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Brief preoperative mind-body therapies for total joint arthroplasty patients: a randomized controlled trial

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Knee and hip replacements are the 3rd and 4th most common inpatient surgeries performed in the United States, respectively [1,53]. 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 [69]. Both preoperative risk factors and postoperative pain management influence surgical outcomes. Preoperative risk factors include pain severity/chronicity and psychological distress (e.g., anxiety) [2,25,31,36,37,39,68]. Barriers to effective postoperative pain management include perceived helplessness, insufficient pain coping education, and lack of non-pharmacological interventions [47,68]. 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 (CBT), are promising, non-pharmacological pain management

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

CONSORT Flow Chart.

Flow of participants through trial comparing mindfulness medication with hypnotic suggestion and cognitive-behavioral pain psychoeducation among patients undergoing total joint arthroplasty of the knee or hip.

Note. MRN = Medical Record Number

strategies [2,22,28,68]. Mindfulness meditation (MM) involves non-reactively observing thoughts, feelings and body sensations as they arise [7,11,34,65]. Hypnosis (HS) modulates the placebo response via suggestions to alter thoughts, feelings, and body sensations [12,55]. CBT is a form of psychotherapy that challenges dysfunctional thoughts as a means of modifying emotional and behavioral responses, and is commonly considered the gold standard behavioral treatment for pain [6,13]. Despite sharing operational processes, these three MBIs represent distinct clinical approaches. Most notably, CBT relies on logical means to consciously dispute dysfunctional thoughts, emotions, and behaviors, while MM and HS leverage attentional techniques to nonreactively observe the mind at work or increase responsiveness to suggestions for change, respectively. MS and HS also differ in that the former is a self-regulated attentional process whereas the latter is dependent on suggestions provided by a therapist. Thus, while evidence suggests that delivering mindfulness [10,40], hypnosis [4,14,16,33,48–50,52,63], and CBT [59,64] preoperatively can improve postoperative outcomes, given their putative mechanistic differences, it may be that these three MBIs differentially impact postoperative outcomes. To date, 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 MM, HS, and cognitive-behavioral education (CBE) interventions all delivered in a very brief (i.e., 15-minute), single session format for patients undergoing total joint arthroplasty (TJA) of the knee or hip. In a prior RCT (N=244), we demonstrated that brief MM and HS decreased acute pain, anxiety, and the desire to take analgesic medication to a significantly greater extent than a CBE control condition among inpatients with a variety of clinical pain conditions [21]. 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 CBE.

Methods

Trial Design and Randomization

This was a single-site, three-arm, parallel-group RCT (trial registry: NCT03665727). The local IRB approved all procedures. Participants provided informed consent after reviewing an informed consent cover letter with study personnel. Patients and the public were not involved in the design or conduct of this study.

Participants were patients at an academic medical center scheduled for knee or hip 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 CBE. 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 who attended Joint Academy from January 2018 to January 2019 were eligible to participate. 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.

Interventions

Study interventions were matched in terms of format (group), duration (15 minutes), and frequency (once). Each intervention was delivered according to a manualized protocol by a licensed psychologist with eight years of experience using CBT in clinical work and seven years of experience using mindfulness-based interventions and hypnotic suggestion. The same individual delivered all interventions to prevent therapist effects, whereas adherence to a manualized protocol helped to protect against potential bias or treatment diffusion. 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 [21]. HS consisted of a 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 hypnotic induction script (see supplementary materials) validated in prior research on hypnosis during acute medical procedures [42]. CBE 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 [32,66]. We selected a CBE 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.

All participants received standard medical care for TJA. Surgical and anesthetic protocols were highly consistent as all TJAs were performed by one of four surgeons working at the same orthopedic center. For all primary TJAs of the knee or hip an intra-operative periarticular joint infiltration was used, consisting of a standardized cocktail of clonidine,

morphine, epinephrine, toradol, ropivicaine, and saline. Some patients also received a pre- or post-operative adductor canal single shot nerve block (See Table 1). Post-operatively, patients received a standardized analgesic regimen that included ASA 81 mg BID for deep venous thrombosis prophylaxis, Tylenol, an NSAID (e.g., Naproxen, Celebrex, Mobic), and Tramadol. For patients still experiencing pain, a breakthrough orally administered narcotic (Oxycodone) was used. There was no difference in the amount of postoperative opioids administered between groups. Intravenous narcotics were avoided and PCA opioids are never used at this orthopedic center.

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 [15], pain unpleasantness [15], pain medication desire [24], and anxiety [41,70,71] 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 [21,27].

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 [17,18,30,35].

PROMIS-PF scores were obtained through medical record review. Medical staff gathering PROMIS-PF data during routine pre- and postoperative visits 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=16, *S.D.*=15). Postoperatively, patients' PROMIS-PF score most proximal to their 6-week follow-up was included ($\bar{x}$ days post-surgery=48, *S.D.*=19). 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 linear mixed modeling, *a priori* power analysis was conducted using Optimal Design [62]. An estimated total sample size of 250 participants in 47 cohorts was determined necessary to detect an overall between-group (MM vs. HS vs. CBE) 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. For the preoperative mixed models, outcome variables were regressed on intervention group (MM vs. HS vs. CBE) after covarying baseline values and scheduled surgery. For the postoperative mixed model, physical functioning was regressed on intervention group (MM vs. HS vs. CBE) after covarying baseline physical functioning, scheduled surgery, and days from surgery to postoperative assessment to account for variance in postoperative recovery time. In accordance with the classical ANCOVA approach endorsed by Frison and Pocock [19] 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 analysis was also performed for the physical functioning outcome adjusting for all sociodemographic characteristics listed in Table 1, including those baseline characteristics found to differ between groups (i.e., age, scheduled surgery), as well as analgesic use. To determine whether surgery type (knee or hip) 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. Finally, we examined within-group effects in the pre- and postoperative outcomes. 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

Of the 481 participants scheduled to attend Joint Academy, 316 attended, with 271 participants (95%) completing the entire preoperative survey. Of the 316 randomized participants, 31 were excluded from the study due to surgery cancellation (n=10) or ineligibility (n=9), or their medical record number was unavailable (n=12). Postoperative PROMIS-PF assessment scores were available for 74% of participants (see supplementary materials for CONSORT Flowchart). Per our *a priori* power analysis, recruitment was stopped after the 47th cohort. No intervention related harms or unintended effects occurred during this study.

Treatment conditions were similar in sociodemographic characteristics and acute clinical symptomology (Table 1). Mean pain intensity, pain unpleasantness, and anxiety scores indicated moderate levels of acute clinical symptomology during Joint Academy. As pain medication desire may simply serve as a proxy for pain intensity and pain unpleasantness in opioid naïve patients, we examined bivariate correlations between pain medication desire, pain intensity, and pain unpleasantness. Pain medication desire was significantly associated with both pain intensity and pain unpleasantness in both opioid naïve (intensity r = .57, p < .001; unpleasantness r = .65, p < .001) and opioid using (intensity r = .60, p < .001; unpleasantness r = .61, p < .001) patients. 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: $\chi^2(2)=1.17$, $p=.56$).

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 CBE. Additionally, patients randomized to MM reported significantly less pain medication desire than those randomized to CBE. No difference was observed between MM and HS on any of the four preoperative outcomes (Figure 1). Significant within-group effects were observed for each preoperative outcome (Table 3).

6-week Postoperative Outcome

After surgery, a significant effect of MBI condition was observed for postoperative physical function (Table 2). Planned pairwise comparisons indicated that participants randomized to MM reported significantly greater physical function than those randomized to HS or CBE and usual care patients (Figure 2). A sensitivity analysis, adjusting for all sociodemographic characteristics listed in Table 1, did not alter these results ($F=6.65$, $p=.002$), and a significant within-group effect was observed for the MM condition only (Table 3). Moderation analysis revealed non-significant interactions between intervention condition and surgery type, indicating that surgery type did not differentially impact the three interventions. Opioid ($F=1.40$, $p=.249$) and NSAIDs ($F=0.63$, $p=.535$) prescriptions did not differ by MBI condition [Opioid: MM=28 (26%), HS=16 (18%), CBE=28 (31%); NSAIDs: MM=69 (65%), HS=62 (70%), CBE=67 (74%)] at the 6-week postoperative visit.

Discussion

In addition to pharmacological pain management, surgical patients need effective, nonpharmacological pain management strategies [20,25,39,47]. 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 [25,39]. 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 CBE. 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 [35]. 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 [35]. 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 psychological 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 [23]. 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 [57]. Despite their apparent differences, neuroimaging demonstrates that mindfulness and hypnosis both alleviate pain by modulating corticothalamic activity integral to processing ascending nociceptive input [9,58,74,75]. 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 [5,38,43,44,51]. Future studies could use psychophysiological measures to discriminate mind-body interventions; for instance, heart rate variability (HRV) has been shown to distinguish the analgesic mechanisms of mindfulness versus slow breathing [3].

Study findings are consistent with evidence that mindfulness and hypnosis relieve clinical pain and reduce emotional distress [10,22,26,29,40,60,72,73]. 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 [21]. 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 [35], and chronic opioid use, which has been observed in 41% of knee TJA patients [54]. 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 [45,46] 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 CBE 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, in the present trial, though there were no observed differences in opioid prescription rates, we were unable to assess intervention effects on actual opioid consumption. 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

TJA is one of the most common surgical procedures performed [1,53], with total knee and hip arthroplasty rates expected to increase 100% to 400% by 2040 [8,56,61,67]. This study demonstrates a single session of a simple, scripted MM intervention had measurable effects on physical function six weeks following surgery, implicating its potential for improving surgical outcomes for the millions of patients receiving TJA each year.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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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 mindfulness) sponsored by institutions of higher education, government agencies, academic teaching hospitals, and medical centers. Dr. Garland receives royalties from the sale of books related to MORE. Dr. Garland also is a consultant to BehaVR, LLC.

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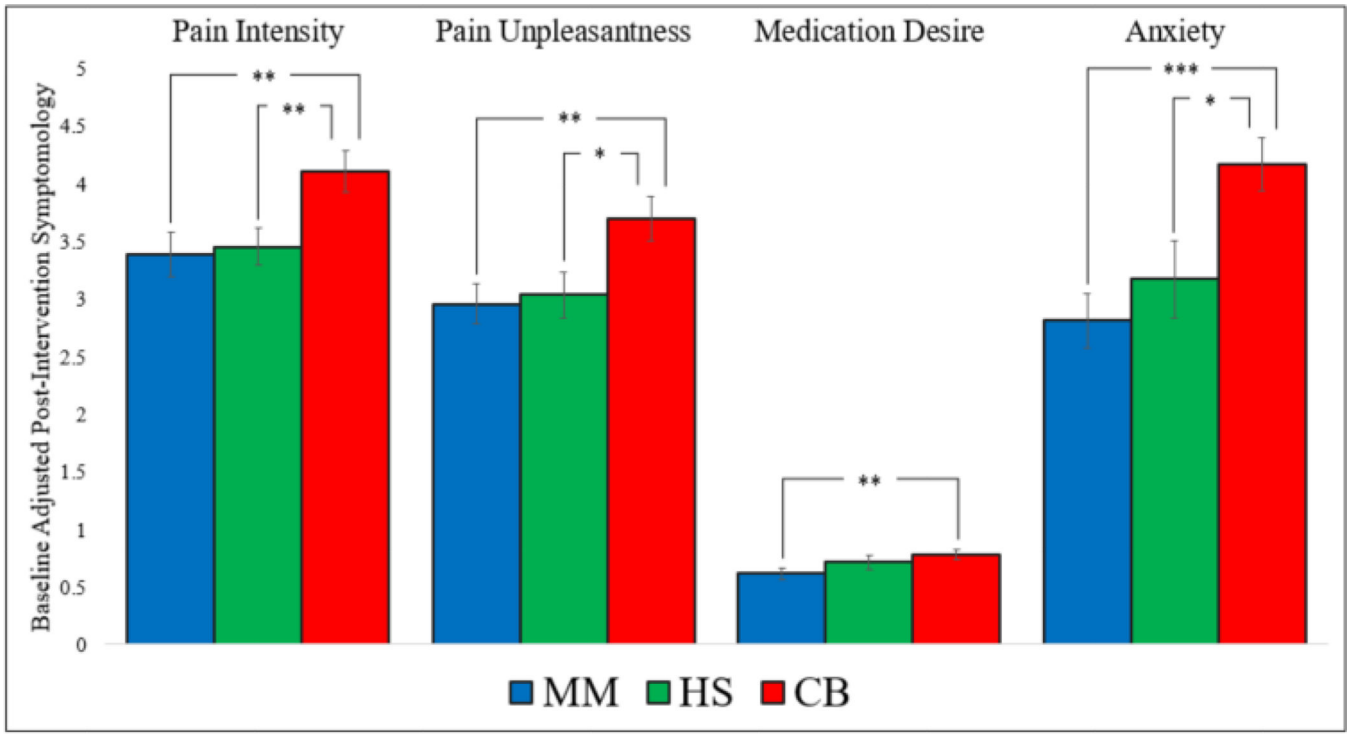

Figure 1.

Bar graphs representing baseline adjusted pain intensity, pain unpleasantness, pain medication desire, and anxiety by condition. MM=Mindfulness Meditation. HS = Hypnotic Suggestion. CBE = Cognitive Behavioral Pain Psychoeducation.

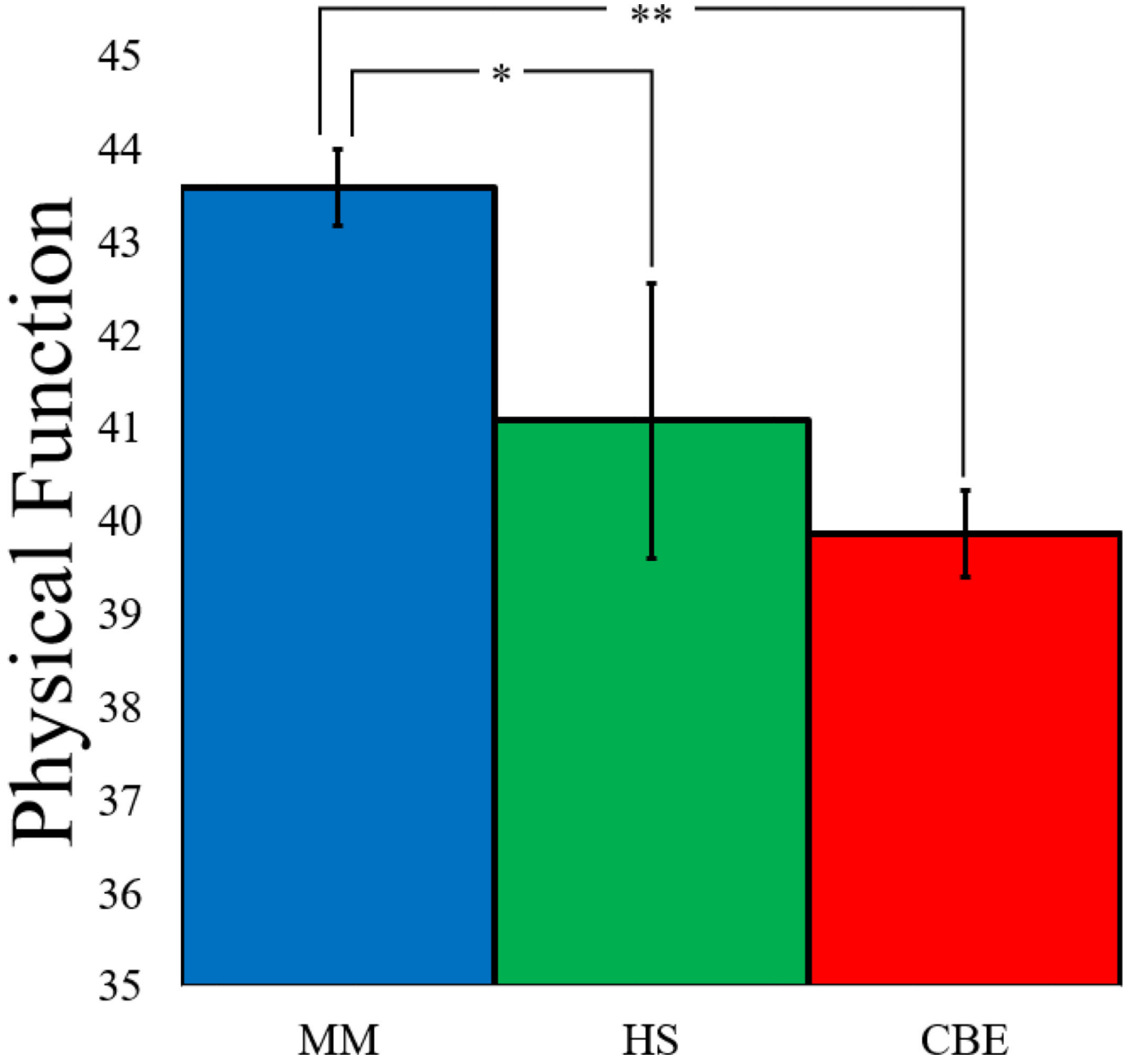

Figure 2.

Bar graph depicting baseline adjusted physical function by condition. MM=Mindfulness Meditation. HS = Hypnotic Suggestion. CBE = Cognitive Behavioral Pain Psychoeducation.

Table 1.

Baseline Characteristics of Participant Sample by Treatment Condition

	Total	Mindfulness Meditation	Hypnotic Suggestion	Cognitive Behavioral Education	Test Statistic	Statistical Significance
N	285	106	89	90		
Cohorts	47	16	15	16		
Sociodemographic Characteristics						
Age, mean (SD)	65.44 (10.56)	65.52 (10.75)	63.20 (10.67)	67.56 (9.88)	F=3.88	*p=.02*
Women, No. (%)	181 (63.5)	63 (59.4)	60 (67.4)	58 (64.4)	χ^2=1.38	*p=.50*
Race, No. (%)					χ^2=13.80	*p=.31*
American Indian or Alaska Native	2 (0.7)	-	2 (2.2)	-		
Asian	1 (0.4)	-	-	1 (1.1)		
Black or African American	2 (0.7)	2 (1.9)	-	-		
Native Hawaiian or Other Pacific Islander	3 (1.1)	-	1 (1.1)	1 (1.1)		
White or Caucasian	262 (91.9)	98 (92.5)	80 (88.9)	84 (93.3)		
Other	9 (3.2)	3 (2.8)	4 (4.5)	2 (2.2)		
Choose not to disclose	6 (2.1)	3 (2.8)	1 (1.1)	2 (2.2)		
Hispanic Ethnicity, No. (%)	12 (4.2)	4 (3.8)	4 (4.5)	4 (4.4)	χ^2=1.77	*p=.78*
Scheduled Surgery, No. (%)					χ^2=8.42	*p=.02*
Hip Arthroplasty	104 (36.5)	46 (43.4)	36 (40.4)	22 (24.4)		
Knee Arthroplasty	181 (63.5)	60 (56.6)	53 (59.6)	68 (75.6)		
BMI, mean (SD)	30.35 (5.98)	29.52 (5.82)	31.31 (6.10)	30.41 (5.97)	F=2.12	*p=.12*
Median Income, mean (SD)	$75,862 ($20,421)	$78,566 ($21,920)	$72,143 (17,595)	$76,354 ($20,855)	F=2.46	*p=.09*
Readmissions, mean (SD)	0.56 (0.98)	0.55 (0.93)	0.52 (0.97)	0.62 (1.05)	F=0.28	*p=.76*
Physical Therapy Sessions, mean (SD)	6.41 (7.74)	6.12 (7.48)	7.25 (8.20)	5.91 (7.59)	F=0.78	*p=.46*
Charlson Comorbidity Index, mean (SD)	1.79 (2.2)	1.78 (2.25)	1.97 (2.35)	1.64 (1.90)	F=0.50	*p=.61*
Tobacco Use, No. (%)	81 (28.4)	28 (26.4)	26 (29.2)	27 (30.0)	χ^2=0.35	*p=.84*
Alcohol Use, No. (%)	132 (46.3)	47 (44.3)	46 (51.7)	39 (43.4)	χ^2=1.52	*p=.47*
Drug Use, No. (%)	14 (4.9)	4 (3.8)	3 (3.4)	7 (7.8)	χ^2=2.33	*p=.31*
Surgeon, No. (%)					χ^2=9.59	*p=.14*
Surgeon A	7 (2.5)	5 (4.7)	-	2 (2.2)		
Surgeon B	66 (23.2)	28 (26.4)	14 (15.7)	24 (26.7)		
Surgeon C	116 (40.7)	41 (38.7)	42 (47.2)	33 (36.7)		
Surgeon D	96 (33.7)	32 (30.2)	33 (37.1)	31 (34.4)		

	Total	Mindfulness Meditation	Hypnotic Suggestion	Cognitive Behavioral Education	Test Statistic	Statistical Significance
Nonsteroidal Anti-Inflammatory Drug Use, No. (%)	189 (66.3)	75 (70.8)	56 (62.9)	58 (64.4)	χ^2=1.54	*p=.46*
Prescription Opioid Use, No. (%)	76 (26.7)	26 (24.5)	27 (30.3)	23 (25.6)	χ^2=0.92	*p=.63*
Psychotropic Medication Use, No. (%)	68 (23.9)	28 (26.4)	17 (19.1)	23 (25.6)	χ^2=1.63	*p=.44*
Spinal Anesthesia, No. (%)	218 (76.5)	82 (77.4)	65 (73.0)	71 (78.9)	χ^2=0.92	*p=.63*
Nerve Block, No. (%)	11 (3.9%)	2 (1.9%)	4 (4.5%)	5 (5.6%)	χ^2=1.91	*p=.39*
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 and Timing of Assessments						
Physical Functioning [b]	37.77 (37.04 to 38.83)	37.87 (37.04 to 38.69)	38.19 (35.26 to 41.12)	37.24 (36.32 to 38.16)	*F*=0.59	*p*=.56
Days from Preoperative Assessment to Surgery	20.28 (17.81 to 22.75)	20.55 (16.37 to 24.73)	17.23 (11.51 to 22.94)	21.75 (18.01 to 25.49)	*F*=0.98	*p=.38*
Days from Surgery to Postoperative Assessment	52.22 (48.67 to 55.77)	54.58 (48.10 to 61.05)	51.63 (45.44 to 57.83)	50.03 (44.20 to 55.85)	*F*=0.57	*p=.56*

[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 23.21 to 55.20. 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)	43.59 (42.02 to 45.16)
	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)	41.08 (39.29 to 42.87)
	Cognitive Behavioral Education	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)	39.87 (38.04 to 41.71)
F		5.27	4.98	3.63	8.82	4.79
Omnibus *P* Value		.006	.008	.028	<.001	.010
Cohen's *d*		.40	.39	.32	.54	.41
Pairwise Comparisons	Mindfulness vs. Cognitive behavioral education	−.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)	3.71 [c] (1.29 to 6.14)
	Hypnosis vs. Cognitive behavioral education	−.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)	1.21 (−1.13 to 3.54)
	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)	2.51 [c] (0.13 to 4.88)

[a] Estimates are from linear mixed models adjusting for baseline score and scheduled surgery.

[b] Estimates are from linear mixed models adjusting for baseline score, scheduled surgery, and time from surgery.

[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

Table 3.

Within-Group Effects for Preoperative and Postoperative Outcomes

	Mindfulness Meditation		**Hypnotic Suggestion**		**Cognitive Behavioral Education**	
Outcome	*t*	Cohen's *d*	*t*	Cohen's *d*	*t*	Cohen's *d*
Pain Intensity	5.91***	.59	6.35***	.70	3.63***	.39
Pain Unpleasantness	7.11***	.70	7.57***	.83	4.52***	.49
Pain Medication Desire	4.78***	.48	3.72***	.41	2.12*	.23
Anxiety	7.47***	.74	5.56***	.61	2.39*	.25
Physical Function	5.69***	.94	1.83	.38	1.43	.22