |                                         | -                                                         | +                                               | +                                        | +                                    | +          |
| Cai 2017           | +                                           |                                         |                                                           |                                                 | +                                        |                                      | +          |
| Cai 2018           | +                                           | +                                       | -                                                         | +                                               | +                                        |                                      | +          |
| Chen 2014          | -                                           | -                                       | -                                                         | -                                               |                                          | +                                    | -          |
| Chen 2015          | +                                           | +                                       | -                                                         | +                                               | +                                        | -                                    | -          |
| Christiansen 2015  | +                                           | +                                       | -                                                         | +                                               | +                                        | +                                    | +          |
| Das Nair 2018      | +                                           | +                                       | -                                                         | +                                               | +                                        | +                                    | -          |
| Harnirattisai 2005 | -                                           | -                                       | -                                                         | +                                               | +                                        |                                      | -          |
| Hiraga 2019        | -                                           | -                                       |                                                           |                                                 | +                                        | +                                    | -          |
| Hsu 2016           | -                                           | -                                       | -                                                         | -                                               | +                                        | +                                    |            |
| Hsu 2019           | -                                           |                                         | -                                                         | -                                               | +                                        | +                                    | -          |
| Huang 2011         | -                                           | -                                       | -                                                         |                                                 | +                                        |                                      |            |
| Huang 2017         | +                                           |                                         |                                                           |                                                 | +                                        |                                      |            |
| Jacobson 2016      | +                                           | +                                       | +                                                         | +                                               | -                                        | +                                    | +          |
| Keshmiri 2014      |                                             | +                                       | +                                                         | +                                               | +                                        |                                      |            |
| Koo 2018           | +                                           | +                                       |                                                           | +                                               | -                                        | +                                    | +          |
| Lee 2019           | +                                           | +                                       | -                                                         | +                                               | +                                        |                                      |            |
| Leonard 2019       | +                                           | +                                       | -                                                         | -                                               | -                                        |                                      | -          |
| Lin 1997           | -                                           | -                                       | -                                                         | -                                               | +                                        | +                                    |            |
| Louw 2019          | +                                           | -                                       |                                                           |                                                 | -                                        | +                                    | -          |
| Malletschek 2019   | -                                           | -                                       | -                                                         |                                                 | +                                        | +                                    |            |
| Moulton 2017       | -                                           | -                                       | -                                                         | -                                               | -                                        | -                                    | -          |
| Notte 2016         | +                                           |                                         | -                                                         | -                                               | -                                        | -                                    | -          |
| Piva 2017          | +                                           | +                                       | +                                                         | +                                               | +                                        | +                                    | -          |
| Reslan 2018        | -                                           | -                                       | -                                                         | +                                               | +                                        |                                      | -          |
| Riddle 2011        | -                                           | -                                       | -                                                         | -                                               | +                                        | +                                    | -          |
| Riddle 2019        | +                                           | +                                       | -                                                         | +                                               | +                                        | +                                    | -          |
| Russo 2016         | +                                           |                                         |                                                           |                                                 | +                                        |                                      |            |
| Santhna 2015       | +                                           | +                                       | -                                                         | -                                               | +                                        | -                                    | -          |
| Simcock 2008       | +                                           | +                                       | +                                                         | +                                               | +                                        | -                                    | +          |
| Timmers 2019       | +                                           | +                                       |                                                           |                                                 | +                                        | +                                    | -          |
| Tristaino 2015     | -                                           | -                                       | -                                                         |                                                 | +                                        | +                                    | +          |
| Wang 2015          | -                                           | -                                       | -                                                         |                                                 | +                                        | +                                    | -          |
| Wilson 2016        | +                                           | +                                       | -                                                         | +                                               | +                                        | +                                    | +          |
| Yajnik 2018        | -                                           | -                                       | -                                                         | -                                               | -                                        |                                      | -          |

This is a methodologically well-conducted systematic review for which a professional medical librarian (CdH) has developed the search strategy to conduct a comprehensive search in several databases to identify eligible studies. Two authors (JS & GO) performed the screening, data extraction, risk of bias assessment, and overall level of evidence grading independently. We have created a complete overview of all studies by minimizing our exclusion criteria regarding study design, minimum follow-up, and language. Studies without significant results on the effect of an intervention

are often refused for publication. Due to the heterogeneity of the outcome measures of the included studies, it was not possible to conduct a funnel plot to assess this type of bias (publication bias) in our systematic review. However, we included multiple studies [32–34, 38, 39, 42, 46, 55, 56, 68] with small sample sizes (smaller than 30 patients) with no significant results on both outcome measures pain and function. Therefore we assume the risk of publication bias to be low.

**Fig. 3** Risk of bias graph. Authors' judgements about each risk of bias item presented as percentages across all included studies. Green: low risk of bias. Red: high risk of bias. No fill: unclear risk of bias



**Table 5** The overall level of evidence using the GRADE approach

| Certainty assessment                                                                   |                                                 |              |               |              |             |                                                                                                | No of patients |         | Certainty        |
|----------------------------------------------------------------------------------------|-------------------------------------------------|--------------|---------------|--------------|-------------|------------------------------------------------------------------------------------------------|----------------|---------|------------------|
| No of studies                                                                          | Study design                                    | Risk of bias | Inconsistency | Indirectness | Imprecision | Other considerations                                                                           | ITPD           | No ITPD |                  |
| Pain (follow up: range 60 min to 6 months; assessed with: Various outcome measures)    |                                                 |              |               |              |             |                                                                                                |                |         |                  |
| 34                                                                                     | 19 randomised trials and 15 remaining*          | Serious      | Serious       | Serious      | Not serious | all plausible residual confounding would suggest spurious effect, while no effect was observed | 1618           | 996     | ⊕⊕○○<br>low      |
| Function (follow up: range 2 days to 2 years; assessed with: Various outcome measures) |                                                 |              |               |              |             |                                                                                                |                |         |                  |
| 29                                                                                     | 16 randomised trials and 13 remaining**         | Serious      | Serious       | Serious      | Not serious | all plausible residual confounding would suggest spurious effect, while no effect was observed | 1580           | 1003    | ⊕⊕○○<br>low      |
| QoL (follow up: range 24 weeks to 3 months; assessed with: Various outcome measures)   |                                                 |              |               |              |             |                                                                                                |                |         |                  |
| 2                                                                                      | 1 randomised trial and one non-randomised trial | Serious      | Serious       | Not serious  | Not serious | all plausible residual confounding would suggest spurious effect, while no effect was observed | 151            | 137     | ⊕⊕⊕○<br>moderate |

GRADE grading of recommendation, assessment, development, and evaluation, *N* number, ITPD intervention targeting psychological distress, QoL quality of life

\* 8 prospective cohort studies, 6 quasi-experimental studies, 1 retrospective cohort study

\*\* 6 prospective cohort studies, 6 quasi-experimental studies, 1 retrospective cohort study

Unfortunately, drawing meaningful conclusions from the included studies was hampered. First of all, there was a substantial heterogeneity with respect to study design, analysis, domain, interventions, and outcome measures, which precluded pooling for a meta-analysis. Second, according to the GRADE approach, we have graded the quality of evidence as low for outcome measures pain and function. Therefore, the true effect of the interventions targeting psychological

distress on postoperative pain and function may be different from our estimate of the effect.

The previous systematic reviews of Szeverenyi et al. [26] and Tong et al. [27] concluded that psychological interventions seem to reduce postoperative side effects and anxiety and to improve recovery and mental components of quality of life after orthopaedic surgeries. However, Szeverenyi et al. [Szeverenyi] did not clarify the type of orthopaedic



procedures (only joint replacement or no joint replacement) and Tong et al. [27] included several orthopaedic procedures (THA, TKA, and spinal procedures) of which only two studies [61, 63] represented separated data of patients undergoing TKA. The findings of our review do not support the earlier systematic review of Bay et al. [25], in which most interventions explored by the included studies were found to be ineffective on patient-reported outcome after THA and TKA. Only three studies with patients receiving TKA were included by Bay et al. [25]. Compared to that review, we included fifteen additional RCTs [33, 34, 37, 38, 41, 44, 45, 49, 53, 54, 56–58, 58, 63]. Second, due to the current lack of RCTs on one specific type of intervention focused on psychological distress (for example only pain coping skills training) applied to patients undergoing TKA, we have decided to also include a wider range of study designs to create a complete overview of the perioperative interventions focused on psychological distress that have been used to decrease pain and improve function and/or QoL after surgery. Besides, ten studies [32, 34, 37, 39, 48, 54, 55, 66, 70, 71] in our systematic review evaluated the degree of postoperative pain not only by measuring pain scores, but also by assessing postoperative prescription of opioids or other types of pain medication. Investigating alternative nonpharmacologic methods to reduce postoperative pain and opioid use may help prevent further expansion of opioid misuse and addiction, which is currently a rapidly evolving public health crisis [7].

To the best of our knowledge, except for the mentioned systematic reviews [25, 26], no other systematic reviews or meta-analysis with comparable objectives have been published. Therefore, this is the first systematic review with wide search and inclusion criteria focused on TKA patients investigating the effect of interventions focused on psychological distress on patient-reported outcome measures pain, function, and QoL after surgery. Unfortunately, our review also highlighted the limitations of current literature on this subject. To avoid heterogeneity of outcome measures between studies, we would discourage the use of different questionnaires to assess patient-reported outcome measures (PROMs) in orthopaedic research. The reliability and reproducibility of the EuroQOL Five-Dimensional Questionnaire (EQ-5D) and the responsiveness of the Patient-Reported Outcomes Measurement Information System (PROMIS) Global Health survey have been well validated for patients undergoing TKA [72]. We would, therefore, recommend the use of the EQ-5D and PROMIS to allow tracking and evaluation of the effectiveness of perioperative interventions for psychological distress in conjunction with TKA in the following studies [72].

## Conclusions

The studies included in our systematic review show the positive effect of multiple perioperative interventions targeting psychological distress for patients receiving TKA to improve postoperative pain (or to decline prescriptions of opioids), function, and QoL. RCTs with strict methodological safeguards (such as long-term follow-up, large number of patients participating in the study, low risk of bias) prospectively comparing outcome for patients with and without perioperative support are still needed to determine if perioperative interventions targeting psychological distress should be used in conjunction with primary TKA for OA of the knee. These studies should also assess which type of intervention will be most effective in improving patient-reported outcome measures and declining opioid prescriptions in the future.

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## Compliance with ethical standard

**Conflict of interest** Author Juliette Caroline Sorel, Geke Marianne Overvliet, Maaïke Gerarda Johanna Gademan, Chantal den Haan declare that they have no conflicts of interest. Author Adriaan Honig reports personal fees from NOV-Dutch Orthopaedic Society, grants from The Netherlands Organisation for Health Research and Development (in Dutch: ZonMw), other from LINK/LIMA, other from Stryker, personal fees from LINK, personal fees from BMJ, non-financial support from LINK, grants from Achmea Healthcare Foundation (in Dutch Stichting Achmea Gezondheidszorg fonds), grants from Dutch health insurances (Zorgverzekeraars Nederland), grants from Foundation of medical research OLVG, Amsterdam, the Netherlands, grants from Van Rens Foundation, grants from Reuma Nederland, other from McMaster University, outside the submitted work.

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