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Longitudinal effects of interoceptive awareness training as an adjunct to medication treatment for opioid use disorder: A randomized clinical trial of Mindful Awareness in Body-oriented Therapy

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ABSTRACT

Background and objective: Medication for opioid use disorder (MOUD) treatment outcomes can be limited by co-occurring mental and physical conditions, and new adjunctive interventions are needed to improve treatment. Mindful Awareness in Body-oriented Therapy (MABT) teaches interoceptive awareness skills to promote well-being. This study evaluated the longitudinal effects of MABT as an adjunct to MOUD treatment.
Methods: Patients stable on MOUD recruited from six community clinics were randomly assigned to MABT+MOUD *or* MOUD. Five assessments delivered over one year (N = 303) examined abstinence from non-prescribed opioid and overall substance use (primary outcomes), and secondary outcomes of mental and physical health distress, interoceptive and mindfulness skills, and opioid craving. An intent-to-treat approach to examine change across time involved generalized estimating equations and linear mixed multilevel models.
Results: This sample demonstrated high percent days abstinence from non-prescribed opioids and other substances, resulting in no statistical between-group differences over time. Significant overall longitudinal effects for MABT+MOUD vs. MOUD were evident on secondary outcomes of physical symptom frequency, and interoceptive awareness. In addition, significant baseline to 12 month between-group improvements were evident on PTSD symptoms, emotion regulation difficulties, and mindfulness skills.
Conclusions: While stable on MOUD, this sample had high levels of chronic pain and mental health distress. The results highlight improved longitudinal health outcomes in response to MABT critical to support recovery on MOUD. The MABT completion rate and maintained use of MABT skills over 12 months demonstrates MABT implementation feasibility and positive intervention response as an adjunct to MOUD treatment.
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1. Introduction

Medication for opioid use disorder (MOUD) has been shown to reduce illicit opioid use and improve health outcomes for patients with OUD (Larochelle et al., 2018; Sordo et al., 2017) However, treatment retention rates are low (Chan et al., 2021) and the high prevalence of co-occurring psychiatric disorders (Leyde et al., 2024; Rodriguez et al., 2024) and chronic pain (Barry et al., 2016; Hser et al., 2017; Leyde et al., 2024) are associated with poor treatment outcomes. The need for behavioral strategies as adjunctive treatment support due to the high levels of psychological and physical distress among this population is well-recognized (Jones and McCance-Katz, 2019; Novak et al., 2019; Watkins et al., 2024).

A meta-analysis of mindfulness-based interventions (MBIs) shows promising treatment effects for reducing substance use and secondary outcomes of craving, psychological distress, and pain outcomes when delivered within the context of substance use disorder (SUD) treatment (Li et al., 2017). The benefits of MBIs for SUD treatment are understood to be due to improvements to underlying cognitive and affective processes, specifically neurocognitive processes that are responsible for modulating automaticity, regulation and stress reactivity (Priddy et al., 2018; Garland, 2016). Interoceptive awareness, defined as the process of consciously sensing, representing, and appraising the body's internal state (Craig, 2003; Khalsa et al., 2018) is linked to regulation and

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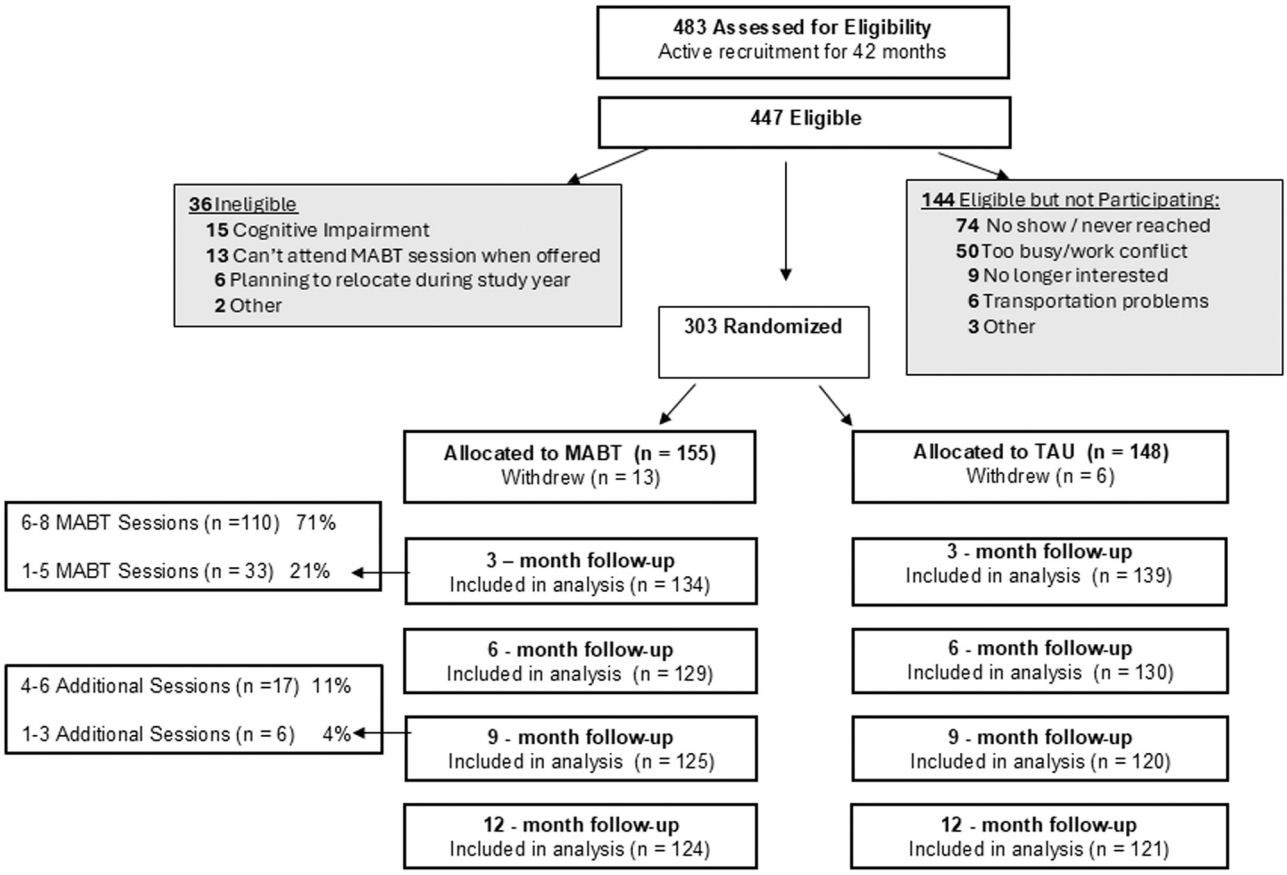

Fig. 1. Consort Diagram.

positive health outcomes (Price and Weng, 2021; Weng et al., 2021), but can be impaired in those with mental health and substance use disorders (Quadt et al., 2018). Mindful Awareness in Body-oriented Therapy (MABT) addresses interoceptive impairments through an individualized protocol designed specifically to develop the capacity for interoceptive awareness and related skills for regulation and self-care (Price and Hooven, 2018). An initial neuroimaging randomized controlled trial (RCT) showed increased sensory processing and associated self-reported interoceptive awareness in response to MABT compared to controls (Price et al., 2023). Prior randomized controlled trials examined MABT as an adjunct to SUD outpatient treatment for women (Price et al., 2019, 2012) and demonstrated longitudinal reductions in days abstinent from substance use, craving, and psychological distress as well as increased interoceptive awareness and mindfulness skills compared to SUD treatment alone.

This clinical trial builds on these prior studies by examining MABT as an adjunct to medication treatment for opioid use disorder for both women and men, to see whether increasing interoceptive capacity and skills through MABT might support MOUD treatment outcomes by addressing prevalent complex and co-occurring conditions such as chronic pain and mental health symptoms. Our immediate pre-post intervention (baseline to 3 months) findings from this study highlighted the acquisition of interoceptive skills, improved pain severity, activity interference, physical symptom frequency, and reduced symptoms of post-traumatic stress for those who received MABT as an adjunct to MOUD versus MOUD alone (Price et al., 2024).

This report describes the longer-term results from the same randomized controlled trial. We hypothesized that from baseline to 12-months MABT + MOUD versus MOUD would result in (1) a higher percentage of days abstinent from opioids and overall substance use, (2) improved health outcomes including mental health distress; emotion regulation; pain severity, pain interference and physical symptom frequency; interoceptive and mindfulness skills; and opioid craving. This study also explored the potential impact of MABT on treatment retention.

2. Methods

2.1. Study design

This NIH-funded randomized controlled trial was a 2-group repeated measures design involving five assessments over 12 months to compare the effectiveness of MABT as an adjunct to usual care (MOUD). Participants assigned to MABT+MOUD were offered 8 weekly individual 75-minute sessions of MABT delivered at their treatment clinic. Participants assigned to MABT+MOUD who reported any use of non-prescribed substances (excluding marijuana) or heavy drinking at the 6-month assessment were offered six additional MABT sessions.

The power analysis for this study, based on results from a RCT of MABT for SUD treatment (Price et al., 2019) indicated a sample of 307 allowed 80 % power with 20 % attrition to detect a minimum difference in proportions of 0.11 (11 %) of days abstinent between MABT+ MOUD vs. MOUD comparing groups from baseline to 12 months. All study procedures were approved by the Institutional Review Board at the University of Washington (#5923 on 12/4/2018) and performed in accordance with the Helskinki Declaration of 1975.

Table 1
Demographic and Clinical Characteristics.

	Total	MOUD	MABT+MOUD
N	303	148	155
Age, median (range)	40 (21–73)	41 (22–71)	37 (21–73)
Gender Identity			
Male	144 (48 %)	69 (47 %)	75 (48 %)
Female	157 (52 %)	78 (53 %)	79 (51 %)
Non-binary	2 (1 %)	1 (1 %)	1 (1 %)
Hispanic	27 (9 %)	15 (10 %)	12 (8 %)
Race			
White	238 (79 %)	113 (76 %)	125 (81 %)
More than one race	28 (9 %)	19 (13 %)	9 (6 %)
Black or African American	16 (5 %)	7 (5 %)	9 (6 %
Native American	13 (4 %)	4 (3 %)	9 (6 %)
Asian	3 (1 %)	2 (1 %)	1 (1 %)
Hawaiian or Pacific Islander	4 (1 %)	3 (2 %)	1 (1 %)
Marital Status			
Married or Domestic Partnership	51 (17 %)	27 (18 %)	24 (15 %)
Single	215 (71 %)	97 (66 %)	118 (76 %)
Unknown (Endorsed "Other")	36 (12 %)	23 (16 %)	13 (8 %)
Highest Education Level			
11th grade or less	36 (12 %)	15 (10 %)	21 (14 %)
High school or GED	132 (44 %)	65 (44 %)	67 (43 %)
Two-year college/technical school	103 (34 %)	55 (37 %)	48 (31 %)
College degree (e.g., BA, BS)	32 (11 %)	13 (9 %)	19 (13 %)
Monthly Income			
No monthly income	47 (16 %)	27 (18 %)	20 (13 %)
Some income but less than $1000	132 (44 %)	64 (43 %)	68 (44 %)
$1000 or more	124 (41 %)	57 (39 %)	67 (43 %)
Employed – full or part time	104 (35 %)	47 (31 %)	57 (37 %)
Insurance[a]			
Medicaid	219 (72 %)	107 (72 %)	112 (72 %)
Medicare	69 (23 %)	36 (24 %)	33 (21 %)
Private	36 (12 %)	13 (9 %)	23 (15 %)
None	5 (2 %)	4 (3 %)	1 (1 %)
Chronic Pain 3 Months or More	172 (57 %)	87 (59 %)	85 (55 %)
Above Cut-off Mental Health Disorder	124 (41 %)	62 (42 %)	62 (40 %)
Post Traumatic Stress Disorder (PTSD)[b]			
Moderate Depression[c]	147 (49 %)	70 (47 %)	77 (48 %)
Moderate Anxiety[d]	121 (40 %)	56 (38 %)	65 (41 %)
Lifetime Trauma Exposure (TLEQ)			
Childhood Sexual Assault	165 (54 %)	86 (58 %)	79 (51 %)
Childhood Physical Assault	127 (42 %)	66 (45 %)	61 (40 %)
Adult Sexual Assault	110 (37 %)	54 (36 %)	56 (37 %)
Adult Physical Assault by Stranger	163 (54 %)	84 (57 %)	79 (51 %)
Intimate Partner Violence (IPV)	223 (74 %)	113 (80 %)	110 (77 %)
Accidents/ Non-interpersonal Trauma	243 (86 %)	117 (82 %)	126 (89 %)
Medication for Opioid Use Disorder (MOUD)			
Methadone	35 (12 %)	17 (12 %)	18 (13 %)
Buprenorphine	249 (88 %)	125 (88 %)	124 (87 %)
Time in Treatment Prior to Enrollment			
3–6 months	25 (9 %)	10 (7 %)	15 (11 %)
6–12 months	44 (15 %)	16 (11 %)	28 (20 %)
> 12 months	188 (66 %)	100 (70 %)	88 (62 %)

Note: No significant differences between study groups. Values are number (percentage) unless otherwise indicated.
[a] Participants could select multiple responses.
[b] PCL-5 $\geq$ 31;
[c] PHQ-9 $\geq$ 10;
[d] GAD-7 $\geq$ 10

2.2. Procedures

2.2.1. Recruitment and Screening

Participants were recruited by clinic staff (nurses, physicians, counselors) at six outpatient MOUD clinics located in western Washington State from August 2019 - January 2023. Five clinics prescribed buprenorphine and one dispensed methadone, with all sites confirming OUD at treatment entry. Interested individuals were screened for eligibility by the clinic research coordinator. Inclusion criteria were: 1) diagnosed with OUD; 2) enrolled in a medication treatment program for opioid use disorder; 3) over 18 years old; 4) stable on medication dose, involving (if buprenorphine) at least four weeks of medication treatment and appointment frequency of less than once/week (to ensure completed initiation and attained degree of stability); involving (if methadone) at least 90 days in treatment with a minimum dose of 60 mg, no missed dose evaluation appointments in past 30 days, and no more than 3 missed doses in 30 days; 5) willing to forego (non-study) manual (e.g., massage) and/or mind-body therapies (e.g., mindfulness meditation) for 3 months (baseline to post-test); 6) willing to sign release for access of electronic medical records; 7) fluent in English; 8) able to attend study sessions when offered. Exclusion criteria: 1) unwilling or unable to remain in MOUD treatment for the duration of the trial (includes planned relocation, pending extended incarceration, etc); 2) over 24 weeks gestation, if pregnant, to avoid intervention interruptions related to childbirth; 3) unmedicated psychosis or other conditions such as cognitive impairment, to be assessed with an adapted 7-item Mini-Mental Status Exam (MMSE),(Tombaugh et al., 1996) if there was reported brain injury or questionable comprehension of the consent form.

2.2.2. Enrollment and Study Group Assignment

Eligible individuals were enrolled after providing informed consent for study participation. Following the baseline assessment, participants were randomly assigned using a 1:1 ratio within clinic to study group (MOUD+MABT or MOUD) and stratified by gender and chronic pain to ensure that the treatment groups had equal numbers of men and women and those with and without chronic pain. Chronic pain was defined as self-reported pain of at least three months duration. Randomization used software program Rand.F,'(Cain, 2009) an algorithm modification of the minimization method (Pocock, 1983)

2.2.3. Data collection

A trained research coordinator at each clinical site administered assessments at baseline, 3, 6, 9 and 12 months. Data were collected at each assessment, taking approximately 45 min, using a) an interview calendar method to gather substance use information and b) an online survey to assess secondary self-report outcomes. A set of baseline-only questionnaires was used to collect information regarding demographic and health history (McLellan et al., 1992), economic and legal status, and life-time trauma exposure (Kubany et al., 2000).

In addition to the assessment procedures outlined above, MABT

Table 2
Substance Use Outcomes.

	Baseline		3 Months		6 Months		9 Months		12 Months		Wald X^2 Group x Time p value		Between Group Mean Difference in Change 0–12 Months (95 % CI), p value Effect Size (95 % CI)
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	X^2	p	
% Days Abstinent Opioid Use[a,b]													
MABT+MOUD	96.9	0.9	97.1	1.0	96.7	1.2	94.0	1.7	95.3	1.8	0.83	.93	−0.06 (−1.65, 1.03), p = .91
MOUD	97.8	1.0	98.7	0.9	98.0	1.0	97.3	1.4	96.9	1.2			d = −.04 (−.29,.21)
% Days Abstinent Total Substance Use[a,c,d]													
MABT+MOUD	90.4	1.7	92.2	1.7	92.4	1.7	89.1	2.2	90.3	2.2	1.76	.78	0.01 (−0.53, 0.54), p = .98
MOUD	90.3	2.0	93.1	1.7	91.2	2.1	89.6	2.3	90.1	2.1			d = −.00 (−.25,.25)

[a]Data are estimates from a GEE model with a logit link and adjusted for number of days since last assessment.
[b]Sample sizes at baseline, 3, 6, 9 and 12 months: MABT+MOUD (155, 139, 134, 130, 124); MOUD (148, 139, 134, 129, 121).
[c]Total Substance Use includes all unprescribed substances and heavy drinking days but does not include cannabis.
[d]Sample sizes at baseline, 3, 6, 9 and 12 months: MABT+MOUD (155, 139, 134, 130, 123); MOUD (148, 139, 134, 129, 121).

participants completed a follow-up questionnaire at 6, 9 and 12 months to assess their continued use of MABT skills; specifically they were asked to indicate frequency of learned skills on a 5 point-scale ranging from "not at all" to "daily or almost daily." Data was also collected from electronic medical records specific to substance use and treatment adherence. For participants who did not come to the clinic for follow-up assessments, substance use data was collected by phone interview when possible. For this reason, there are slight variations in the number of study participants with reported primary outcomes and secondary outcomes. Participants were compensated $30 for completion of the baseline assessment, and $40, $50, $60, and $70 respectively, for completion of each subsequent assessment.

2.3. Measures

2.3.1. Primary outcome

The primary outcome of days abstinent from non-prescribed opioids and overall substance use was assessed with the Time-Line Follow-back interview (TLFB) (Sobell et al., 1996; Sobell and Sobell, 1992) over the past 90 days. The primary outcomes were a) percent days abstinent from non-prescribed opioid use, and b) percent days abstinent from overall substance use, including short-term heavy drinking ($\geq$ 4 drinks for a woman, $\geq$ 5 drinks for a man) and non-prescribed drugs (excluding marijuana, legal in Washington State). Marijuana use is reported separately. The baseline TLFB was 90 days; the subsequent TLFBs were based on participant assessment periods (approximately 90 days).

2.3.2. Secondary outcomes

Secondary outcomes included measures of: a) mental health distress and emotion regulation difficulties, b) pain and physical symptoms, c) interoceptive awareness and mindfulness skills, and d) opioid craving. Treatment retention was explored using medical records; MABT practice was collected as descriptive data.

Mental health distress was assessed using three scales with screening cut-off values including the Posttraumatic Stress Disorder (PTSD) Checklist (PCL-5) (Dickstein et al., 2015), the Patient Health Questionnaire (PHQ-9) for depression (Kroenke et al., 2001); and the General Anxiety Disorder −7 (GAD-7) (Spitzer et al., 2006). To assess emotion dysregulation, the Difficulties in Emotion Regulation Short Form (DERS-SF) (Kaufman et al., 2016) was used.

Pain was measured using the Brief Pain Inventory (Poquet and Lin, 2016) which assessed pain severity, and two distinct dimensions of pain interference (Cleeland et al., 1996; Miettinen et al., 2019): activity interference (walking, work, general activity) and affective interference (mood, social relations, life enjoyment, sleep). To measure physical symptoms, the Medical Symptoms Checklist (Leserman et al., 1998) was used to assess the number and frequency of 33 common physical symptoms.

The Multidimensional Assessment of Interoceptive Awareness (MAIA) v.2 (Mehling et al., 2018, 2012) assessed interoceptive awareness. Mindfulness skills were assessed on the Freiburg Mindfulness Inventory (Walach et al., 2006).

Opioid craving level was assessed using an 11-point numeric scale (Rosenberg, 2009). Craving was assessed for the medication prescribed (buprenorphine or methadone). Additionally, for those who endorsed craving, if endorsed, participants were asked to rate craving level on a 1–10 point numeric scale. In addition, participants were asked if they experienced craving for opioids other than their medication. The subgroup that endorsed craving for non-prescribed opioids were then asked to rate their level of craving on a 1–10 point numeric scale.

Please see Price et al., (2024) for detailed description of each of the measures listed above, including scale range and reliability.

2.4. Study conditions and intervention

All study participants were enrolled in MOUD, which served as the control condition. At each clinic, routine initial intake in MOUD involved a comprehensive assessment of substance use and related consequences, medical and mental health status, and current barriers to and supports for recovery; formal diagnosis of opioid use disorder and appropriateness for MOUD; scheduling and monitoring of medication initiation and urine drug testing. Limited counseling and/or behavioral health services were available at all clinical settings but required only for those receiving methadone. The COVID pandemic changed policies and procedures at some clinical sites (for over one year of the study period, starting in March 2020), primarily reducing urine drug testing and use of telemedicine instead of in-person visits in buprenorphine settings and increased take-home methadone dosing in the opioid treatment program.

Those assigned to MABT+MOUD served as the experimental study condition. MABT is a manualized protocol composed of 8-weekly 75-minute individual sessions, delivered over 8–12 weeks. The MABT approach is designed to sequentially teach interoceptive awareness through three stages of learning, involving a trauma-informed approach that combines touch, psychoeducation and mindfulness to develop interoceptive capacity and integration of learned skills into daily life to promote self-care (Price and Hooven, 2018). Stage 1 develops body literacy, the ability to identify and articulate sensory awareness. Stage 2 focuses on learning to access sensory awareness through interoceptive attention. Stage 3 furthers the development and practice of mindful body awareness, involving sustained mindful presence with interoceptive attention on regions of the body, aiming to facilitate positive shifts in sensory experience as well as insights that promote somatic reappraisal and support behavior change (Price and Weng, 2021). MABT integrates touch to help orient and maintain interoceptive attention and was delivered individually by massage therapists trained in the MABT

Table 3
Secondary Outcomes.

	Baseline		3 Months		6 Months		9 Months		12 Months		Wald X^2 Group x Time p value		Between Group Mean Difference in Change 0–12 Months, (95 % CI), p value Effect Size (95 % CI)
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	X^2	p	
Mental Health Distress and Emotion Dysregulation													
PTSD Symptoms[a]													
MABT+MOUD	27.7	1.3	21.7	1.3	22.1	1.4	20.8	1.4	20.8	1.5	8.60	.07	−4.62 (−8.27, −0.98), $p = .01$
MOUD	27.7	1.5	25.1	1.7	23.8	1.6	23.6	1.7	25.5	1.7			$d = -.33$ (−.59, −.08)
Depression Symptoms[b]													
MABT+MOUD	9.9	0.4	7.9	0.4	8.1	0.5	7.5	0.5	8.0	0.5	3.41	.49	−0.35 (−1.72, 1.02), $p = .62$
MOUD	9.9	0.5	8.5	0.5	8.0	0.5	8.1	0.6	8.4	0.6			$d = -.15$ (−.40,.11)
Anxiety Symptoms[c]													
MABT+MOUD	8.7	0.4	6.3	0.4	6.6	0.4	6.1	0.4	6.5	0.4	3.70	.44	−1.07, (−2.38, 0.25), $p = .11$
MOUD	8.7	0.5	7.3	0.5	7.2	0.5	7.1	0.5	7.5	0.5			$d = -.30$ (−.55, −.05)
Emotion Regulation Difficulties[d]													
MABT+MOUD	39.5	0.9	35.6	0.9	35.7	1.0	35.6	0.9	35.0	.09	4.60	.33	−2.53 (−5.03, −0.03), $p = .047$
MOUD	39.9	1.1	37.7	1.2	37.5	1.1	37.1	1.1	38.0	1.2			$d = -.31$ (−.56, −.05)
Pain and Physical Symptoms													
Pain Severity[e]													
MABT+MOUD	3.8	0.2	3.3	0.2	3.3	0.2	3.3	0.2	3.3	0.2	7.29	.12	−0.12 (−0.53, 0.29), $p = .58$
MOUD	3.8	0.2	3.6	0.2	3.3	0.2	3.4	0.2	3.4	0.2			$d = -.10$ (−.35,.15)
Pain Activity Interference[f]													
MABT+MOUD	11.2	0.7	9.0	.07	9.6	0.7	8.8	0.7	9.1	0.7	9.40	.05	−0.62 (−2.52, 1.28), $p = .52$
MOUD	10.8	0.7	10.7	0.7	9.0	0.7	9.6	0.8	9.4	0.7			$d = -.05$ (−.31,.20)
Pain Affective Interference[g]													
MABT+MOUD	14.5	0.8	12.2	0.8	12.1	0.9	11.3	0.9	12.1	0.9	3.70	.45	−0.61 (−2.98, 1.76), $p = .61$
MOUD	14.8	0.9	13.8	0.9	12.3	0.9	12.9	0.9	13.0	0.9			$d = -.07$ (−.32,.18)
Physical Symptom Frequency[h]													
MABT+MOUD	2.2	0.04	2.0	0.04	2.0	0.05	2.0	0.05	2.0	0.05	11.2	.02	−0.11 (−0.25, 0.04), $p = .15$
MOUD	2.2	0.04	2.1	0.05	2.1	0.05	2.0	0.05	2.1	0.05			$d = -.29$ (−.54, −.04)
Interoceptive Awareness and Mindfulness Skills													
Interoceptive Awareness[i]													
MABT+MOUD	2.5	0.1	2.9	0.1	2.9	0.1	2.9	0.1	2.9	0.1	24.3	< .001	0.38 (0.21, 0.54), $p < .001$
MOUD	2.6	0.1	2.7	0.1	2.7	0.1	2.6	0.1	2.6	0.1			$d = .62$ (.37,.88)
Mindfulness Skills[j]													
MABT+MOUD	34.4	0.7	38.2	0.6	38.4	0.7	38.8	0.7	38.8	0.7	6.90	.14	2.18 (0.36, 4.01), $p = .02$
MOUD	35.1	0.8	37.6	0.7	37.7	0.7	37.2	0.8	37.3	0.8			$d = .35$ (.10,.60)
MOUD Medication Craving (full sample)[k]													
MABT+MOUD	1.7	0.2	1.2	0.2	1.5	.02	1.3	0.2	1.1	0.2	6.70	.15	−0.62 (−1.24, 0.00), $p = .05$
MOUD	1.5	0.2	1.3	0.2	1.5	0.2	1.0	.02	1.4	.02			$d = -.18$ (−.44,.07)
Non-Prescribed Opioid Craving (sub-sample)[l]													
MABT+MOUD	4.1	0.3	4.4	0.4	5.0	0.4	5.0	0.4	4.3	0.5	0.52	.97	−0.5 (−1.8, 0.9), p = .48
MOUD	4.1	0.3	4.5	0.4	5.2	0.4	5.2	0.4	4.8	0.5			$d = -.05$ (−.30,.20)

[a] PCL-5; Sample sizes at baseline, 3, 6, 9 &12 months: MABT+MOUD: (155, 135, 129, 125, 124); MOUD (148, 131, 131, 120, 121).
[b] PHQ-9; Sample sizes at baseline, 3, 6, 9 & 12 months: MABT+MOUD (155, 135, 127, 125, 124); MOUD (148, 131, 131, 120, 120).
[c] GAD-7; Sample sizes at baseline, 3, 6, 9 &12 months: MABT+MOUD (155, 134, 129, 125, 124); MOUD (148, 131, 130, 120, 121).
[d] DERS-SF; Sample sizes at baseline, 3, 6, 9 & 12 months: MABT+MOUD (155, 135, 129, 125, 124); MOUD (148, 131, 131, 119, 121).
[e] BPI; Sample sizes at baseline, 3, 6, 9 & 12 months: MABT+MOUD (154, 135, 129, 124, 124); MOUD (148, 131, 131, 119, 121).
[f] BPI; Sample sizes at baseline, 3, 6, 9 & 12 months: MABT+MOUD (155, 135, 129, 125, 124); MOUD (148, 131, 131, 120, 121).
[g] BPI; Sample sizes at baseline, 3, 6, 9 & 12 months: MABT+MOUD (155, 134, 129, 125, 124); MOUD (148, 131, 131, 120, 121).
[h] MSC; Sample sizes at baseline, 3, 6, 9 & 12 months: MABT+MOUD (154, 134, 127, 122, 122); MOUD (148, 129, 129, 117, 119).
[i] MAIA; Sample sizes at baseline, 3, 6, 9 & 12 months: MABT+MOUD (155, 134, 129, 125, 124); MOUD (148 131, 130, 119, 121).
[j] FMI; Sample sizes at baseline, 3, 6, 9 & 12 months: MABT+MOUD (154, 134, 129, 125, 124); MOUD (147, 131, 131, 120, 121).
[k] Craving: Sample sizes at baseline, 3, 6, 9 & 12 months: MABT+MOUD (154, 135, 129, 125, 124); MOUD (148 131, 132, 120, 121).
[l] Craving: Sample sizes at baseline, 3, 6, 9 & 12 months: MABT+MOUD (49, 35, 26, 29, 26); MOUD (44, 34, 30, 20, 31).

approach, all of whom had psychotherapy and/or mindfulness training. Fidelity monitoring included weekly review of audio-recorded sessions and adherence to process evaluation forms.

2.5. Data analyses

Primary outcome measures (opioid use and overall substance use) were analyzed as percent days abstinent. Generalized Estimating Equations (GEE) was used for examination of the primary outcome to manage data that was measured in percentages (i.e. days abstinent from substance), using logit transformations of the outcome variable (total days abstinent) and specified the binomial distribution based on the actual total number of days in the measurement period. This accounted for the number of days in the measurement period that varied across individuals. Secondary outcomes were analyzed using linear mixed multilevel models. An intent-to-treat approach was followed; no missing data was imputed and to handle missing data we used listwise deletion.

Two analytic strategies were used to test primary and secondary outcomes. The first involved longitudinal models that included data from all assessment time points (0, 3, 6, 9 and 12-months). Models included a random intercept to account for within-participant correlation across time and were estimated using robust standard errors. The longitudinal models included terms for the effect of group (MABT+MOUD vs MOUD), month, a month x group interaction. Omnibus tests of group differences for both primary and secondary outcomes were assessed using Wald χ^2 with significance set by a two-sided p of 0.05. The second strategy was to examine focal differences in change between groups within 4 intervals: from baseline to 3, 6, 9 and 12 months. Table 2 & 3 include means on all measures at all time points, but only the long-term change (baseline to 12-months) is reported in the

Table 4
Treatment Retention Status Over Time.

Assessment Study Group	In treatment n (%)	Not in treatment n (%)	Tapered off opioids n (%)	Withdrawn/ Unknown n (%)
3 Months				
MABT+MOUD	146 (94.2)	3 (1.9)	0 (0.0)	6 (3.9)
MOUD	143 (96.6)	2 (1.4)	1 (0.7)	2 (1.4)
6 Months				
MABT+MOUD	146 (94.2)	5 (3.2)	1 (0.7)	13 (10.4)
MOUD	132 (89.2)	4 (2.7)	3 (2.0)	9 (6.1)
9 Months				
MABT+MOUD	126 (81.3)	8 (5.2)	2 (1.3)	17 (12.9)
MOUD	120 (81.1)	11 (7.4)	3 (2.0)	12 (8.1)
12 Months				
MABT+MOUD	119 (76.8)	10 (6.5)	2 (1.3)	24 (15.5)
MOUD	114 (77.0)	13 (8.8)	3 (2.0)	18 (12.2)

Note. No significant group differences

text.

Due to significant baseline differences by clinical site and chronic pain, entropy balancing (Hainmueller, 2012; Hainmueller and Xu, 2013) was employed to control for multiple baseline factors prior to running the analyses allowing for the main analysis to be run without the use of multiple covariates and to retain the full sample. Entropy balancing created matching weights for the treatment and control groups on demographic and baseline outcome variables, including site, time in treatment prior to enrollment, chronic pain status, levels of mental health distress, levels of pain severity and interference, gender, and age. Please see prior publication for details (Price et al., 2024). In addition, predictive models were used (controlling for gender, age, clinical site, and time in treatment at enrollment) to explore whether chronic pain influenced response to outcomes and the results showed that it did not. For parsimony these findings are not reported.

To explore the potential helpfulness of additional MABT sessions with reported substance use at 6 months among those assigned to MABT, comparisons were made between those who received additional MABT sessions ($n = 23$) and those in usual care who also reported substance use at 6 months ($n = 43$). In addition, differences in outcomes were examined between these subgroups and the non-substance using sample (MABT+MOUD vs. MOUD) at 9 and 12 months. There were no significant group differences observed in these analyses; indicating that the 6-month additional MABT sessions in this subset of MABT participants did not influence outcomes. Given this, our report is for the full sample with a focus on the longitudinal effects of MABT.

3. Results

3.1. Participants

Of the 483 individuals screened for participation between August 2019 and January 2023, 303 enrolled and were randomized to study groups (see Fig. 1). Demographic characteristics are shown in Table 1 (no participants in this study were pregnant). This study sample was of low socio-economic status (SES): the majority were unemployed (65 %), and on Medicaid (72 %). Prior to study enrollment the majority (67 %) had been in MOUD treatment for over 12 months. Approximately 6 % of the enrolled participants withdrew from study participation soon after enrollment, and another 8 % were lost to follow-up and did not complete an assessment after baseline. Of the participants assigned to MABT, 109 (71 %) completed the intervention program, defined as completing at least 75 % of the intervention. Forty participants assigned to MABT (15 %) reported use of substances (excluding marijuana) at 6 months and were offered six additional MABT sessions; of these, 23 received 1–6 sessions.

3.2. Opioid and overall substance use: primary outcomes

Both study groups retained relatively high mean percent days abstinence from opioids across time (> 94 % abstinent days), representing a non-significant between group difference in opioid use on both the omnibus test ($\chi 2 = .83$; $p = .93$) and from baseline to 12 months (-0.06 difference; 95 % CI: −1.65–1.03), $p = .91$). Similarly, a non-

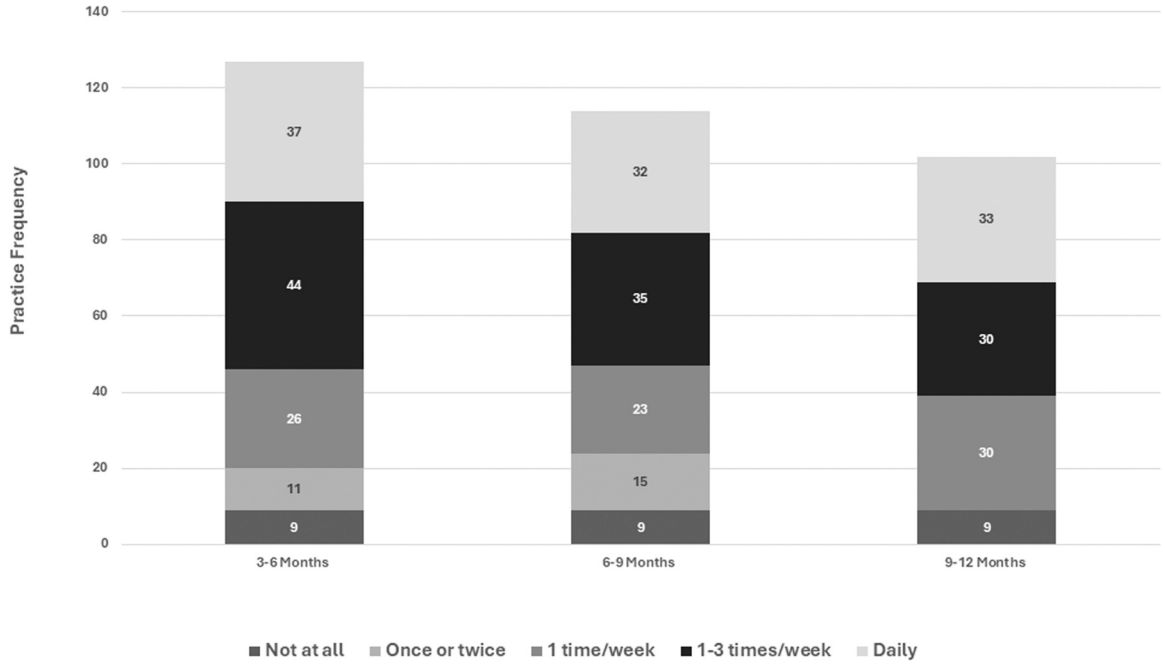

Fig. 2. Frequency of MABT Skills Practice.

significant difference was observed for overall substance use (> 89 % abstinent days) in both study groups across time ($\chi2 = 1.76$; $p = .78$) on omnibus; 0.01 difference; 95 % CI: −0.53–0.54, $p = .98$ on focal comparison from baseline to 12 months), see Table 2.

3.3. Secondary Outcomes

3.3.1. Mental Health Distress and Emotion Dysregulation

MABT+MOUD vs. MOUD did not quite reach significance on the omnibus test ($\chi2 = 8.6$; $p = .07$) but demonstrated a significant focal reduction in PTSD symptoms (-4.62 difference; 95 % CI: −8.27 to −0.98; $p = .01$) vs. MOUD from 0 to 12 months. In contrast, symptoms of depression and anxiety improved for both study groups and differences were non-significant for both the omnibus ($\chi2 = 3.41$; $p = .49$ and $\chi2 = 3.7$; $p = .44$ respectively) and focal analyses (-0.35 difference; CI: −1.72–1.02: $p = .62$ & −1.07 difference: CI: −2.38–0.25; $p = .11$ respectively), see Table 3. Greater clinical improvement in anxiety symptoms at 12 months was observed for the MABT +MOUD study group, with 54 % dropping from above to below the screening cut-off for moderate to severe anxiety vs. 29 % in MOUD.

For emotion regulation difficulties, the omnibus test did not show a difference between groups ($\chi2 = 4.6$; $p = .33$), however the focal 0–12 month comparison showed a significant improvement for MABT+MOUD vs. MOUD (-2.53 difference; 95 % CI: −5.03 to −0.03; $p < .05$), see Table 3.

3.3.2. Pain and Physical Symptom Outcomes

Physical symptom frequency was significantly improved on the omnibus test for MABT+MOUD vs MOUD ($\chi2 = 11.23$; $p = .02$). Pain activity interference for MABT+MOUD vs MOUD was marginally significant ($\chi2 = 9.41$; $p = .05$). In contrast, pain severity and pain affective interference improved for both study groups over time and showed non-significant longitudinal differences for both omnibus ($\chi2 = 7.29$; $p = .12$ and $\chi2 = 3.70$; $p = .45$ respectively) and focal comparisons (0.12 difference; 95 % CI: −0.53–0.29; $p = .58$ and −0.61 difference; 95 % CI: −2.98–1.76; $p = .61$ respectively), see Table 3.

3.3.3. Interoceptive awareness and Mindfulness skills

The omnibus test for interoceptive awareness was highly significant ($\chi2 = 24.37$; $p = <.001$).

Mindfulness skills did not show a significant omnibus result ($\chi2 = 6.90$; $p = .14$), however there was a significant long-term focal improvement for MABT+MOUD vs MOUD (2.18 difference; 95 % CI: 0.36–4.01; $p = .02$), see Table 3.

3.3.4. Opioid craving

Opioid craving for prescribed medication did not show an omnibus effect ($\chi2 = 6.70$; $p = .15$) and showed marginally significant improvement on the focal long-term comparison for MABT+MOUD vs. MOUD (-0.62 difference; 95 % CI: −1.24–0.00; $p = .05$). For the subset that endorsed craving for non-prescribed opioids, there were no between-group differences in craving (-.05 difference; 95 % CI: −1.8 to.09; $p = .48$), see Table 3.

3.4. Exploratory Outcome: MOUD Treatment Retention

Overall retention in MOUD treatment was > 75 % for the 12-month study period (Table 4); the decrease in treatment retention across both study groups was similar from 3 to 12 months (94–77 % for MABT+MOUD; 97–77 % for MOUD).

3.5. Continued use of MABT skills learned

Participants assigned to MABT reported continued practice of interoceptive awareness skills over time. Notably, the vast majority of the sample (79–90 %) at each follow-up time point reported practice of MABT skills at least one time per week; approximately one third practiced MABT skills on a daily basis (Fig. 2).

3.6. MABT intervention adverse events

Six participants assigned to MABT reported a mild to moderate adverse response to an MABT session, involving increased emotional or physical discomfort; all were resolved.

4. Discussion

The primary outcomes of abstinence from opioids or overall substance use were not different between those who received MABT+MOUD vs. MOUD. This finding is likely attributable to the medication stability required for enrollment and resulted in a sample study that showed little overall substance use and maintained engagement in MOUD treatment. However, while stable on medication, this sample had substantial physical and mental health distress with over 50 % reporting chronic pain, 40–50 % meeting screening criteria for at least one mental health disorder, and over 70 % reporting exposure to 5 types of traumatic events (Leyde et al., 2024; Rodriguez et al., 2024) On secondary outcomes, MABT demonstrated a significant omnibus result on physical symptom frequency, and interoceptive awareness indicating a superior effect on these outcomes for MABT+MOUD compared to MOUD. Pain activity interference and PTSD symptoms also showed an overall omnibus improvement for MABT+MOUD vs MOUD but not quite at the level of significance. Focal long-term effects (mean change from baseline to 12 months) showed significant improvement for MABT+MOUD vs. MOUD on PTSD symptoms, emotion regulation difficulties, and mindfulness skills. Interoceptive awareness showed a medium effect size for change over 12 months (.62), and other measures with significant mean change over 12 months had an effect size ranging from.31–.35, consistent with longitudinal findings from other studies of mindfulness-based approaches used in SUD treatment (Li et al., 2017).

The MABT completion rate and the ongoing use of MABT skills over the year of study involvement demonstrated high interest and perceived benefit of additional services involving a mind-body approach to support recovery and address symptoms of distress common in those with OUD. Medication stability likely allowed those receiving MABT to participate in the intervention more fully than if less stable participants were chosen. Notably, although this sample had little to no prior familiarity with MBIs, and a high prevalence of trauma exposure and chronic pain, MABT participants increased and maintained capacity to mindfully attend, listen and regulate in response to sensory cues, as measured by the MAIA (see also qualitative findings in Price et al., 2024). Overall, as an adjunctive study with a highly traumatized and distressed sample, the results show remarkable gains over 12 months in response to a relatively short intervention.

Pain outcomes within and between study groups varied over time. For example, pain severity was significantly and positively impacted by MABT in the short term (pre to post intervention, see Price et al., 2024) but the differences between study groups diminished over the following nine months of the study; similarly, while the MABT intervention had an immediate (though not significant) positive affect on pain affective interference these differences by study group were not maintained over time due to improvements among those in MOUD treatment only. A similar pattern is visible in depression symptoms over time, reflecting the ongoing health improvements in response to MOUD treatment among this treatment-engaged sample. In contrast, physical symptom frequency and pain activity interference showed, respectively, significant and near-significant improvement across time for those who received MABT+MOUD compared to MOUD. Prior research shows that although significantly correlated, pain intensity and pain interference are separate constructs (Edwards et al., 2022; Vowles et al., 2017) and that among those with chronic pain and OUD, pain interference was significantly and positively related to pain acceptance after controlling

for pain intensity (Mun et al., 2019). As a mindfulness-based approach, MABT includes a focus on awareness, acceptance and increased connection to areas of bodily pain (Price and Mehling, 2016), which may explain the reduction in frequency of physical symptoms and pain activity interference in response to MABT+MOUD compared to MOUD alone. These results correspond with a prior MABT SUD study (Price and Herting, 2013) that showed positive changes in bodily dissociation and emotion regulation to have an indirect effect on decreased symptoms of post-traumatic stress. Learning to be present with and accepting of one's bodily experiences is critically important for reconnecting with the body, particularly for those who've developed maladaptive coping patterns to manage pain and/or distress from interpersonal trauma (Price and Hooven, 2018).

Unlike many interventions with effects that are greatest immediately after treatment but gradually diminish, MABT's effects were sustained, consistent with prior MABT SUD studies (Price et al., 2019, 2012). This is likely a function of MABT's unique underlying processes of interoceptive training, including enhanced connectivity in areas of the brain associated with sensory processing (Price et al., 2023) and increased bodily connection/embodiment in the presence of traumatic stress (Price and Herting, 2013), supported by ongoing practice of interoceptive skills in daily life. The effect size (.62) for interoceptive awareness skills at the twelve-month follow-up supports the clinical meaningfulness of this longitudinal result. While medication for OUD is an effective treatment, by itself it does not address these underlying sensory awareness processes important for regulation and management of chronic pain (Gnall et al., 2024), and post-traumatic stress (Joshi et al., 2023) that are theorized to negatively impact addictive behavior (Garland, 2016; Priddy et al., 2018; Quadt et al., 2018; Witkiewitz et al., 2013).

To date, only one prior fully scaled RCT of a mindfulness-based intervention (MBI) as an adjunct to MOUD vs. MOUD has been published (Cooperman et al., 2023) enrolling patients with chronic pain on methadone into a group intervention involving no dose stability eligibility requirements. Comparisons with the current study are difficult due to these differences but may inform future research. For example, Cooperman's study demonstrated significant reductions in opioid and substance use outcomes as well as improved treatment retention for the MBI+MOUD vs MOUD (Cooperman et al., 2023), indicating the vulnerability to relapse and the related positive impact on substance use outcomes when recruiting at the time of treatment initiation. Like the current study, significant between-group improvement on pain outcomes were evident (Cooperman et al., 2023) supporting interoceptive awareness as a possible mechanism underlying improved pain (Gnall et al., 2024). A different RCT that did not have a true control, but like the current study recruited only those stable on opioid dose, examined a group MBI intervention +MOUD vs. group psychological support+MOUD (Schuman-Olivier et al., 2025) and also showed no change in opioid or overall substance use in either treatment arm. This finding, along with those from the current study, highlights the high levels of abstinence from non-prescribed drugs when MOUD dose stability is an eligibility criterion, an important design consideration for future research, as well as a highly positive indicator of MOUD treatment for this sub-set of committed patients. Related, as in the current study, opioid craving was also found to be reduced in response to the mindfulness intervention compared to the comparison condition (Schuman-Olivier et al., 2025); given the low levels of substance use across the sample and the mixed findings depending on whether assessing craving for opioid medication or non-prescribed opioids, this result needs to be interpreted with caution. In consideration of the clinical implications of these findings from various MBIs as adjuncts to MOUD treatment, it is notable that while there are distinct differences between the MBIs in the studies mentioned above, there are important overlaps in intervention content involving the development of mindfulness skills for reappraisal and regulation in response to life stressors. Future research to compare or combine these approaches holds promise. Likewise, implementation science research is needed to examine integrative service uptake and related patient outcomes.

4.1. Limitations

Study limitations include enrolling patients stable on medication to maximize their ability to participate and benefit from MABT, resulting in the inability to demonstrate the potential impact of MABT on substance use outcomes. Study clinics served a primarily low SES population, and thus it is unknown if these results generalize to higher SES. A prior SUD MABT study based on a higher SES population showed a more positive longitudinal effect on depression (Price et al., 2012) suggesting that the intervention length may need to be modified depending on internal resources and external supports of the population being served. Last, it is recommended that future studies include only those with chronic pain or only those without, to facilitate analysis and interpretation of findings.

Study strengths included implementation in community-based programs to an underserved population, and a range of clinical outcomes to reflect the complexity of patients receiving MOUD. There was excellent study retention, and intervention completion, with little missing data over the study period. Also, we enrolled a large sample of both men and women with sufficient statistical power to detect meaningful effects and to show an equivalent response to treatment by gender.

5. Conclusions

The study results showed MABT to be efficacious on longitudinal health outcomes indicating improved support for the physical and mental wellbeing of individuals engaged in MOUD treatment. As an adjunct to MOUD in patients stabilized on MOUD, MABT did not reduce opioid or overall substance use. These study findings are consistent with neuroscience models and research, and mindfulness frameworks, that suggest the importance of interoceptive skills to reduce distress and support regulation among those in SUD treatment. Future implementation science research is needed to determine if MABT can be effectively implemented as an integrative service in the context of standard medical care.

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CRediT authorship contribution statement

Cynthia J Price: Writing – original draft, Research team supervision, Project administration, Investigation, Funding acquisition, Conceptualization. **Kenneth C Pike:** Writing – review & editing, Formal analysis, Data curation. **Joseph O Merrill:** Writing – review & editing,

Investigation, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data Availability

A de-identified data set is available through ICPSR at: http://doi.org/10.3886/ICPSR39235

References

Barry, D.T., Cutter, C.J., Beitel, M., Kerns, R.D., Liong, C., Schottenfeld, R.S., 2016. Psychiatric disorders among patients seeking treatment for Co-Occurring chronic pain and opioid use disorder. J. Clin. Psychiatry 77, 1413–1419. https://doi.org/10.4088/JCP.15m09963.

Cain, K.C., 2009. RandF Computer software. University of Washington Office of Nursing Research.

Chan, B., Gean, E., Arkhipova-Jenkins, I., Gilbert, J., Hilgart, J., Fiordalisi, C., Hubbard, K., Brandt, I., Stoeger, E., Paynter, R., Korthuis, P.T., Guise, J.-M., 2021. Retention strategies for medications for opioid use disorder in adults: a rapid evidence review. J. Addict. Med 15, 74–84. https://doi.org/10.1097/ADM.0000000000000739.

Cleeland, C.S., Nakamura, Y., Mendoza, T.R., Edwards, K.R., Douglas, J., Serlin, R.C., 1996. Dimensions of the impact of cancer pain in a four country sample: new information from multidimensional scaling. Pain 67, 267–273. https://doi.org/10.1016/0304-3959(96)03131-4.

Cooperman, N.A., Lu, S.-E., Hanley, A.W., Puvananayagam, T., Dooley-Budsock, P., Kline, A., Garland, E.L., 2023. Telehealth Mindfulness-Oriented Recovery Enhancement vs Usual Care in Individuals With Opioid Use Disorder and Pain. JAMA Psychiatry. https://doi.org/10.1001/jamapsychiatry.2023.5138

Craig, A.D., 2003. Interoception: the sense of the physiological condition of the body. Curr. Opin. Neurobiol. 13, 500–505.

Dickstein, B.D., Weathers, F.W., Angkaw, A.C., Nievergelt, C.M., Yurgil, K., Nash, W.P., Baker, D.G., Litz, B.T., 2015. Diagnostic utility of the posttraumatic stress disorder (PTSD) checklist for identifying full and partial PTSD in Active-Duty military. Assessment 22, 289–297. https://doi.org/10.1177/1073191114548683.

Edwards, K.A., Vowles, K.E., McHugh, R.K., Venner, K.L., Witkiewitz, K., 2022. Changes in pain during buprenorphine maintenance treatment among patients with opioid use disorder and chronic pain. J. Consult. Clin. Psychol. 90 (4), 314–325. https://doi.org/10.1037/ccp0000692.

Garland, E.L., 2016. Restructuring reward processing with Mindfulness-Oriented recovery enhancement: novel therapeutic mechanisms to remediate hedonic dysregulation in addiction, stress, and pain. Ann. N. Y Acad. Sci. 1373, 25–37. https://doi.org/10.1111/nyas.13034.

Gnall, K.E., Sinnott, S.M., Laumann, L.E., Park, C.L., David, A., Emrich, M., 2024. Changes in interoception in Mind-body therapies for chronic pain: a systematic review and Meta-Analysis. Int J. Behav. Med 31, 833–847. https://doi.org/10.1007/s12529-023-10249-z.

Hainmueller, J., 2012. Entropy balancing for causal effects: a multivariate reweighting method to produce balanced samples in observational studies. Political Anal. 20, 25–46. https://doi.org/10.1093/pan/mpr025.

Hainmueller, J., Xu, Y., 2013. **ebalance**: a *stata* package for entropy balancing. J. Stat. Softw. 54. https://doi.org/10.18637/jss.v054.i07.

Hser, Y.-I., Mooney, L.J., Saxon, A.J., Miotto, K., Bell, D.S., Huang, D., 2017. Chronic pain among patients with opioid use disorder: results from electronic health records data. J. Subst. Abus. Treat. 77, 26–30. https://doi.org/10.1016/j.jsat.2017.03.006.

Jones, C.M., McCance-Katz, E.F., 2019. Co-occurring substance use and mental disorders among adults with opioid use disorder. Drug Alcohol Depend. 197, 78–82. https://doi.org/10.1016/j.drugalcdep.2018.12.030.

Joshi, S.A., Aupperle, R.L., Khalsa, S.S., 2023. Interoception in fear learning and posttraumatic stress disorder. Focus (Madison) 21, 266–277. https://doi.org/10.1176/appi.focus.20230007.

Kaufman, E.A., Xia, M., Fosco, G., Yaptangco, M., Skidmore, C.R., Crowell, S.E., 2016. The difficulties in emotion regulation scale short form (DERS-SF): validation and replication in adolescent and adult samples. J. Psychopathol. Behav. Assess. 38, 443–455. https://doi.org/10.1007/s10862-015-9529-3.

Khalsa, S.S., Adolphs, R., Cameron, O.G., Critchley, H.D., Davenport, P.W., Feinstein, J. S., Feusner, J.D., Garfinkel, S.N., Lane, R.D., Mehling, W.E., Meuret, A.E., Nemeroff, C.B., Oppenheimer, S., Petzschner, F.H., Pollatos, O., Rhudy, J.L., Schramm, L.P., Simmons, W.K., Stein, M.B., Stephan, K.E., Van den Bergh, O., Van Diest, I., von Leupoldt, A., Paulus, M.P., Ainley, V., Al Zoubi, O., Aupperle, R., Avery, J., Baxter, L., Benke, C., Berner, L., Bodurka, J., Breese, E., Brown, T., Burrows, K., Cha, Y.-H., Clausen, A., Cosgrove, K., Deville, D., Duncan, L., Duquette, P., Ekhtiari, H., Fine, T., Ford, B., Garcia Cordero, I., Gleghorn, D., Guereca, Y., Harrison, N.A., Hassanpour, M., Hechler, T., Heller, A., Hellman, N., Herbert, B., Jarrahi, B., Kerr, K., Kirlic, N., Klabunde, M., Kraynak, T., Kriegsman, M., Kroll, J., Kuplicki, R., Lapidus, R., Le, T., Hagen, K.L., Mayeli, A., Morris, A., Naqvi, N., Oldroyd, K., Pané-Farré, C., Phillips, R., Poppa, T., Potter, W., Puhl, M., Safron, A., Sala, M., Savitz, J., Saxon, H., Schoenhals, W., Stanwell-Smith, C., Teed, A., Terasawa, Y., Thompson, K., Toups, M., Umeda, S., Upshaw, V., Victor, T., Wierenga, C., Wohlrab, C., Yeh, H., Yoris, A., Zeidan, F., Zotev, V., Zucker, N., 2018. Interoception and mental health: a roadmap. Biol. Psychiatry Cogn. Neurosci. Neuroimaging 3, 501–513. https://doi.org/10.1016/j.bpsc.2017.12.004.

Kroenke, K., Spitzer, R.L., Williams, J.B.W., 2001. The PHQ-9. J. Gen. Intern Med 16, 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x.

Kubany, E.S., Leisen, M.B., Kaplan, A.S., Watson, S.B., Haynes, S.N., Owens, J.A., Burns, K., 2000. Development and preliminary validation of a brief broad-spectrum measure of trauma exposure: The Traumatic Life Events Questionnaire. Psychological Assessment 12, 210–224. https://doi.org/10.1037/1040-3590.12.2.210.

Larochelle, M.R., Bernson, D., Land, T., Stopka, T.J., Wang, N., Xuan, Z., Bagley, S.M., Liebschutz, J.M., Walley, A.Y., 2018. Medication for opioid use disorder after nonfatal opioid overdose and association with mortality. Ann. Intern Med 169, 137. https://doi.org/10.7326/M17-3107.

Leserman, J., Li, Z., Drossman, D.A., Hu, Y., 1998. Selected symptoms associated with sexual and physical abuse history among female patients with gastrointestinal disorders: the impact on subsequent health care visits. Psychol. Med 28, S0033291797006508. https://doi.org/10.1017/S0033291797006508.

Leyde, S., Price, C.J., Colgan, D.D., Pike, K.C., Tsui, J.I., Merrill, J.O., 2024. Mental health distress is associated with higher pain interference in patients with opioid use disorder stabilized on buprenorphine or methadone. Subst. Use Addict. J. 45, 423–433. https://doi.org/10.1177/29767342241227402.

Li, W., Howard, M.O., Garland, E.L., McGovern, P., Lazar, M., 2017. Mindfulness treatment for substance misuse: a systematic review and meta-analysis. J. Subst. Abus. Treat. 75, 62–96. https://doi.org/10.1016/j.jsat.2017.01.008.

McLellan, A.T., Kushner, H., Metzger, D., Peters, R., Smith, I., Grissom, G., Pettinati, H., Argeriou, M., 1992. The fifth edition of the addiction severity index. Journal of Substance Abuse Treatment 9 (3), 199–213. https://doi.org/10.1016/0740-5472(92)90062-S.

Mehling, W.E., Acree, M., Stewart, A., Silas, J., Jones, A., 2018. The multidimensional assessment of interoceptive awareness, version 2 (MAIA-2). PLoS One 13, e0208034. https://doi.org/10.1371/journal.pone.0208034.

Mehling, W.E., Price, C., Daubenmier, J.J., Acree, M., Bartmess, E., Stewart, A., 2012. The multidimensional assessment of interoceptive awareness (MAIA). PLoS One 7, e48230. https://doi.org/10.1371/journal.pone.0048230.

Miettinen, T., Kautiainen, H., Mäntyselkä, P., Linton, S.J., Kalso, E., 2019. Pain interference type and level guide the assessment process in chronic pain: categorizing pain patients entering tertiary pain treatment with the brief pain inventory. PLoS One 14, e0221437. https://doi.org/10.1371/journal.pone.0221437.

Mun, C.J., Beitel, M., Oberleitner, L., Oberleitner, D.E., Madden, L.M., Bollampally, P., Barry, D.T., 2019. Pain catastrophizing and pain acceptance are associated with pain severity and interference among methadone-maintained patients. J. Clin. Psychol. 75 (12), 2233–2247. https://doi.org/10.1002/jclp.22842.

Novak, P., Feder, K.A., Ali, M.M., Chen, J., 2019. Behavioral health treatment utilization among individuals with co-occurring opioid use disorder and mental illness: evidence from a national survey. J. Subst. Abus. Treat. 98, 47–52. https://doi.org/10.1016/j.jsat.2018.12.006.

Pocock, S.J., 1983. Methods of randomization. in: Clinical Trials: A Practical Approach. Wiley & Sons, Ltd, Chichester England, pp. 66–89.

Poquet, N., Lin, C., 2016. The brief pain inventory (BPI). J. Physiother. 62, 52. https://doi.org/10.1016/j.jphys.2015.07.001.

Price, C.J., Herting, J.R., 2013. Changes in post traumatic stress symptoms among women in substance use disorder treatment: the mediating role of bodily dissociation and emotion regulation. Subst. Abus. 7. https://doi.org/10.4137/SART.S12426.
Price, C.J., Hooven, C., 2018. Interoceptive awareness skills for emotion regulation: theory and approach of mindful awareness in body-oriented therapy (MABT). Front Psychol. 9. https://doi.org/10.3389/fpsyg.2018.00798.
Price, C.J., Mehling, W.E., 2016. Body awareness and pain. In: Thompson, D., Brooks, M. (Eds.), Integrative Pain Management. HandSpring Publishers, Scotland, pp. 235–251.
Price, C.J., Pike, K.C., Treadway, A., Palmer, J.K., Merrill, J.O., 2024. Immediate effects of mindful awareness in Body-Oriented therapy as an adjunct to medication for opioid use disorder. Mindfulness (N. Y) 15, 2794–2811. https://doi.org/10.1007/s12671-024-02463-.
Price, C.J., Sevinc, G., Farb, N.A.S., 2023. Within-Person modulation of neural networks following interoceptive awareness training through mindful awareness in Body-Oriented therapy (MABT): a pilot study. Brain Sci. 13, 1396. https://doi.org/10.3390/brainsci13101396.
Price, C.J., Thompson, E.A., Crowell, S., Pike, K., 2019. Longitudinal effects of interoceptive awareness training through mindful awareness in body-oriented therapy (MABT) as an adjunct to women's substance use disorder treatment: a randomized controlled trial. Drug Alcohol Depend. 198. https://doi.org/10.1016/j.drugalcdep.2019.02.012.
Price, C.J., Wells, E.A., Donovan, D.M., Rue, T., 2012. Mindful awareness in body-oriented therapy as an adjunct to women's substance use disorder treatment: a pilot feasibility study. J. Subst. Abus. Treat. 43. https://doi.org/10.1016/j.jsat.2011.09.016.
Price, C.J., Weng, H.Y., 2021. Facilitating adaptive emotion processing and somatic reappraisal via sustained mindful interoceptive attention. Front Psychol. 12. https://doi.org/10.3389/fpsyg.2021.578827.
Priddy, S.E., Howard, M.O., Hanley, A.W., Riquino, M.R., Friberg-Felsted, K., Garland, E. L., 2018. Mindfulness meditation in the treatment of substance use disorders and preventing future relapse: neurocognitive mechanisms and clinical implications. Subst. Abus. Rehabil. 9, 103–114. https://doi.org/10.2147/SAR.S145201.
Quadt, L., Critchley, H.D., Garfinkel, S.N., 2018. The neurobiology of interoception in health and disease. Ann. N. Y Acad. Sci. 1428, 112–128. https://doi.org/10.1111/nyas.13915.
Rodriguez, M., Colgan, D., Leyde, S., Pike, K., Merrill, J., Price, C., 2024. Trauma Exposure Across the Lifespan among Individuals Engaged in Treatment with Medication for Opioid Use Disorder: Differences by Gender, PTSD Status, and Chronic Pain. Seattle.
Rosenberg, H., 2009. Clinical and laboratory assessment of the subjective experience of drug craving. Clin. Psychol. Rev. 29, 519–534. https://doi.org/10.1016/j.cpr.2009.06.002.
Schuman-Olivier, Z., Goodman, H., Rosansky, J., Fredericksen, A., Barria, J., Parry, G., Sokol, R., Gardiner, P., Le Cook, B., Weiss, R., 2025. Mindfulness training vs recovery support for opioid use, craving, and anxiety during buprenorphine treatment: a randomized clinical trial. JAMA Netw. Open 8 (1), e2454950. https://doi.org/10.1001/jamanetworkopen.2024.54950.
Sobell, L.C., Sobell, M.B., 1992. Timeline follow-back. in: Measuring Alcohol Consumption. Humana Press, Totowa, NJ, pp. 41–72.
Sobell, L.C., Sobell, M.B., Buchan, G., Cleland, P.A., Fedoroff, I., Leo, G.I., 1996. The reliability of the timeline followback method applied to drug, cigarette, and cannabis use. in: 30th Annual Meeting of the Association for Advancement of Behavior Therapy. Association for Advancement of Behavior Therapy, New York.
Sordo, L., Barrio, G., Bravo, M.J., Indave, B.I., Degenhardt, L., Wiessing, L., Ferri, M., Pastor-Barriuso, R., 2017. Mortality risk during and after opioid substitution treatment: systematic review and meta-analysis of cohort studies. BMJ j1550. https://doi.org/10.1136/bmj.j1550
Spitzer, R.L., Kroenke, K., Williams, J.B.W., Löwe, B., 2006. A brief measure for assessing generalized anxiety disorder. Arch. Intern Med 166, 1092. https://doi.org/10.1001/archinte.166.10.1092.
Tombaugh, T.N., McDowell, I., Kristjansson, B., Hubley, A.M., 1996. Mini-Mental state examination (MMSE) and the modified MMSE (3MS): a psychometric comparison and normative data. Psychol. Assess. 8, 48–59. https://doi.org/10.1037/1040-3590.8.1.48.
Vowles, K.E., Witkiewitz, K., Levell, J., Sowden, G., Ashworth, J., 2017. Are reductions in pain intensity and pain-related distress necessary? An analysis of within-treatment change trajectories in relation to improved functioning following interdisciplinary acceptance and commitment therapy for adults with chronic pain. J. Consult. Clin. Psychol. 85 (2), 87–98. https://doi.org/10.1037/ccp0000159.
Walach, H., Buchheld, N., Buttenmüller, V., Kleinknecht, N., Schmidt, S., 2006. Measuring mindfulness—the freiburg mindfulness inventory (FMI). Pers. Individ Dif. 40, 1543–1555. https://doi.org/10.1016/j.paid.2005.11.025.
Watkins, K.E., Weir, R., Pak, L., Griffin, B.A., Griffo, A., Sutherland, A.T., McCullough, C. M., Meredith, L.S., Schoenbaum, M., Komaromy, M., Carrejo, V., Osilla, K.C., 2024. Collaborative care model for patients with opioid use disorder and mental illness. JAMA Netw. Open 7, e2449012. https://doi.org/10.1001/jamanetworkopen.2024.49012.
Weng, H.Y., Feldman, J.L., Leggio, L., Napadow, V., Park, J., Price, C.J., 2021. Interventions and manipulations of interoception. Trends Neurosci. 44, 52–62. https://doi.org/10.1016/j.tins.2020.09.010.
Witkiewitz, K., Lustyk, M.K.B., Bowen, S., 2013. Retraining the addicted brain: a review of hypothesized neurobiological mechanisms of mindfulness-based relapse prevention. Psychol. Addict. Behav. 27, 351–365. https://doi.org/10.1037/a0029258.