Brief Preoperative Mind-Body Therapies for Total Joint Arthroplasty Patients: A Randomized Controlled Trial

Adam W. Hanley, PhD ^{1,2}

Jeremy Gililland, MD ^{3,4}

Jill Erickson, PA ³

Christopher Pelt, MD ³

Christopher Peters, MD ³

Jamie Rojas, BS ^{1,2}

Eric L. Garland, PhD ^{1,2,4}

¹ = Center on Mindfulness and Integrative Health Intervention Development (C-MIIND),
University of Utah

² = College of Social Work, University of Utah

³ = University of Utah Department of Orthopaedic Surgery

⁴ = Salt Lake City Veterans Affairs Medical Center

Word Count: 2,988

Corresponding author: Eric L. Garland, 395 South, 1500 East, University of Utah, Salt Lake City, UT 84112, eric.garland@socwk.utah.edu

Funding/support: E.L.G. was supported by grant number R01DA042033 from the National Institutes of Health during the preparation of this manuscript. The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Author contributions: Dr. Garland had full access to all the data and takes full responsibility for the completeness and integrity of the data. *Study concept and design:* Hanley, Garland. *Acquisition of data:* Hanley, Erickson, Rojas. *Analysis and interpretation of data:* Hanley, Garland, Gililland. *Drafting of the manuscript:* Hanley, Garland, Gililland. *Critical revision of the manuscript for important intellectual content:* Hanley, Garland, Gililland, Erickson. *Statistical analysis:* Hanley, Garland. *Obtained funding:* Garland. *Administrative, technical, and material support:* Hanley, Gililland, Pelt, Peters, Erickson, Rojas. *Study supervision:* Hanley, Garland, Gililland.

Conflict of interest disclosure: Eric Garland, PhD, LCSW is the Director of the Center on Mindfulness and Integrative Health Intervention Development. The Center provides Mindfulness-Oriented Recovery Enhancement (MORE), mindfulness-based therapy, and cognitive behavioral therapy in the context of research trials for no cost to research participants; however, Dr. Garland has received honoraria and payment for delivering seminars, lectures, and teaching engagements (related to training clinicians in MORE and mindfulness) sponsored by institutions of higher education, government agencies, academic teaching hospitals, and medical

centers. Dr. Garland also receives royalties from the sale of books related to MORE. The other authors declare that they have no competing interests.

Data Sharing Statement: De-identified study data will be made available to qualified parties upon request following manuscript publication.

68 **Abstract:**

69 **Background:** More than 80% of surgical patients report inadequate pain management, which is
70 associated with prolonged recovery and functional impairment.

71 **Methods:** A single-site, three-arm, parallel-group randomized clinical trial conducted at an
72 orthopedic clinic, among patients undergoing total joint arthroplasty (TJA) of the hip or knee. A
73 nonrandomized usual care group of patients was also collected. Mindfulness meditation (MM),
74 hypnotic suggestion (HS), and cognitive-behavioral pain psychoeducation (CB) were each
75 delivered in a single, 15-minute group session as part of a 2-hour, preoperative education
76 program. Preoperative outcomes - pain intensity, pain unpleasantness, pain medication desire,
77 and anxiety - were measured with numeric rating scales. Postoperative physical functioning at 6-
78 week follow-up was assessed with the Patient-Reported Outcomes Measurement Information
79 System Physical Function computer adaptive test.

80 **Results:** TJA patients (N=727) were randomized to preoperative MM, HS, or CB (n=285) or
81 received usual care (n=443). MM and HS led to significantly less preoperative pain intensity,
82 pain unpleasantness, and anxiety. MM also decreased preoperative pain medication desire
83 relative to CB and increased postoperative physical functioning at 6-week follow-up relative to
84 HS, CB, and usual care. Moderation analysis revealed MM increased physical function
85 regardless of surgery type.

86 **Conclusion:** In one of the largest studies of mind-body interventions ever conducted, a single
87 15-minute, preoperative mindfulness intervention immediately decreased pain, pain medication
88 desire, and anxiety while also increasing physical function at the 6-week follow-up assessment.

89 **Level of Evidence:** Level 1.

Brief Preoperative Mind-Body Therapies for Total Joint Arthroplasty Patients: A Randomized Controlled Trial

Knee and hip replacements are the 3rd and 4th most common inpatient surgeries performed in the United States, respectively.^{1,2} While intended to relieve pain and improve function, up to 44% of knee replacement patients and 27% of hip replacement patients reports persistent postoperative joint pain.³ Improving surgical pain management is essential. Both preoperative risk factors and postoperative pain management influence surgical outcomes. Preoperative risk factors include pain severity/chronicity and psychological distress (e.g., anxiety).⁴⁻⁷ Barriers to effective postoperative pain management include perceived helplessness, insufficient pain coping education, and lack of non-pharmacological interventions.⁸ Thus, identifying scalable, time-limited interventions with preoperative and postoperative impacts is critical for maximizing surgical outcomes. Surgical patients could benefit from non-pharmacological, preoperative interventions that a) teach psychological techniques for immediately decreasing pain and distress, and that b) can be self-administered as needed.

Mind-body interventions (MBIs), such as mindfulness meditation, hypnotic suggestion, and cognitive-behavioral therapy, are promising, non-pharmacological pain management strategies.⁹ Mindfulness is a form of mental training that develops meta-awareness and acceptance of thoughts, feelings and body sensations.¹⁰⁻¹² Hypnotic suggestion involves inducing an altered state of consciousness in which focused attention and reduced peripheral awareness enhance responsiveness to suggestions for changing thoughts, feelings, and body sensations.¹³ Cognitive-behavioral therapy (CBT) is a style of psychotherapy designed to modify

dysfunctional thoughts, emotions, and behaviors.^{14,15} All three MBIs have been shown to decrease clinical pain for a variety of medical conditions,¹⁶ and reduce emotional distress.¹⁷⁻²¹

Evidence suggests that delivering hypnosis,²²⁻³⁰ mindfulness,^{31,32} and CBT^{33,34} preoperatively can improve postoperative outcomes. Yet, despite these promising findings, there are no large-scale, comparative studies of the pre- and postoperative impacts of these three MBIs. Furthermore, to our knowledge, no study has compared very brief forms (i.e., 15-minute interventions) of these MBIs. Brief MBIs may be more feasible to implement in clinical settings and thus present a promising avenue for improving surgical outcomes. Determining which type of very brief preoperative MBI is most likely to improve pre- and postoperative symptomology has significant implications for surgical patients and medical professionals charged with optimizing limited resources.

This randomized controlled trial (RCT) compared preoperative mindfulness meditation (MM), hypnotic suggestion (HS), and cognitive-behavioral (CB) interventions all delivered in a very brief (i.e., 15-minute), single session format for patients undergoing total joint arthroplasty (TJA) of the hip or knee. We also examined the impact of these three preoperative interventions on postoperative physical functioning relative to a nonrandomized comparison control condition of TJA patients receiving usual care. In a prior RCT (N=244), we demonstrated that brief MM and HS decreased acute pain, anxiety levels, and the desire to take analgesic medication to a significantly greater extent than a psychoeducation control condition among inpatients with a variety of clinical pain conditions.³⁵ In light of these prior results, we hypothesized that TJA patients receiving either a brief MM or HS intervention would report less preoperative pain intensity, pain unpleasantness, pain medication desire, and anxiety, as well as better physical functioning six weeks following surgery, compared with patients receiving CB or usual care.

Methods

Trial Design and Randomization

This was a single-site, three-arm, parallel-group RCT, with a supplemental nonrandomized usual care comparison group (trial registry: NCT03665727). The local IRB approved all procedures. Participants provided informed consent after reviewing an informed consent cover letter with study personnel.

Participants were patients at an academic medical center scheduled for hip or knee TJA. At a preoperative visit, patients were encouraged to attend a 2-hour preoperative education program, *Joint Academy*, during which patients learned from a team of medical professionals (i.e., nurses, physical therapists, psychologists) how to ensure the best possible outcome for their TJA. First, a nurse discussed health optimization, anesthesia choice, typical length of hospital stay, and wound care. Second, a physical therapist discussed prehabilitation exercises, the physical therapy timeline, and the process of functional recovery. Finally, the psychologist delivered the MBI. Joint Academy was held once a week and conducted in groups of 9±3 patients. Weekly group cohorts were randomized via a computer-generated randomization schedule with simple random allocation (1:1:1) to one of three MBIs: MM, HS, and CB. Randomization sequence was generated by a researcher uninvolved with intervention delivery or data collection before the trial began, and any differences in random allocation were purely due to chance. Patients experiencing surgical complications and those scheduled for multiple, consecutive surgeries were excluded from the study, due to the possibility that an additional surgeries or procedures would confound their 6-week physical function assessment. We also collected physical function data from a supplemental usual care comparison group of patients

who underwent hip or knee TJA at the same academic medical center during the study period but who did not attend Joint Academy. Patients and the public were not involved in the design or conduct of this study.

Interventions

All participants received standard medical care for TJA. Study interventions were matched in terms of format (group), duration (15 minutes), and frequency (once). Each intervention was delivered according to a manualized protocol. All three interventions began with a 5-minute presentation about biopsychosocial aspects of pain followed by a 10-minute MBI script. MM consisted of instruction in focused attention on breath and body sensations and metacognitive monitoring and acceptance of discursive thoughts, negative emotions, and pain. This script closely followed a standardized mindfulness induction script (see supplementary materials) validated in prior research on mindfulness in medical settings.³⁵ HS consisted of a self-hypnosis session in which patients were invited to focus on sensations of floating before imagining a richly detailed, pleasant scene of their choosing. Next, suggestions for transforming pain into sensations of warmth, coolness, or tingling were provided. This script closely followed a standardized self-hypnotic induction script (see supplementary materials) validated in prior research on self-hypnosis during acute medical procedures.³⁶ CB consisted of psychoeducation about the link between thoughts, emotions, and behavior and provided instruction in the use logic to dispute maladaptive thoughts about pain that might otherwise exacerbate pain and distress. This script (see supplementary materials) accorded with standard cognitive restructuring techniques employed in CBT interventions for pain.^{37,38} We selected a CB arm for this study to provide a rigorous, active control for a range of non-specific therapeutic factors that might otherwise confound assessment of mindfulness and hypnotic suggestion's specific mechanisms

of action, including attention by a caring professional, and the expectation of therapeutic benefit. The usual care comparison group did not receive any MBI or psychosocial intervention.

Measures

Sociodemographic and diagnostic information as well as preoperative physical functioning levels were obtained from patient medical records. Preoperative, self-report measures of acute clinical symptoms were administered immediately before and after the MBI, which comprised a 15-minute interval. The postoperative physical function assessment was completed during a routine, postoperative follow-up visit 6-weeks after surgery.

Preoperative Clinical Symptom Assessment. Pain intensity,³⁹ pain unpleasantness,³⁹ pain medication desire,⁴⁰ and anxiety⁴¹ were measured with individual items rated on a numeric rating scale (0–10), a widely used and validated approach to measuring clinical pain and related symptomology.^{35,42}

Postoperative Physical Function Assessment. Self-reported physical function was assessed with the Patient-Reported Outcomes Measurement Information System (PROMIS) Physical Function (-PF) computer adaptive test. The PROMIS-PF has demonstrated reliability, validity, and sensitivity to clinical change, with higher scores indicating greater functional ability.^{43–46}

PROMIS-PF scores were obtained through medical record review. Assessors were blind to experimental condition. Patients' most proximal preoperative PROMIS-PF score was included if that assessment occurred in the 6 weeks preceding surgery ($\bar{x}$ days=22, $S.D.$ =14). Postoperatively, patients' PROMIS-PF score most proximal to their 6-week follow-up was included ($\bar{x}$ days post-surgery=52, $S.D.$ =27). Days from preoperative PROMIS-PF assessment to

surgery ($F=0.15$, $p=.86$) and days from surgery to postoperative PROMIS-PF assessment ($F=0.55$, $p=.58$) did not differ between MBI conditions.

Power Calculation

For liner mixed modeling, *a priori* power analysis was conducted using Optimal Design.⁴⁷ An estimated total sample size of 250 participants in 47 cohorts was determined necessary to detect an overall between-group effect on baseline-adjusted outcomes ($f=0.25$, or of medium size) with 80% power, two-sided, $p < 0.05$.

Statistical Analysis

Following our prespecified analysis plan, between-group differences were assessed by fitting linear mixed models for each preoperative (pain intensity, pain unpleasantness, pain medication desire, anxiety) and postoperative (physical functioning) outcome. Mixed models were conducted from an intention-to-treat (ITT) framework using full information maximum likelihood estimation, and included random intercepts for individuals nested within each weekly cohort to account for clustering. In mixed models, outcome variables were regressed on intervention group (MM vs. HS vs. CB vs. Usual Care) after covarying baseline values. In accordance with the classical ANCOVA approach endorsed by Frison and Pocock⁴⁸ for analyzing clinical trial outcomes, covarying baseline values performs statistical matching on the prerandomization scores and ensures that comparisons of postrandomization values by treatment group are independent of baseline differences. Sensitivity analyses were also performed adjusting for all sociodemographic characteristics listed in Table 1. To determine whether surgery type (hip or knee) moderated experimental outcomes, we tested the interaction between treatment condition (dummy-coded for each study intervention relative to usual care) and a dichotomous variable representing surgery type. All tests and CIs were 2-sided and statistical

significance was defined as a *P* value less than .05. All linear models were conducted using SPSS version 25.

Results

The CONSORT chart is reported in Figure 1. Of the 481 participants scheduled to attend Joint Academy, 316 attended, with 271 participants (95%) completing the entire preoperative survey. Postoperative PROMIS-PF assessment scores were available for 74% of participants. No intervention related harms or unintended effects occurred during this study.

-----Figure 1-----

Treatment conditions were similar in sociodemographic characteristics, admitting diagnoses, and acute clinical symptomology (Table 1). Mean pain intensity, pain unpleasantness, and anxiety scores indicated moderate levels of acute clinical symptomology during Joint Academy. Missing data analyses on self-reported physical functioning scores at pre- and postoperative assessment points revealed the observed missing data pattern was consistent with data being missing completely at random (Little's MCAR test: $\chi^2(2)=3.34$, $p=.19$).

-----Table 1-----

Preoperative Outcomes

Immediately after the MBI, a significant effect of MBI condition was observed for pain intensity, pain unpleasantness, pain medication desire, and anxiety (Table 2). Planned pairwise

comparisons indicated that patients randomized to MM or HS reported significantly less pain intensity, pain unpleasantness, and anxiety than those randomized to CB. Additionally, patients randomized to MM reported significantly less pain medication desire than those randomized to CB. No difference was observed between MM and HS on any of the four preoperative outcomes.

-----Figure 2-----

6-week Postoperative Outcome

After surgery, a significant effect of MBI condition was observed for postoperative physical function (N=727; Table 2). Planned pairwise comparisons indicated that participants randomized to MM reported significantly greater physical function than those randomized to HS or CB and usual care patients. A sensitivity analysis, adjusting for all sociodemographic characteristics, did not alter these results ($F=8.45$, $p<.001$). Moderation analysis revealed non-significant interactions between intervention condition and surgery type, indicating that MM (but not HS, CB or usual care) increased physical function regardless of surgery type.

-----Table 2-----

-----Figure 3-----

Discussion

In addition to pharmacological pain management, surgical patients need effective, nonpharmacological pain management strategies.^{4,7,8,49} Unfortunately, little evidence exists on

the comparative efficacy of brief, preoperative, MBIs designed to teach surgical patients how to manage the pain and distress that often accompany surgery. In one of the largest clinical trials of MBIs ever conducted, we examined the effects of MBIs on preoperative pain, pain medication desire, and anxiety as well as postoperative physical function following primary TJA. Results revealed a single, 15-minute MM or HS intervention immediately reduced preoperative pain intensity from joint disease (-24% and -27%, respectively), as well as pain unpleasantness (-29% and -34%, respectively), and anxiety (-43% and -29%, respectively) in patients preparing for TJA - improving important preoperative risk factors known to influence postoperative outcomes.^{4,7} MM also decreased pain medication desire by 35%.

At 6-week postoperative follow-up, patients receiving MM reported significantly better physical function when compared with usual care patients as well as those receiving preoperative HS or CB. Beyond statistical significance, patients receiving preoperative MM reported postoperative physical function scores indicative of clinically significant improvement. Typically, TJA patients do not realize clinically significant improvements in physical function 6-weeks after surgery, with 6-week physical function scores tending to be very similar to preoperative scores.⁴⁶ However, in the present study, the level of physical function reported by patients in the MM arm rose by nearly 5.5 points on the PROMIS-PF (i.e., to 43.36), to a level of physical function more commonly seen 3-months after surgery.⁴⁶ Thus, it appears that a single session of preoperative mindfulness training accelerated TJA patients' recovery from surgery, allowing them to more quickly engage in more strenuous physical activities, such as manual labor, housework, yardwork, and hiking.

Differences in efficacy observed between MM and HS may be a result of the distinct mechanisms of these two MBIs. Mindfulness aims to promote acceptance, reduce pain

catastrophizing, and foster reappraisal of pain as innocuous sensory information rather than as an emotionally-laden indicator of bodily harm.⁵⁰ In contrast, hypnosis aims to reduce pain by dissociating awareness from the body and using imagination to superimpose pleasurable sensations onto the painful body part.⁵¹ Despite their apparent differences, neuroimaging demonstrates that mindfulness and hypnosis both alleviate pain by modulating corticothalamic activity integral to processing ascending nociceptive input.^{52–55} Although both techniques may attenuate nociceptive peripheral afference from joint disease or the surgical site, the therapeutic mechanisms of mindfulness may be especially well suited for improving physical function, which is highly influenced by known targets of mindfulness including cognitive schemas, attentional biases, and distress intolerance.^{56–60}

Study findings are consistent with evidence that mindfulness and hypnosis relieve clinical pain and reduce emotional distress.^{16,19,20,31,32,61,62} Additionally, these results are congruent with our previous RCT, which found that 15 minutes of MM or HS decreased *inpatients'* pain intensity, pain unpleasantness, pain medication desire, and anxiety compared with a psychoeducation control.³⁵ Taken together, these two trials suggest that very brief mindfulness and hypnosis interventions have the capacity to relieve pre- and postoperative clinical symptomology. Combining preoperative MM -- and potentially HS -- with postoperative, inpatient support may result in even better postoperative outcomes. This combined approach may be particularly valuable for decreasing chronic postsurgical pain, which is estimated to occur in 8%-20% of TJA patients,⁴⁶ and chronic opioid use, which has been observed in 41% of knee TJA patients.⁶³ Future studies are needed to directly investigate whether adding postoperative booster sessions to preoperative MM training has added benefit. Of further interest for future study may

be the synergistic effects of mindful surgeons^{64,65} operating on mindful patients, and whether having both parties trained in mindfulness has added benefit.

Despite study strengths, including the use of an active, rigorous CB control condition, limitations should be noted. First, physical function was assessed by self-report, which may be subject to bias. Future studies could use actigraphy to objectively quantify physical function. Second, participants were patients who voluntarily attended a preoperative education program before TJA, and thus may have been more motivated to engage in behavioral strategies than other patients. As such, these results may not generalize to all TJA patients. Third, although this study did not find surgery type to moderate experimental outcomes, knee and hip TJA patients may require distinct intervention strategies. Behavioral treatment development research could tailor pre-/postoperative training packages for a variety of surgical procedures to meet patients' individual needs while maximizing treatment adherence and transportability into medical settings. Fourth, the majority of participants were white and living in the mountain west. As such, the generalizability of findings to other populations is unknown. Fifth, we were unable to track intervention usage after preoperative training. While participants were not explicitly instructed to continue practicing the MBIs, MM may have been perceived as more easily self-administered than HS, increasing the likelihood that participants would continue using mindfulness skills to manage pain and distress. Future studies should assess patient use of MBIs pre- and postoperatively to determine whether intervention dosage impacts postoperative outcomes. Finally, future studies should track postoperative pain and medication use to cessation as both may impact physical function, and extend the postoperative follow-up period to examine longer-term outcomes.

Conclusions

340 TJA is one of the most common surgical procedures performed,^{1,2} with total hip and knee
341 arthroplasty rates expected to increase 100% to 400% by 2040.⁶⁶⁻⁶⁹ This study demonstrates a
342 single session of a simple, scripted MM intervention had measurable effects on physical function
343 six weeks following surgery, implicating its potential for improving surgical outcomes for the
344 millions of patients receiving TJA each year.

References

1. Abbott TEF, Fowler AJ, Dobbs TD, Harrison EM, Gillies MA, Pearse RM. Frequency of surgical treatment and related hospital procedures in the UK: a national ecological study using hospital episode statistics. *BJA Br J Anaesth*. 2017;119(2):249–257.
2. Most Common Hospital Inpatient Operations - HCUP Fast Stats. Accessed December 23, 2018. <https://www.hcup-us.ahrq.gov/faststats/NationalProceduresServlet>
3. Wylde V, Hewlett S, Learmonth ID, Dieppe P. Persistent pain after joint replacement: prevalence, sensory qualities, and postoperative determinants. *PAIN®*. 2011;152(3):566–572.
4. Glare P, Aubrey KR, Myles PS. Transition from acute to chronic pain after surgery. *The Lancet*. 2019;393(10180):1537–1546.
5. Ip HYV, Abrishami A, Peng PW, Wong J, Chung F. Predictors of postoperative pain and analgesic consumption: a qualitative systematic review. *Anesthesiol J Am Soc Anesthesiol*. 2009;111(3):657–677.
6. Katz J, Seltzer Z. Transition from acute to chronic postsurgical pain: risk factors and protective factors. *Expert Rev Neurother*. 2009;9(5):723–744.
7. Kim DH, Pearson-Chauhan KM, McCarthy RJ, Buvanendran A. Predictive factors for developing chronic pain after total knee arthroplasty. *J Arthroplasty*. 2018;33(11):3372–3378.
8. Lin RJ, Reid MC, Liu LL, Chused AE, Evans AT. The barriers to high-quality inpatient pain management: a qualitative study. *Am J Hosp Palliat Med*. 2015;32(6):594–599.
9. HEAL Initiative Research Plan. National Institutes of Health (NIH). Published June 11, 2018. Accessed July 15, 2019. <https://www.nih.gov/research-training/medical-research-initiatives/heal-initiative/heal-initiative-research-plan>
10. Dreyfus G. Is mindfulness present-centred and non-judgmental? A discussion of the cognitive dimensions of mindfulness. *Contemp Buddhism*. 2011;12(01):41–54.
11. Kabat-Zinn J. *Full Catastrophe Living*. Delacorte Press; 1990.
12. Tang Y-Y, Hölzel BK, Posner MI. The neuroscience of mindfulness meditation. *Nat Rev Neurosci*. 2015;16(4):213–225.
13. Elkins GR, Barabasz AF, Council JR, Spiegel D. Advancing research and practice: The revised APA Division 30 definition of hypnosis. *Int J Clin Exp Hypn*. 2015;63(1):1–9.
14. Beck AT. Cognitive therapy: Nature and relation to behavior therapy. *Behav Ther*. 1970;1(2):184–200.

15. Ellis A. Reason and emotion in psychotherapy. Published online 1962.
16. Garland EL, Brintz C, Hanley A, et al. Mind-Body Therapies for Opioid-Treated Pain: A Systematic Review and Meta-Analysis. *JAMA Intern Med*. Published online in press.
17. Butler AC, Chapman JE, Forman EM, Beck AT. The empirical status of cognitive-behavioral therapy: a review of meta-analyses. *Clin Psychol Rev*. 2006;26:17-31.
18. D'Silva S, Poscablo C, Habousha R, Kogan M, Kligler B. Mind-body medicine therapies for a range of depression severity: a systematic review. *Psychosomatics*. 2012;53(5):407–423.
19. Hammond DC. Hypnosis in the treatment of anxiety-and stress-related disorders. *Expert Rev Neurother*. 2010;10(2):263–273.
20. Hilton L, Hempel S, Ewing BA, et al. Mindfulness meditation for chronic pain: systematic review and meta-analysis. *Ann Behav Med*. 2017;51(2):199–213.
21. Veehof MM, Oskam M-J, Schreurs KMG, Bohlmeijer ET. Acceptance-based interventions for the treatment of chronic pain: A systematic review and meta-analysis. *PAIN*. 2011;152(3):533-542. doi:10.1016/j.pain.2010.11.002
22. Enqvist B, Fischer K. Preoperative hypnotic techniques reduce consumption of analgesics after surgical removal of third mandibular molars: a brief communication. *Int J Clin Exp Hypn*. 1997;45(2):102-108. doi:10.1080/00207149708416112
23. Montgomery GH, Bovbjerg DH, Schnur JB, et al. A Randomized Clinical Trial of a Brief Hypnosis Intervention to Control Side Effects in Breast Surgery Patients. *J Natl Cancer Inst*. 2007;99(17):1304-1312. doi:10.1093/jnci/djm106
24. Akgul A, Guner B, Çırak M, Çelik D, Hergünsel O, Bedirhan S. The Beneficial Effect of Hypnosis in Elective Cardiac Surgery: A Preliminary Study. *Thorac Cardiovasc Surg*. 2016;64(07):581-588. doi:10.1055/s-0036-1580623
25. Faymonville ME, Mambourg PH, Joris J, et al. Psychological approaches during conscious sedation. Hypnosis versus stress reducing strategies: a prospective randomized study. *Pain*. 1997;73(3):361-367.
26. Joudi M, Fathi M, Izanloo A, Montazeri O, Jangjoo A. An Evaluation of the Effect of Hypnosis on Postoperative Analgesia following Laparoscopic Cholecystectomy. *Int J Clin Exp Hypn*. 2016;64(3):365-372. doi:10.1080/00207144.2016.1171113
27. Mackey EF. An Extension Study Using Hypnotic Suggestion as an Adjunct to Intravenous Sedation. *Am J Clin Hypn*. 2018;60(4):378-385. doi:10.1080/00029157.2017.1416279
28. Mackey EF. Effects of hypnosis as an adjunct to intravenous sedation for third molar extraction: a randomized, blind, controlled study. *Int J Clin Exp Hypn*. 2010;58(1):21-38. doi:10.1080/00207140903310782

29. Marc I, Rainville P, Masse B, et al. Hypnotic analgesia intervention during first-trimester pregnancy termination: an open randomized trial. *Am J Obstet Gynecol*. 2008;199(5):469.e1-9. doi:10.1016/j.ajog.2008.01.058
30. Syrjala KL, Cummings C, Donaldson GW. Hypnosis or cognitive behavioral training for the reduction of pain and nausea during cancer treatment: a controlled clinical trial. *Pain*. 1992;48(2):137–146.
31. Kiran U, Ladha S, Makhija N, et al. The role of Rajyoga meditation for modulation of anxiety and serum cortisol in patients undergoing coronary artery bypass surgery: A prospective randomized control study. *Ann Card Anaesth*. 2017;20(2):158.
32. Dindo L, Zimmerman MB, Hadlandsmayth K, et al. Acceptance and Commitment Therapy for Prevention of Chronic Post-surgical Pain and Opioid Use in At-Risk Veterans: A Pilot Randomized Controlled Study. *J Pain*. Published online 2018.
33. Rolving N, Nielsen CV, Christensen FB, Holm R, Bünger CE, Oestergaard LG. Preoperative cognitive-behavioural intervention improves in-hospital mobilisation and analgesic use for lumbar spinal fusion patients. *BMC Musculoskelet Disord*. 2016;17(1):217.
34. Syrjala KL, Donaldson GW, Davis MW, Kippes ME, Carr JE. Relaxation and imagery and cognitive-behavioral training reduce pain during cancer treatment: a controlled clinical trial. *Pain*. 1995;63(2):189-198.
35. Garland EL, Baker AK, Larsen P, et al. Randomized controlled trial of brief mindfulness training and hypnotic suggestion for acute pain relief in the hospital setting. *J Gen Intern Med*. 2017;32(10):1106–1113.
36. Lang EV, Joyce JS, Spiegel D, Hamilton D, Lee KK. Self-hypnotic relaxation during interventional radiological procedures: effects on pain perception and intravenous drug use. *Int J Clin Exp Hypn*. 1996;44(2):106-119. doi:10.1080/00207149608416074
37. Jamison RN, Ross EL, Michna E, Chen LQ, Holcomb C, Wasan AD. Substance misuse treatment for high-risk chronic pain patients on opioid therapy: A randomized trial. *PAIN*. 2010;150(3):390-400. doi:10.1016/j.pain.2010.02.033
38. Thorn BE, Kuhajda MC. Group cognitive therapy for chronic pain. *J Clin Psychol*. 2006;62(11):1355–1366.
39. Farrar JT, Young JP, LaMoreaux L, Werth JL, Poole RM. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain*. 2001;94(2):149–158.
40. Garland EL, Manusov EG, Froeliger B, Kelly A, Williams JM, Howard MO. Mindfulness-oriented recovery enhancement for chronic pain and prescription opioid misuse: results from an early-stage randomized controlled trial. *J Consult Clin Psychol*. 2014;82(3):448.

41. Lang EV, Berbaum KS, Faintuch S, et al. Adjunctive self-hypnotic relaxation for outpatient medical procedures: a prospective randomized trial with women undergoing large core breast biopsy. *Pain*. 2006;126(1-3):155–164.
42. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual analog scale for pain (vas pain), numeric rating scale for pain (nrs pain), mcgill pain questionnaire (mpq), short-form mcgill pain questionnaire (sf-mpq), chronic pain grade scale (cpgs), short form-36 bodily pain scale (sf-36 bps), and measure of intermittent and constant osteoarthritis pain (icoap). *Arthritis Care Res*. 2011;63(S11).
43. Fries JF, Cella D, Rose M, Krishnan E, Bruce B. Progress in assessing physical function in arthritis: PROMIS short forms and computerized adaptive testing. *J Rheumatol*. 2009;36(9):2061–2066.
44. Fries JF, Krishnan E, Rose M, Lingala B, Bruce B. Improved responsiveness and reduced sample size requirements of PROMIS physical function scales with item response theory. *Arthritis Res Ther*. 2011;13(5):R147.
45. Hung M, Clegg DO, Greene T, Saltzman CL. Evaluation of the PROMIS physical function item bank in orthopaedic patients. *J Orthop Res*. 2011;29(6):947–953.
46. Kagan R, Anderson MB, Christensen JC, Peters CL, Gililand JM, Pelt CE. The recovery curve for the patient-reported outcomes measurement information system patient-reported physical function and pain interference computerized adaptive tests after primary total knee arthroplasty. *J Arthroplasty*. 2018;33(8):2471–2474.
47. Spybrook J, Raudenbush SW, Liu X, Congdon R, Martínez A. Optimal design for longitudinal and multilevel research: Documentation for the “Optimal Design” software. *Ann Arbor Univ Mich Sch Educ Hierarchical Models Proj*. Published online 2006.
48. Frison L, Pocock SJ. Repeated measures in clinical trials: analysis using mean summary statistics and its implications for design. *Stat Med*. 1992;11(13):1685–1704.
49. Gan TJ. Poorly controlled postoperative pain: prevalence, consequences, and prevention. *J Pain Res*. 2017;10:2287.
50. Garland EL, Gaylord SA, Palsson O, Faurot K, Mann JD, Whitehead WE. Therapeutic mechanisms of a mindfulness-based treatment for IBS: effects on visceral sensitivity, catastrophizing, and affective processing of pain sensations. *J Behav Med*. 2012;35(6):591–602.
51. Patterson DR, Jensen MP. Hypnosis and clinical pain. *Psychol Bull*. 2003;129(4):495.
52. Del Casale A, Ferracuti S, Rapinesi C, et al. Hypnosis and pain perception: An Activation Likelihood Estimation (ALE) meta-analysis of functional neuroimaging studies. *J Physiol-Paris*. 2015;109(4):165-172. doi:10.1016/j.jphysparis.2016.01.001

53. Rainville P, Duncan GH, Price DD, Carrier B, Bushnell MC. Pain affect encoded in human anterior cingulate but not somatosensory cortex. *Science*. 1997;277:968-971.
54. Zeidan F, Martucci KT, Kraft RA, Gordon NS, McHaffie JG, Coghill RC. Brain mechanisms supporting the modulation of pain by mindfulness meditation. *J Neurosci*. 2011;31(14):5540–5548.
55. Zeidan F, Vago DR. Mindfulness meditation–based pain relief: a mechanistic account. *Ann N Y Acad Sci*. 2016;1373(1):114–127.
56. Lautenbacher S, Huber C, Kunz M, et al. Hypervigilance as predictor of postoperative acute pain: its predictive potency compared with experimental pain sensitivity, cortisol reactivity, and affective state. *Clin J Pain*. 2009;25(2):92–100.
57. Lautenbacher S, Huber C, Schöfer D, et al. Attentional and emotional mechanisms related to pain as predictors of chronic postoperative pain: A comparison with other psychological and physiological predictors. *PAIN®*. 2010;151(3):722-731. doi:10.1016/j.pain.2010.08.041
58. Masselin-Dubois A, Attal N, Fletcher D, et al. Are Psychological Predictors of Chronic Postsurgical Pain Dependent on the Surgical Model? A Comparison of Total Knee Arthroplasty and Breast Surgery for Cancer. *J Pain*. 2013;14(8):854-864. doi:10.1016/j.jpain.2013.02.013
59. Banka TR, Ruel A, Fields K, YaDeau J, Westrich G. Preoperative Predictors of Postoperative Opioid Usage, Pain Scores, and Referral to a Pain Management Service in Total Knee Arthroplasty. *HSS J*. 2015;11(1):71-75. doi:10.1007/s11420-014-9418-4
60. Kaunisto MA, Jokela R, Tallgren M, et al. Pain in 1,000 Women Treated for Breast Cancer: A Prospective Study of Pain Sensitivity and Postoperative Pain. *Anesthesiol J Am Soc Anesthesiol*. 2013;119(6):1410-1421. doi:10.1097/ALN.0000000000000012
61. Zeidan F, Gordon NS, Merchant J, Goolkasian P. The effects of brief mindfulness meditation training on experimentally induced pain. *J Pain*. 2009;11:199-209.
62. Zeidan F, Adler-Neal AL, Wells RE, et al. Mindfulness-Meditation-Based Pain Relief Is Not Mediated by Endogenous Opioids. *J Neurosci*. 2016;36(11):3391-3397. doi:10.1523/JNEUROSCI.4328-15.2016
63. Namba RS, Inacio MC, Pratt NL, Graves SE, Roughead EE, Paxton EW. Persistent opioid use following total knee arthroplasty: a signal for close surveillance. *J Arthroplasty*. 2018;33(2):331–336.
64. Lebares CC, Hersherberger AO, Guvva EV, et al. Feasibility of Formal Mindfulness-Based Stress-Resilience Training Among Surgery Interns: A Randomized Clinical Trial. *JAMA Surg*. 2018;153(10):e182734-e182734. doi:10.1001/jamasurg.2018.2734

65. Lebares CC, Guvva EV, Olaru M, et al. Efficacy of Mindfulness-Based Cognitive Training in Surgery: Additional Analysis of the Mindful Surgeon Pilot Randomized Clinical Trial. *JAMA Netw Open*. 2019;2(5):e194108–e194108.
66. Wallace IJ, Worthington S, Felson DT, et al. Knee osteoarthritis has doubled in prevalence since the mid-20th century. *Proc Natl Acad Sci*. 2017;114(35):9332–9336.
67. Cross M, Smith E, Hoy D, et al. The global burden of hip and knee osteoarthritis: estimates from the global burden of disease 2010 study. *Ann Rheum Dis*. 2014;73(7):1323–1330.
68. Singh JA, Yu S, Chen L, Cleveland JD. Rates of Total Joint Replacement in the United States: Future Projections to 2020–2040 Using the National Inpatient Sample. *J Rheumatol*. Published online 2019:jrheum–170990.
69. Patel A, Pavlou G, Mújica-Mota RE, Toms AD. The epidemiology of revision total knee and hip arthroplasty in England and Wales: a comparative analysis with projections for the United States. A study using the National Joint Registry dataset. *Bone Jt J*. 2015;97(8):1076–1081.

Table 1. Baseline Characteristics of Initial Participant Sample by Treatment Group and Usual Care Patients

	Total	Mindfulness Meditation	Hypnotic Suggestion	Cognitive Behavioral Psychoeducation	Usual Care		
N	727	106	89	90	442		
Cohorts	47	16	15	16	-		
Sociodemographic Characteristics							
Age, mean (SD)	64.37 (11.16)	65.68 (10.78)	62.62 (10.73)	66.96 (9.97)	63.38 (12.55)	$F=3.76$	$p=.01$
Women, No. (%)	418 (57.5)	63 (59.4)	60 (67.4)	58 (64.4)	237 (53.6)	$\chi^2=8.24$	$p=.04$
Race, No. (%)						$\chi^2=19.64$	$p=.35$
American Indian or Alaska Native	9 (1.2)	-	2 (2.2)	-	7 (1.5)		
Asian	6 (0.8)	-	-	1 (1.1)	5 (1.1)		
Black or African American	8 (1.1)	2 (1.9)	-	-	6 (1.4)		
Native Hawaiian or Other Pacific Islander	6 (0.8)	-	1 (1.1)	1 (1.1)	3 (0.7)		
White or Caucasian	643 (88.4)	98 (92.5)	80 (88.9)	84 (93.3)	381 (86.2)		
Other	42 (5.8)	3 (2.8)	4 (4.5)	2 (2.2)	33 (7.5)		
Choose not to disclose	13 (1.8)	3 (2.8)	1 (1.1)	2 (2.2)	7 (1.6)		
Hispanic Ethnicity, No. (%)	42 (5.8)	4 (3.8)	4 (4.5)	4 (4.4)	30 (6.8)	$\chi^2=4.73$	$p=.58$
Admitting Diagnosis, No. (%)						$\chi^2=9.92$	$p=.02$
Hip Arthroplasty	287 (39.5)	46 (43.4)	36 (40.4)	22 (24.4)	183 (41.4)		
Knee Arthroplasty	440 (60.5)	60 (56.6)	53 (59.6)	68 (75.6)	259 (58.6)		
BMI, mean (SD)	30.40 (6.11)	29.52 (5.82)	31.31 (6.10)	30.41 (5.97)	30.43 (6.19)	$F=1.36$	$p=.25$
Median Income, mean (SD)	\$71,879 (\$19,083)	\$78,566 (\$21,920)	\$72,143 (17,595)	\$76,354 (\$20,855)	\$69,293 (\$17,712)	$F=8.97$	$p<.01$
Readmissions, mean (SD)	0.51 (0.95)	0.55 (0.93)	0.52 (0.97)	0.62 (1.05)	0.47 (0.92)	$F=0.71$	$p=.55$
Physical Therapy Sessions, mean (SD)	4.44 (7.31)	6.12 (7.48)	7.25 (8.20)	5.91 (7.59)	3.16 (6.72)	$F=12.55$	$p<.01$
Charlson Comorbidity Index, mean (SD)	1.78 (2.3)	1.78 (2.25)	1.97 (2.35)	1.64 (1.90)	1.76 (2.40)	$F=0.30$	$p=.83$
Spinal Anesthesia, No. (%)	533 (73.3)	82 (77.4)	65 (73.0)	71 (78.9)	315 (71.3)	$\chi^2=6.92$	$p=.33$
Tobacco Use, No. (%)	222 (30.5)	28 (26.4)	26 (29.2)	27 (30.0)	141 (31.9)	$\chi^2=2.01$	$p=.92$
Alcohol Use, No. (%)	316 (43.5)	47 (44.3)	46 (51.7)	39 (43.4)	184 (41.6)	$\chi^2=4.26$	$p=.64$
Drug Use, No. (%)	33 (4.5)	4 (3.8)	3 (3.4)	7 (7.8)	19 (4.3)	$\chi^2=5.88$	$p=.44$
Surgeon, No. (%)						$\chi^2=11.25$	$p=.26$
Surgeon A	30 (4.1)	5 (4.7)	-	2 (2.2)	23 (5.2)		
Surgeon B	166 (22.8)	28 (26.4)	14 (15.7)	24 (26.7)	100 (22.6)		
Surgeon C	294 (40.4)	41 (38.7)	42 (47.2)	33 (36.7)	178 (40.3)		
Surgeon D	237 (32.6)	32 (30.2)	33 (37.1)	31 (34.4)	141 (31.9)		
Nonsteroidal Anti-Inflammatory Drug Use, No. (%)	481 (66.2)	75 (70.8)	56 (62.9)	58 (64.4)	292 (66.1)	$\chi^2=1.54$	$p=.67$
Prescription Opioid Use, No. (%)	204 (28.1)	26 (24.5)	27 (30.3)	23 (25.6)	128 (29.0)	$\chi^2=1.34$	$p=.72$
Psychotropic Medication Use, No. (%)	195 (26.8)	28 (26.4)	17 (19.1)	23 (25.6)	127 (28.7)	$\chi^2=3.61$	$p=.31$
Baseline Measures of Preoperative Outcomes							
Pain Intensity ^a	4.59 (4.30 to 4.89)	4.42 (3.93 to 4.91)	4.71 (4.17 to 5.24)	4.65 (4.12 to 5.18)	-	$F=0.34$	$p=.71$
Pain Unpleasantness ^a	4.40 (4.08 to 4.72)	4.14 (3.61 to 4.66)	4.56 (3.99 to 5.13)	4.51 (3.93 to 5.08)	-	$F=0.70$	$p=.50$
Pain Medication Desire ^{a,c}	0.91 (0.78 to 1.03)	0.96 (0.75 to 1.16)	0.97 (0.75 to 1.19)	0.80 (0.57 to 1.02)	-	$F=0.75$	$p=.47$
Anxiety ^a	4.62 (4.29 to 4.95)	4.95 (4.41 to 5.50)	4.49 (3.91 to 5.08)	4.40 (3.82 to 4.99)	-	$F=1.07$	$p=.34$
Baseline Measure of Postoperative Outcome							
Physical Functioning ^b	37.53 (36.70 to 38.36)	37.87 (35.96 to 37.67)	38.19 (36.02 to 40.36)	37.24 (35.61 to 38.87)	36.82 (35.96 to 37.67)	$F=0.72$	$p=.54$

^a Baseline measures of preoperative outcome scores' range is 0 to 10. Higher scores indicate more of the respective construct.

^b Baseline measure of postoperative outcome score's range is 19.13 to 56.27. Higher scores indicate better physical functioning.

^c Square root transformed values reported due to negatively skewed raw values.

Table 2. Outcomes by Treatment Group and Mean (95% CI) Differences Between Treatment Groups (Adjusted Analyses)^{a,b}						
		Pain Intensity ^a	Pain Unpleasantness ^a	Pain Medication Desire ^{a, d}	Anxiety ^a	Physical Function ^b
Estimated Marginal Means	Mindfulness Meditation	3.38 (3.00 to 3.76)	2.96 (2.61 to 3.30)	0.62 (0.52 to 0.71)	2.81 (2.35 to 3.28)	43.36 (41.80 to 44.93)
	Hypnotic Suggestion	3.45 (3.14 to 3.77)	3.03 (2.64 to 3.43)	0.72 (0.59 to 0.84)	3.17 (2.52 to 3.82)	40.88 (39.27 to 42.50)
	Cognitive-behavioral Psychoeducation	4.11 (3.75 to 4.46)	3.70 (3.32 to 4.08)	0.78 (0.70 to 0.86)	4.17 (3.72 to 4.63)	39.69 (37.97 to 41.41)
	Usual Care	-	-	-	-	40.39 (40.24 to 40.54)
F		5.27	4.98	3.63	8.82	4.95
Omnibus P Value		.006	.008	.028	<.001	.002
Pairwise Comparisons	Mindfulness vs. Cognitive behavioral psychoeducation	-.72 ^c (-1.22 to -0.22)	-.74 ^c (-1.24 to -0.25)	-0.17 ^c (-0.29 to -0.04)	-1.35 ^c (-2.14 to -0.57)	3.68 ^c (1.36 to 6.00)
	Hypnosis vs. Cognitive behavioral psychoeducation	-.65 ^c (-1.15 to -0.19)	-.66 ^c (-1.21 to -0.12)	-0.07 (-0.21 to 0.08)	-1.00 ^c (-1.82 to -0.19)	1.20 (-1.10 to 3.49)
	Mindfulness vs. Hypnosis	-.07 (-0.56 to 0.42)	-.08 (-0.60 to 0.45)	-0.10 (-0.26 to 0.06)	-0.35 (-1.14 to 0.44)	2.48 ^c (0.22 to 4.74)
	Mindfulness vs. Usual Care	-	-	-	-	2.99 ^c (1.39 to 4.57)
	Hypnosis vs. Usual Care	-	-	-	-	0.50 (-1.09 to 2.08)
	Cognitive behavioral psychoeducation vs. Usual Care	-	-	-	-	-0.70 (-2.41 to 1.01)
^a Estimates are from linear mixed models adjusting for baseline score and admitting diagnosis. ^b Estimates are from linear mixed models adjusting for baseline score, time from surgery, and admitting diagnosis. ^c P value is less than .05 for pairwise comparison. ^d Square root transformed values reported due to negatively skewed raw values. Note. Pain intensity, pain unpleasantness, pain medication desire, and anxiety were not measured in the usual care condition as these patients did not attend Joint Academy