Check for updates

Received: 15 July 2019 | Revised: 29 January 2020 | Accepted: 7 February 2020

DOI: 10.1111/nmo.13828

ORIGINAL ARTICLE

Neurogastroenterology & Motility NGM WILEY

# Mindfulness-based stress reduction improves irritable bowel syndrome (IBS) symptoms via specific aspects of mindfulness

Bruce D. Naliboff[1] | Suzanne R. Smith[1] | John G. Serpa[2] | Kelsey T. Laird[3] | Jean Stains[1] | Lynn S. Connolly[1] | Jennifer S. Labus[1] | Kirsten Tillisch[1]

[1]G Oppenheimer Center for Neurobiology of Stress and Resilience, Department of Medicine, David Geffen School of Medicine, University of California, Los Angeles, CA, USA

[2]Department of Psychology, University of California Los Angeles, Los Angeles, CA, USA

[3]Department of Psychiatry and Biobehavioral Sciences, David Geffen School of Medicine, University of California, Los Angeles, CA, USA

**Correspondence**
Bruce D. Naliboff, G. Oppenheimer Center for Neurobiology of Stress and Resilience, 10833 Le Conte Avenue, CHS 42-210, Los Angeles, California 90095-7378.
Email: naliboff@ucla.edu

**Funding information**
National Institute of Diabetes and Digestive and Kidney Diseases, Grant/Award Number: P50 DK64539 ; National Center for Complementary and Alternative Medicine, Grant/Award Number: R01 AT007137

## Abstract

**Background:** Irritable bowel syndrome (IBS) is a common and often debilitating chronic gastrointestinal disorder characterized by abdominal pain and altered bowel habits. Pharmacological treatments are often ineffective, leading to the development of a variety of behavioral interventions. Mindfulness-based stress reduction (MBSR) is one such program that has shown efficacy in reducing gastrointestinal (GI) symptoms and improving quality of life (QOL). This single-arm intervention study examines the association of clinical outcomes with changes in specific aspects of mindfulness.

**Methods:** Adults with IBS (53 women, 15 men) participated in an 8-week MBSR class. Primary outcomes of GI symptom severity, quality of life, and GI-specific anxiety, as well as specific aspects of mindfulness using the Five Factor Mindfulness Questionnaire (FFMQ), were assessed at baseline, post-treatment, and 6-month follow-up.

**Key Results:** Gastrointestinal symptom responder rate was 71%, and there was a significant pre-post treatment change for three of the five FFMQ scales. Regression analysis indicated that change in the Act with Awareness ($P$ = .02) facet of mindfulness was the strongest predictor of GI symptom and QOL improvement.

**Conclusions & Inferences:** Mindfulness-based stress reduction training was associated with robust improvements in GI symptoms and associated problems in participants with IBS. Although significant increases in 3 of the 5 measured facets of mindfulness were found, regression analyses suggest that increases in the ability to retain present moment focus and act with awareness may be particularly important for improving outcomes in individuals with IBS. These results may inform the refinement of mindfulness-based protocols specifically for treatment of IBS.

KEYWORDS
irritable bowel syndrome, meditation, mindfulness, visceral sensitivity

## 1 | INTRODUCTION

Irritable bowel syndrome (IBS) is a common and often debilitating chronic gastrointestinal disorder with primary symptoms of abdominal pain or discomfort and altered bowel habits.[1] IBS is highly comorbid with and shares several similarities with other chronic pain disorders (eg, headache and fibromyalgia), including high healthcare costs and reduced quality of life.[2,3] Among those individuals with IBS seeking treatment for their symptoms, quality of life (QOL) is as poor as that of adults with heart disease, heart

 © 2020 John Wiley & Sons Ltd 

failure, and diabetes.[4] Estimates of annual direct costs of IBS in the United States range from $950 million to $1.35 billion.[5,6] While there is no known biological cause or biomarker of these disorders, research suggests that both IBS and other chronic pain syndromes result from reciprocal interactions between biological, psychological, and social factors.[7] Several psychological and mind-body therapies for chronic pain have demonstrated efficacy in IBS, including cognitive behavior therapy (CBT), hypnosis, and mindfulness-based interventions.[8] Mindfulness-based stress reduction (MBSR) is an intensive 8-week manualized workshop focused on the cultivation of mindfulness, defined as intentional, non-judgmental, present-focused awareness.[9] In contrast to CBT, which aims to challenge and modify unhelpful or inaccurate thoughts, MBSR invites participants to notice their present moment experience (including physical sensations, thoughts, and emotions) with non-judgmental curiosity and compassion. Several controlled trials have demonstrated the efficacy of MBSR for improving symptoms of IBS, with effects maintained up to 6 months post-treatment.[10-13] It has been suggested that facilitating non-reactivity to GI-related anxiety may be a significant factor in positive outcomes from MBSR in IBS[14] and that that meditation may alter the experience of unpleasantness associated with painful symptoms through a change in threat appraisal.[15] However, very few studies have examined how individual components of mindfulness as taught by MBSR relate to clinical outcomes, so it is not clear which might be most important. In addition, whether there are specific cognitive changes that may account for the effect of MBSR on QOL compared to gastrointestinal (GI) symptoms in IBS is unknown.

Similar to many other structured group behavioral interventions, MBSR requires substantial investment of patient and clinician time, requiring 28 hours of instruction from highly trained group leaders plus roughly 40 hours of home practice. With 7%-16% of the population in the United States meeting criteria for IBS,[16] more potent, cost-effective, and tailored behavioral interventions for IBS are urgently needed. A better understanding of the most "active ingredients" of MBSR is critical for informing development of more efficient and scalable therapies for individuals with IBS and other chronic pain conditions.

In this secondary analysis of a broader study on the mechanisms of MBSR effects on IBS, we present an interventional study that builds on the existing literature demonstrating the effectiveness of MBSR for IBS symptom reduction. This analysis determines the facets of mindfulness that are most associated with key clinical outcomes. The study examined two hypotheses: a) MBSR will result in robust pre-post improvements in GI symptoms, QOL and GI symptom-related anxiety, replicating prior trials; b) symptom improvement will be most closely associated with changes in mindfulness related to developing an attitude of non-judgmental acceptance toward present moment experience (which we conceptualized as conducive to more adaptive and less catastrophic appraisals of threat). In addition, because of possible sex differences underlying brain-gut interactions and the higher prevalence of IBS in women vs men, we explored whether sex moderates the relation between changes in specific facets of mindfulness and outcomes.

**Key Points**

- MBSR led to a GI symptom responder rate of 71% and a significant pre-post treatment change for three of five facets of mindfulness (FFMQ scales).
- Regression analysis indicated that change in the Act with Awareness (p=.02) facet of mindfulness was the strongest predictor of GI symptom and QOL improvement.
- Increases in the ability to retain present-moment focus and act with awareness may be particularly important for improving outcomes in individuals with IBS

## 2 | MATERIALS AND METHODS

### 2.1 | Study participants

A total of 68 participants meeting ROME III symptom criteria for IBS (53 women, 15 men) completed the MBSR class and the baseline and post-treatment assessments. Fifty-nine participants (47 women, 12 men) or 87% of the initial sample completed a follow-up assessment (FU) at 3 months post-treatment. Participants were recruited from community advertisement and GI clinics for a study involving MBSR treatment for their IBS. A gastroenterologist or nurse practitioner experienced with diagnosing IBS obtained a medical history and physical examination to confirm the IBS diagnosis based on the ROME III criteria.[17] Patients with IBS with any bowel habit were included. Exclusionary criteria for all subjects included the following: (a) serious medical conditions or medications that would limit full participation in the MBSR intervention or could compromise interpretation of functional brain imaging for the parent study; (b) psychiatric diagnosis with psychotic or suicidal features; and c) active substance use disorder. Sample characteristic include 69% White, 15% Asian, 10% African American, 6% other, and 25% self-identified as Hispanic. Most subjects had graduated from college or completed some postgraduate work (26.5% and 33.8%, respectively), while 32.4% had attended some college, and 7.4% had a high school education or less. Most subjects were never married (57.4%), 19% were married, 7.4% were divorced or separated, and 16.2% declined to state.

All procedures complied with the principles of the Declaration of Helsinki and were approved by the Institutional Review Board at UCLA, and the trial was registered with ClinicalTrials.gov (NCT01602575). The primary goal of the overall project was to

identify neuroimaging biomarkers of MBSR treatment response, and the present analysis examines only a subset of the project dataset.

## 2.2 | Study design

The study was a single-arm longitudinal trial. Clinical and psychosocial variables were assessed at baseline (pretreatment), post-treatment, and 3-month follow-up (FU). Primary outcomes were additionally assessed mid-treatment (at week 4). The primary clinical outcomes were chosen to assess degree of mindfulness and major domains of IBS severity including a composite measure of GI symptoms, an IBS-specific measure of QOL, and a measure of IBS-specific fear and anxiety (established as an important treatment target for IBS and other chronic pain targets[18]). Secondary outcomes were included to assess a broader array of problem areas often reported by individuals with IBS including negative affect, pain catastrophizing, and widespread bodily symptoms. Magnetic resonance brain imaging scans were completed at baseline and post-treatment and will be reported separately.

## 2.3 | MBSR intervention

The MBSR intervention was based on the standard MBSR protocol as developed and disseminated from the Center for Mindfulness in Medicine, Health Care, and Society at the University of Massachusetts Medical School[9] and that used previously for IBS.[19] Participants attended eight 2 hour, weekly classes plus a 4-hour retreat. Class sizes ranged from 8 to 12 participants. Daily home practice of meditation (30 minutes) was also required. Classes were led by two clinicians who had completed MBSR teacher training and had >5 years mindfulness practice (JGS and SRS).

## 2.4 | Primary outcomes

Gastrointestinal symptom severity was assessed using the severity score from the IBS Severity Scoring System (IBS-SSS), a validated and widely used 5-item instrument used to measure severity of abdominal pain, distension, and dissatisfaction with bowel habits, and interference with QOL over the past 10 days.[20] Quality of life was assessed using the total score from the IBS-QOL,[21] a validated 34-item instrument assessing the interference of symptoms with various domains of daily activities. GI-related fear and anxiety was assessed using the Visceral Sensitivity Index (VSI), a validated 15-item index of fear and worry related to IBS symptoms.[18]

Mindfulness was assessed using the Five Facet Mindfulness Questionnaire (FFMQ), a validated measure of five aspects of mindfulness: Observing, Describing, Acting with Awareness, Nonjudging of Inner Experience, and Nonreactivity to Inner Experience[22] (see Table 1 for a description of each scale). The FFMQ contains 39 items that are rated on a 5-point Likert scale, ranging from 1 (never or very rarely true) to 5 (very often or always true). The FFMQ was developed by examining items from multiple prior mindfulness questionnaires using a factor analytic strategy to determine the number of relatively independent aspects of self-reported mindfulness and the best items for each. The five factor structure of the FFMQ has been confirmed in subsequent studies for persons who meditate or have participated in an meditation training program like MBSR although the Observing scale is less distinct in meditation naïve persons.[23] Higher FFMQ scores reflect greater mindfulness.

## 2.5 | Secondary outcomes

Symptoms of anxiety and depression were assessed using the Hospital Anxiety and Depression (HAD) scale. The HAD is a well-validated and widely used measure designed to assess symptoms of anxiety (HAD-A) and depression (HAD-D) over the past two weeks in non-psychiatric populations.[24] The Personal Health Questionnaire-12 (PHQ-12) is a validated scale assessing the degree to which an individual is bothered by common somatic symptoms over the past 2 weeks including back pain, headache.[25] Three items assessing GI-related symptoms were omitted from the original 15 item version. The Pain Catastrophizing Scale (PCS)[26] is a 13-item scale assessing pain-related catastrophic thinking in three dimensions, helplessness, rumination, and magnification. The total score was used in this analysis.

## 2.6 | Process variables

Treatment expectancy was assessed via a single pretreatment question, "How much do you think mindfulness meditation training and daily practice will affect your IBS symptoms?" rated on a 21-point scale ranging from −10 (symptoms much worse) to +10 ("symptoms much improved"). Degree of home practice was measured via self-report (number of hours per week) and collected weekly for the final 4 weeks of treatment and 4 weeks before the follow-up assessment.

## 2.7 | Statistical analyses

Treatment effects were examined for each of the primary outcomes using a mixed model ANOVA (pretreatment, post-treatment, and follow-up) and pairwise comparisons of estimated marginal means (SPSS Mixed Model Analysis, IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY). Sex was tested as a between-subjects variable. Similar analyses were also performed for the secondary outcomes. Stepwise multiple regression analyses were used to determine the relationship between pre- to post- and pre- to follow-up change (difference scores) on FFMQ facets

**TABLE 1** FFMQ scales and descriptions

| FFMQ Scale | Abbreviation | Description | Example Item |
|---|---|---|---|
| Observing | Observe | Noticing or attending to internal and external experiences (eg, sounds, emotions, thoughts, bodily sensations) | I notice the smells and aromas of things |
| Describing | Describe | Labeling internal experiences with words | I am good at finding words to describe my feelings |
| Acting with Awareness | ActAware | Attending to one's activities of the moment (in contrast to acting on "autopilot") | I find myself doing things without paying attention. (*R*) |
| Nonjudging of Inner Experience | NonJudge | Accepting one's thoughts and emotions without evaluation (eg, as "good" or "bad") | I think some of my emotions are bad or inappropriate and I should not feel them. (*R*) |
| Nonreactivity to Inner Experience | NonReact | Detaching from one's thoughts and emotions; allowing them to come and go without becoming overly identified with them | I perceive my feelings and emotions without having to react to them |

*Note:* Descriptions drawn from Baer et al.
Abbreviation: *R*, reverse-scored.

and change for the primary outcomes over the same periods. Participants with missing follow-up values were not used in the follow-up analyses. For the primary outcomes, sex was included in the model; however, given the relatively small number of males enrolled, any findings regarding sex should be interpreted with caution. FFMQ scales at baseline were also examined as predictors of pre-post and pretreatment to follow-up change on the primary outcome variables. Additional exploratory analyses examined the effect of treatment process variables on outcome including extent of home practice, changes at mid-treatment, and efficacy expectations. Before analyses, the distributions of the major variables were evaluated for skewness. All values were within acceptable limits (−0.6 to +0.6). For all analyses, $P < .05$ was used to determine statistical significance.

## 3 | RESULTS

### 3.1 | Gastrointestinal symptom outcomes

Table 2 includes the means and standard deviations for the primary and secondary variables at each time point stratified by sex. ANOVAs testing change for the primary outcomes across the three time points for the study are shown in Table 3 and Figures 1-4. A significant decrease in GI symptoms (IBS-SSS) was observed across time ($F(2,129) = 37.70$, $P < .001$), with significant changes from pre- to post-treatment and pretreatment to follow-up (ps < 0.001). No significant change from post-treatment to follow-up and no main effect for Sex or Sex x Time interaction was observed. Using the established IBS-SSS marker of clinical improvement (>50 point

**TABLE 2** Means and Standard Deviations for Primary and Secondary Variables

| | Baseline | | Post-Tx | | FU | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| | M (SD) | M (SD) | M (SD) | M (SD) | M (SD) | M (SD) |
| IBS-SSS | 279.64 (75.28) | 268.83 (75.87) | 132.14 (74.46) | 185.38 (101.50) | 127.83 (108.35) | 157.34 (86.13) |
| IBS-QOL | 56.01 (19.00) | 59.66 (21.44) | 75.57 (19.86) | 71.21 (18.76) | 78.23 (15.81) | 72.25 (18.91) |
| VSI | 46.35 (15.16) | 44.79 (15.88) | 26.80 (18.45) | 31.68 (17.60) | 22.00 (18.83) | 30.60 (16.32) |
| FFMQ Observe | 24.87 (4.60) | 26.91 (5.28) | 27.47 (6.69) | 29.49 (4.81) | 27.25 (7.63) | 29.87 (4.99) |
| FFMQ Describe | 27.07 (5.50) | 29.28 (6.07) | 29.87 (5.57) | 29.60 (6.67) | 29.50 (6.72) | 29.70 (7.14) |
| FFMQ ActAware | 24.40 (5.74) | 25.79 (6.20) | 27.33 (5.47) | 27.49 (5.63) | 29.17 (6.56) | 27.77 (6.48) |
| FFMQ Nonjudge | 28.13 (8.23) | 26.62 (8.45) | 31.53 (6.78) | 29.98 (7.22) | 31.67 (7.13) | 29.09 (8.63) |
| FFMQ Nonreact | 22.73 (5.34) | 22.28 (4.59) | 23.00 (6.31) | 24.28 (4.58) | 22.75 (6.80) | 23.62 (5.48) |
| HAD Depression | 4.67 (3.02) | 3.45 (3.05) | 4.16 (3.34) | 2.60 (2.53) | 3.25 (2.99) | 2.75 (2.45) |
| HAD Anxiety | 7.57 (3.44) | 8.00 (4.09) | 6.00 (4.06) | 6.36 (3.87) | 4.67 (3.73) | 6.51 (3.72) |
| PCS | 17.47 (14.05) | 20.80 (11.56) | 8.80 (9.39) | 12.40 (9.27) | 8.55 (9.68) | 11.71 (9.31) |
| PHQ-12 | 6.11 (3.54) | 7.64 (3.93) | 4.91 (4.25) | 6.63 (3.89) | 3.77 (3.13) | 7.11 (3.39) |

Abbreviations: FFMQ, Five Facet Mindfulness Questionnaire; HAD, Hospital Anxiety and Depression Scales; IBS-SSS, IBS Severity Scoring System; PCS, Pain Catastrophizing Scale; PHQ-12, Personal Health Questionnaire 12 Items; VSI, Visceral Sensitivity Index.

**TABLE 3** ANOVAs for Pre- to Post-Tx and FU Outcomes

| | Time | | | Pre-Tx vs Post-Tx | Pre-Tx vs FU | Post-Tx vs FU | Sex | Sex × Time interaction |
|---|---|---|---|---|---|---|---|---|
| Variable | *F* | *P* | *df* | *P* | *P* | *P* | *P* | *P* |
| IBS-SSS | 37.70 | <.001* | 2/129 | <.001* | <.001* | .381 | .196 | .094 |
| IBS-QOL | 31.36 | <.001* | 2/124 | <.001* | <.001* | .901 | .819 | .133 |
| VSI | 39.99 | <.001* | 2/128 | <.001* | <.001* | .112 | .301 | .096 |
| FFMQ Observe | 9.34 | <.001* | 2/124 | <.001* | .001* | .555 | .141 | .998 |
| FFMQ Describe | 3.13 | .047 | 2/125 | - | - | - | .730 | .142 |
| FFMQ ActAware | 6.79 | .002* | 2/123 | .001* | .001* | .302 | .832 | .561 |
| FFMQ NonJudge | 10.59 | <.001* | 2/123 | <.001* | .007* | .520 | .386 | .792 |
| FFMQ NonReact | 1.75 | .178 | 2/123 | - | - | - | .816 | .290 |
| HAD Depression | 2.53 | .083 | 2/125 | - | - | - | .091 | .570 |
| HAD Anxiety | 7.53 | .001* | 2/123 | .002* | <.001* | .077 | .662 | .157 |
| PCS | 21.31 | <.001* | 2/121 | <.001* | <.001* | .883 | .231 | .936 |
| PHQ-12 | 3.12 | .048* | 2/125 | .017* | .049* | .804 | .030* | .442 |

Abbreviations: FFMQ, Five Facet Mindfulness Questionnaire; HAD, Hospital Anxiety and Depression Scales; IBS-SSS, IBS Severi.ty Scoring System; PCS, Pain Catastrophizing Scale; PHQ-12, Personal Health Questionnaire 12 Items; VSI, Visceral Sensitivity Index.
*$P < .05$.

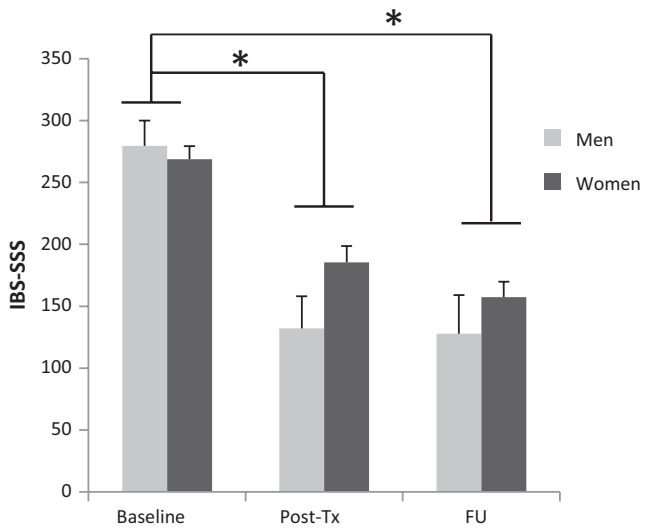



**FIGURE 1** Mean values in IBS-SSS for males and females. Error bars are standard errors of the mean and overhead connecting lines indicate significantly different combined male and female values (*$P < .05$)

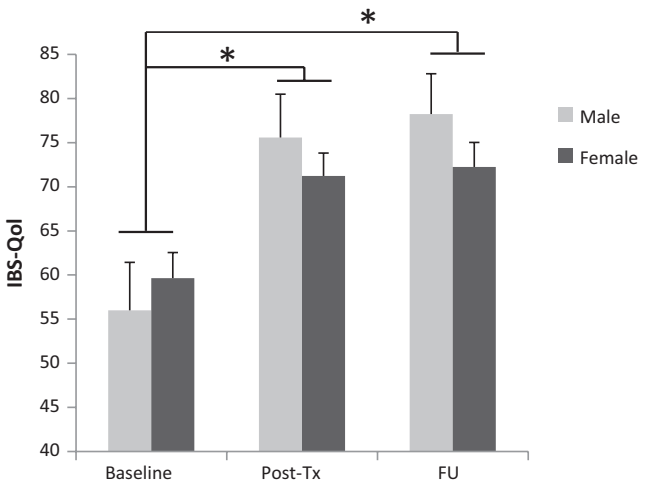



**FIGURE 2** Mean values in IBS-QOL for males and females. Error bars are standard errors of the mean and overhead connecting lines indicate significantly different combined male and female values (*$P < .05$)

reduction),[20] 71.6% and 76.3% of participants showed improvement at post-treatment and follow-up, respectively.

## 3.2 | Quality of life and symptom-related anxiety outcomes

Similar positive outcomes were found for QOL (IBS-QOL) and GI-specific anxiety (VSI). There was a significant improvement in QOL across time ($F(2,124) = 31.36$, $P < .001$) with significant changes from pre- to post-treatment and pretreatment to follow-up (ps < 0.001). A significant reduction in GI-specific anxiety was found ($F(2,128) = 39.99$, $P<.001$), with significant changes from pre- to post-treatment and pretreatment to follow-up (ps < 0.001) and no difference between post-treatment and follow-up. No main effects for Sex or Sex x Time interactions were observed for these two variables.

## 3.3 | Mindfulness outcomes

Three of the mindfulness facet (FFMQ) scales showed a similar pattern of change to the primary symptom outcomes. The Observe,

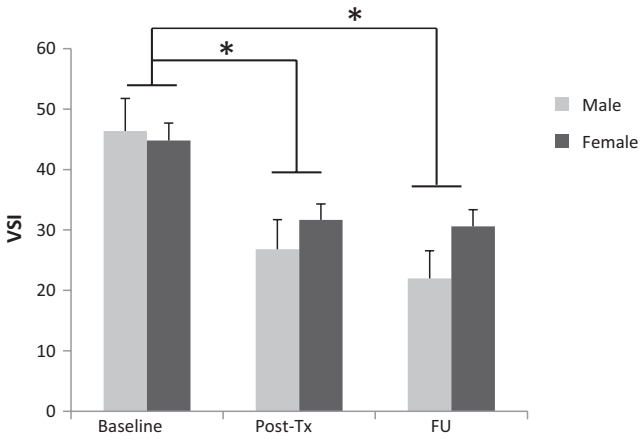



**FIGURE 3** Mean values in VSI for males and females. Error bars are standard errors of the mean and overhead connecting lines indicate significantly different combined male and female values (*$P < .05$)

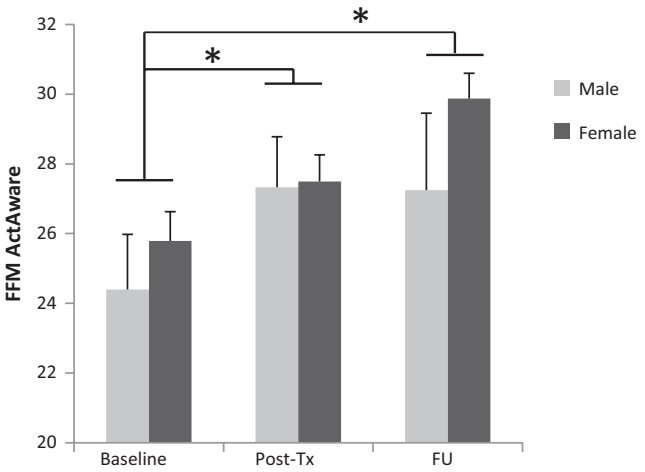



**FIGURE 4** Mean values in FFMQ ActAware for males and females. Error bars are standard errors of the mean and overhead connecting lines indicate significantly different combined male and female values (*$P < .05$)

ActAware, and NonJudge scales all showed large pre-post treatment and pretreatment to follow-up increases and no time by sex interactions (see Table 3 and Figures 1-4). The Describe and NonReact scales did not show reliable changes over the treatment and follow-up periods.

### 3.4 | Secondary outcomes

Three of the secondary outcomes also showed significant declines following treatment with no sex main effects or interactions. These included symptoms of anxiety (HAD-A) and catastrophizing (PCS) (ps < 0.001) and degree of widespread somatic symptoms (PHQ-12) ($P < .05$). Depressive symptoms (HAD-D) did not show reliable changes.

### 3.5 | Associations of change in mindfulness with symptom improvement

Regression analyses examining the relationship between change in the mindfulness facet scores and change in the primary and secondary outcomes at post-treatment are shown in Table 4. Degree of improvement in GI symptoms was best predicted by change on the ActAware scale ($P < .003$) with a small but significant amount of additional variance predicted by the Describe scale (increase in $R^2$, $P = .033$). The ActAware scale also was the strongest predictor of improvement for the VSI and IBS-QOL variables ($P = .001$ and $P < .001$ respectively). For the secondary outcome of anxiety, the NonJudge scale was the strongest predictor ($P < .001$) with small additional variance predicted by the ActAware scale (increase in $R^2$, $P = .037$). ActAware was the strongest predictor for catastrophizing ($P < .001$) and PHQ-12 ($P < .001$). None of the above regressions showed a significant effect for participant sex.

Regression analyses examining the relationship between change in mindfulness facet scores pretreatment to follow-up and change in the primary and secondary outcomes are shown in Table 5. Results are generally similar to those of the pre-post treatment analyses. Degree of improvement in the GI symptoms was best predicted by change on the ActAware scale ($P = .018$). The ActAware scale also was the strongest predictor of improvement for GI-specific anxiety; however, small additional variance was predicted by NonReact ($R^2$ increase, $P = .021$) and participant sex ($R^2$ increase, $P = .042$), with males showing greater improvement than females after controlling for the ActAware and NonReact scales. Change in the NonJudge scale was the strongest predictor of QOL change ($P < .001$), but a small additional variance was predicted by the ActAware scale ($R^2$ increase, $P = .041$). For the secondary outcome of anxiety symptoms, the NonJudge scale was the strongest predictor ($P = .001$), with additional variance predicted by the Describe scale ($R^2$ increase, $P = .031$). ActAware was also the strongest predictor for catastrophizing ($P < .001$). Sex was the strongest predictor of change in somatic symptoms ($P = .012$) with small additional prediction from ActAware ($R^2$ increase, $P = .046$). NonJudge was a significant predictor for depression symptoms ($P = .005$).

### 3.6 | Exploratory analyses

#### 3.6.1 | Baseline mindfulness and outcomes

Regression analyses were performed to examine the relationship between pretreatment levels of the five mindfulness facets and post-treatment and follow-up change in the primary outcomes. Neither the IBS-SSS or VSI outcomes at post-treatment or follow-up were significantly related to pretreatment mindfulness. Pretreatment ActAware score was positively related to change in IBS-QOL at post-treatment ($R = .266$, $F(1,67) = 4.61$, $P = .036$) but not at follow-up.

**TABLE 4** Regression Analysis Predicting Pre- to Post-Tx Change

| Variable | Predictor | *R* | $R^2$ | *F*(*df*) | *P* | $R^2$ Change | *P* |
|---|---|---|---|---|---|---|---|
| IBS-SSS | ActAware | .358 | .128 | 9.550 | .003* | | |
| | Describe | .434 | .189 | 7.435 | .001* | .060 | .033* |
| VSI | ActAware | .404 | .163 | 12.897 | .001* | | |
| IBS-QOL | ActAware | .519 | .269 | 24.285 | <.001* | | |
| HAD Anxiety | NonJudge | .434 | .189 | 15.127 | <.001* | | |
| | ActAware | .492 | .242 | 10.233 | <.001* | .057 | .037* |
| PCS | ActAware | .510 | .260 | 23.207 | <.001* | | |
| PHQ-12 | ActAware | .602 | .363 | 37.598 | <.001* | | |

Abbreviations: HAD, Hospital Anxiety and Depression Scales; IBS-SSS, IBS Severity Scoring System; PCS, Pain Catastrophizing Scale; PHQ-12, Personal Health Questionnaire 12 Items; VSI, Visceral Sensitivity Index.

*$P < .05$.

**TABLE 5** Regression Analysis Predicting Pre-Tx to FU Change

| Variable | Predictor | *R* | $R^2$ | *F*(*df*) | *P* | $R^2$ Change | *P* |
|---|---|---|---|---|---|---|---|
| IBS-SSS | ActAware | .307 | .094 | 5.914 | .018* | | |
| VSI | ActAware | .464 | .215 | 15.634 | <.001* | | |
| | NonReact | .536 | .287 | 11.266 | <.001* | .072 | .021* |
| | Sex | .582 | .339 | 9.388 | <.001* | .052 | .042* |
| IBS-QOL | NonJudge | .519 | .270 | 21.036 | <.001* | | |
| | ActAware | .568 | .323 | 13.341 | <.001* | .053 | .041* |
| HAD Anxiety | NonJudge | .414 | .171 | 11.764 | .001* | | |
| | Describe | .488 | .238 | 4.903 | <.001* | .067 | .031* |
| PCS | ActAware | .524 | .275 | 21.206 | <.001* | | |
| PHQ-12 | Sex | .325 | .106 | 6.732 | .012* | | |
| | ActAware | .409 | .168 | 5.632 | .006* | .062 | .046* |
| HAD Depression | NonJudge | .358 | .128 | 8.362 | .005* | | |

Abbreviations: HAD, Hospital Anxiety and Depression Scales; IBS-SSS, IBS Severity Scoring System; PCS, Pain Catastrophizing Scale; PHQ-12, Personal Health Questionnaire 12 Items; VSI, Visceral Sensitivity Index.

*$P < .05$

### 3.6.2 | Association of mid-treatment change in IBS severity with post-treatment and follow-up outcomes

Change in IBS severity at mid-treatment (week 4) was significantly correlated with post-treatment ($r = .70$, $P < .001$) and follow-up change ($r = .45$, $P = .001$). Mid-treatment IBS-SSS change was also correlated with post-treatment change in IBS-QOL ($r = .31$, $P = .011$) and VSI ($r = .32$, $P = .01$) but not with change in these measures at follow-up (ps > 0.05).

### 3.6.3 | Prediction of outcome from home practice

Extent of home practice at post-treatment was not associated with post-treatment outcomes. Hours practiced at follow-up were associated with follow-up change in IBS-SSS ($r = .32$, $P = .008$), but not IBS-QOL or VSI.

### 3.6.4 | Prediction of outcome from expectation of treatment efficacy

Pretreatment efficacy expectation for MBSR was general high (median of 6.0 on scale of −10 to +10) and not correlated with the post-treatment IBS-SSS outcome. However, expectation was significantly correlated with IBS-SSS change at follow-up ($r = .26$, $P = .04$). Efficacy expectation was not significantly related to IBS-QOL outcomes (ps > 0.05) or MBSR practice at any time point (ps > 0.05).

## 4 | DISCUSSION

Consistent with prior clinical trials of MBSR,[10,27] we found robust change from pre- to post-treatment and pretreatment to 3-month follow-up on the primary IBS outcomes (GI symptom severity, QOL, and GI symptom-specific anxiety). There was a high responder rate

(>70%) on the IBS-SSS at both post-treatment and follow-up, and large effect sizes for the IBS-QOL and the VSI as well. Participants showed significant and lasting increases on 3 of the 5 mindfulness scales. Overall, participants' sex was not a significant factor in these outcomes.

A unique aspect of the current study was the examination of how changes in specific facets of mindfulness relate to positive clinical outcome. The data clearly point to improvement in IBS being most strongly tied to changes in the ActAware scale on the FFMQ. For most of the outcomes, at both post-treatment and follow-up, changes in the ActAware scale although moderate in size had the strongest relationship with clinical change although the Describe and NonReact facets did add a small amount of predictability for some variables.

The predominant association of changes in the ActAware facet of mindfulness with both the GI and QOL outcomes is consistent with some current conceptualizations of cognitive processes in IBS. The ActAware scale is considered a cultivated aspect of mindfulness as opposed to dispositional[28] and indexes one's ability to focus on the present moment, refrain from acting on "automatic pilot," and not engage with worries about the past or future. Anticipatory fear, worry, and shame regarding IBS symptoms are hallmark psychological issues in IBS and are important targets for psychological interventions.[29,30] The cultivation of present moment awareness allows one to experience and intentionally respond to what is present rather than reacting automatically to thoughts, emotions, and internal sensations using conditioned patterns. This may cultivate a sense of confidence that one can stay in the present moment with unpleasant stimuli, thereby decreasing the perceived threat. This ability may also serve as an exposure technique and may promote self-regulation and lessen the tendency to focus on thoughts about the future, leading to worries and catastrophizing. Of note, the ActAware scale was significantly associated with reduced frequency of obsessive intrusive thoughts in a large non-clinical sample,[31] and with reduced pain interference and depressive symptoms in a chronic pain sample.[32] We can hypothesize that the components of MBSR that foster present moment awareness may therefore represent an experiential training that addresses these issues and leads to improvements in both GI symptoms (via modulation of the brain-gut axis) and well-being. The relationship of changes in ActAware with changes in IBS symptom anxiety (measured by the VSI) further supports the important relationship between development of more present-focused cognitions and a decrease in fears and avoidance behaviors following treatment. The VSI has been shown to be a robust mediator of IBS symptom outcomes following other psychological interventions, especially those directly addressing symptom fears.[33,34] The current data suggest that a similar relationship may occur even when the intervention is not directly targeted at changing fear and anxiety. Neuroimaging studies of participants with IBS have demonstrated structural and functional alterations of attentional networks, especially those linked to interoception[35] and hypervigilance.[36]

Improvement in the ActAware facet was also the strongest predictor of post-treatment improvement in catastrophizing and degree of comorbid somatic symptoms, while the NonJudge scale was the strongest predictor for decreasing HADs anxiety. Similar findings were obtained at follow-up. Thus, it seems that facilitation of present moment awareness predicts improvements in psychological well-being, in addition to decreasing GI symptoms in IBS. A recent mechanistic review of mindfulness interventions for health problems has emphasized the interacting therapeutic processes of altering attention and acceptance.[37] In the current study, acceptance as assessed by the NonJudge FFMQ scale showed significant pre-post change, and change in this facet was the strongest predictor of pre-post improvement in symptoms of anxiety. Further study is needed to confirm the relative importance of these two processes in IBS and other populations experiencing chronic pain.

The lack of significant improvement in the Describe and NonReact scales in the current study was unexpected. Studies of MBSR conducted with other clinical populations (eg, adult cancer survivors[38]) have found significant improvements in these mindfulness facets and a previous MBSR study in IBS found the NonReact subscale to be a significant mediator of changes in IBS symptoms, acting through changes in visceral anxiety and catastrophizing.[14] Interestingly, the Garland et al study[14] did not find significant changes in the ActAware scale despite use of the same MBSR intervention. Several potential differences between this study and the Garland study may contribute to the variation in results. Their subject group was all female, was smaller (n = 34), and was more likely to be white and married, and the intervention included the assignment of additional weekly readings about IBS (assigned from "IBS for Dummies") which is not typical of other MBSR protocols. Further, while MBSR is a standardized intervention, the teaching styles of the instructors may have varied at the two sites, with more effective instruction of some facets of mindfulness vs another. Clearly, further study of mindfulness facets is needed to investigate why these two studies show similar overall mindfulness effects, but differ on the importance of NonReact vs ActAware facets, but the data do suggest that how and to whom mindfulness is taught can have a significant impact on the process of change. We would also note that in our sample, the NonReact subscale had the lowest scores of all of the subscales, potentially suggesting a missed opportunity for change. Additional research is needed to determine whether a longer duration of training or practice beyond 8 weeks would be helpful for allowing adults with IBS to achieve more consistent improvement across all the facets of mindfulness.

With regard to differences between the Describe and Observe facets, we might speculate that individuals with IBS, a population known to exhibit hypervigilance toward internal sensations and accustomed to describing them to physicians, may already be highly skilled in describing internal sensations with words; thus, the Describe facet did not show improvement with the intervention. This raises the question as to why significant increases *were* detected in the Observe facet, which one would also tend to associated with hypervigilance. This apparent dichotomy may be a result of type of visceral observations most commonly experienced by individuals with IBS. While individuals with IBS may experience

this hypervigilance as involuntary, 5 of the 8 Observe items assess voluntary observation (eg, "When I'm walking, I deliberately notice the sensations of my body moving"; "When I take a shower or a bath, I stay alert to the sensations of water on my body"). Only one of the items ("I notice how foods and drinks affect my thoughts, bodily sensations, and emotions") appears to target the potentially involuntary vigilance toward internal sensations that is a hallmark of IBS. This suggests that the IBS participants show increases in observation of non-visceral sensations.

Although the study was not powered to definitively test the interaction of sex with outcome, inclusion of sex in our prediction models revealed no evidence that the relationship between change in mindfulness facets and clinical outcomes was different for men vs women. Interestingly, initial levels of mindfulness were not in and of themselves significant predictors of clinical change. MBSR was developed as a program for the general population and structured to accommodate those with varying levels of initial mindfulness. It appears that the program was successful in this regard with our sample of individuals with IBS. In addition, higher expectation for positive treatment response at baseline was not associated with GI symptom severity improvement at post-treatment, although expectation was significantly associated with both GI symptom improvement and symptom-specific anxiety (VSI) improvement at follow-up. It is not clear why expectation has a stronger relationship with longer term change as expectation was not related to degree of home practice at either time point. One possibility is that participants with greater positive expectation regarding the intervention are better able to incorporate the strategies leading to maintenance of cognitive change even without increased practice. Most participants had moderate to high expectations for MBSR, and this restriction of range is likely to have dampened the relationship between efficacy expectation and outcomes. As with other behavioral interventions, degree of continued practice was positively associated with sustained outcome improvement, underscoring the importance of continued practice and/ or booster sessions.

Several limitations for this study should be mentioned in addition to those related to our low power for detecting sex differences discussed above. Potential participants with major psychiatric disorders or unstable medication regimens were excluded, resulting in a sample with likely less severe affective symptoms (especially depression) compared to patients typically seen in tertiary GI clinics. In addition, the time commitment required for MBSR and testing sessions led to self-selection of participants willing to invest considerable time in the program (although that treatment expectancy did not significantly predict outcomes post-treatment). Additional randomized attention-controlled studies with longer follow-up duration are needed in order to assess the relative efficacy of MBSR compared to other available behavioral therapies for IBS and determine the duration of treatment effects. As a single-arm trial, with concurrent measurement of the outcomes and mindfulness facets at post-treatment and follow-up, the present data were not amenable to a true causal mediation analysis. Future studies designed for mediation analysis will help to confirm the importance of ActAware vs the other aspects of mindfulness and perhaps identify other potential mediators of treatment response.

Considerable controversy exists regarding the measurement of mindfulness as a construct. Some argue that attempting to assess mindfulness via self-report is futile, both because scientists create imperfect measures and because participants are intrinsically biased and unreliable in completing these assessments.[39] Several studies have found evidence of convergent validity of the FFMQ, with moderate-sized positive correlations between all FFMQ subscales and psychological wellbeing.[40] However, the discriminant validity of the FFMQ has been called into question, with at least one RCT finding similar increases in the FFMQ in an attention control group (health enhancement) and MBSR.[40] Nevertheless, we believe that the FFMQ provides the unique and important opportunity to identify constructs associated with the greatest symptom improvement in this difficult-to-treat disorder. Further research in this area is needed to inform the development of more effective behavioral interventions specifically tailored for individuals with IBS.

## 5 | CONCLUSIONS

We found that MBSR training was associated with significant pre-post improvements in GI symptoms, symptom-related anxiety, and QOL in our sample of 68 adults with IBS. The size of these effects was large and remained significant at 3-month follow-up. Significant increases in 3 of the 5 measured facets of mindfulness were also found. Degree of improvement in GI symptoms was most strongly predicted by increases in the ability to stay in the present moment and act with awareness. These results have implications for the development of more effective and tailored behavioral interventions for individuals with IBS.

### ACKNOWLEDGMENTS

We thank study participants and staff of the G Oppenheimer Center for Neurobiology of Stress and Resilience (CNSR) for their contributions to this project. Contributions: BDN, KT, JSL designed the research study; SRS, JGS designed and led the MBSR groups; BDN, KT, SRS, JGS, LSC, JS performed the research study; BDN, KT, JSL performed the statistical analysis; all authors had input into the final manuscript. Competing Interests: The authors have no competing interests. Funding was provided by NIH grants: R01 AT007137 (KT and BDN) and P50 DK64539 (Emeran A. Mayer, PI).

### ORCID

*Bruce D. Naliboff* https://orcid.org/0000-0003-0959-8670

### REFERENCES

1. Drossman DA. Functional gastrointestinal disorders: history, pathophysiology, clinical features, and Rome IV. *Gastroenterology*. 2016;150:1262-1279.
2. Ballou S, Keefer L. The impact of irritable bowel syndrome on daily functioning: Characterizing and understanding daily consequences of IBS. *Neurogastroenterol Motil*. 2016;29(4):e12982.

3. Maixner W, Fillingim RB, Williams DA, et al. Overlapping chronic pain conditions: implications for diagnosis and classification. *J Pain*. 2016;17:T93-T107.
4. Lea R, Whorwell PJ. Quality of life in irritable bowel syndrome. *Pharmacoeconomics*. 2001;19:643-653.
5. Everhart JE, Ruhl CE. Burden of digestive diseases in the United States part I: overall and upper gastrointestinal diseases. *Gastroenterology*. 2009;136:376-386.
6. Inadomi JM, Fennerty MB, Bjorkman D. Systematic review: the economic impact of irritable bowel syndrome. *Aliment Pharmacol Ther*. 2003;18:671-682.
7. Enck P, Aziz Q, Barbara G, et al. Irritable bowel syndrome. *Nat Rev Dis Primers*. 2016;2:16014.
8. Laird KT, Tanner-Smith EE, Russell AC, et al. Comparative efficacy of psychological therapies for improving mental health and daily functioning in irritable bowel syndrome: a systematic review and meta-analysis. *Clin Psychol Rev*. 2017;51:142-152.
9. Kabat-Zinn J, Hanh TN. Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness. Delta, 2009.
10. Gotink RA, Chu P, Busschbach JJ, et al. Standardised mindfulness-based interventions in healthcare: an overview of systematic reviews and meta-analyses of RCTs. *PLoS ONE ONE*. 2015;10:e0124344.
11. Zernicke KA, Campbell TS, Blustein PK, et al. Mindfulness-based stress reduction for the treatment of irritable bowel syndrome symptoms: a randomized wait-list controlled trial. *Int J Behav Med*. 2013;20:385-396.
12. Kearney DJ, McDermott K, Martinez M, et al. Association of participation in a mindfulness programme with bowel symptoms, gastrointestinal symptom-specific anxiety and quality of life. *Aliment Pharmacol Ther*. 2011;34:363-373.
13. Gaylord SA, Palsson OS, Garland EL, et al. Mindfulness training reduces the severity of irritable bowel syndrome in women: results of a randomized controlled trial. *Am J Gastroenterol*. 2011;106(9):1678-1688.
14. Garland EL, Gaylord SA, Palsson O, et al. Therapeutic mechanisms of a mindfulness-based treatment for IBS: effects on visceral sensitivity, catastrophizing, and affective processing of pain sensations. *J Behav Med*. 2012;35:591-602.
15. Zeidan F, Martucci KT, Kraft RA, et al. Brain mechanisms supporting the modulation of pain by mindfulness meditation. *J Neurosci*. 2011;31:5540-5548.
16. Lovell RM, Ford AC. Global prevalence of and risk factors for irritable bowel syndrome: a meta-analysis. *Clin Gastroenterol Hepatol*. 2012;10:712-721.
17. Longstreth GF, Thompson WG, Chey WD, et al. Functional bowel disorders. *Gastroenterology*. 2006;130:1480-1491.
18. Labus JS, Bolus R, Chang L, et al. The Visceral Sensitivity Index: development and validation of a gastrointestinal symptom-specific anxiety scale. *Aliment Pharmacol Ther*. 2004;20:89-97.
19. Gaylord SA, Whitehead WE, Coble RS, et al. Mindfulness for irritable bowel syndrome: protocol development for a controlled clinical trial. *BMC Complement Altern Med*. 2009;9:24.
20. Francis CY, Morris J, Whorwell PJ. The irritable bowel severity scoring system: a simple method of monitoring irritable bowel syndrome and its progress. *Aliment Pharmacol Ther*. 1997;11:395-402.
21. Patrick DL, Drossman DA, Frederick IO, et al. Quality of life in persons with irritable bowel syndrome: Development and validation of a new measure. *Dig Dis Sci*. 1998;43:400-411.
22. Baer RA, Smith GT, Lykins E, et al. Construct validity of the five facet mindfulness questionnaire in meditating and nonmeditating samples. *Assessment*. 2008;15:329-342.
23. Gu J, Strauss C, Crane C, et al. Examining the factor structure of the 39-item and 15-item versions of the Five Facet Mindfulness Questionnaire before and after mindfulness-based cognitive therapy for people with recurrent depression. *Psychol Assess*. 2016;28:791-802.
24. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand*. 1983;67:361-370.
25. Kroenke K, Spitzer RL, Williams JB. The PHQ-15: validity of a new measure for evaluating the severity of somatic symptoms. *Psychosom Med*. 2002;64:258-266.
26. Sullivan MJL, Bishop SR, Pivik J. The Pain Catastrophizing Scale: Development and validation. *Psychological Assessment*. 1995;7(4):524–532. https://doi.org/10.1037/1040-3590.7.4.524
27. Gaylord SA, Palsson OS, Garland EL, et al. Mindfulness training reduces the severity of irritable bowel syndrome in women: results of a randomized controlled trial. *Am J Gastroenterol*. 2011;106(9):1678-1688.
28. Duan W, Li J. Distinguishing dispositional and cultivated forms of mindfulness: item-level factor analysis of five-facet mindfulness questionnaire and construction of short inventory of mindfulness capability. *Front Psychol*. 2016;7:1348.
29. Drossman DA, Chang L, Schneck S, et al. A focus group assessment of patient perspectives on irritable bowel syndrome and illness severity. *Dig Dis Sci*. 2009;54:1532-1541.
30. Craske MG, Wolitzky-Taylor KB, Labus J, et al. A cognitive-behavioral treatment for irritable bowel syndrome using interoceptive exposure to visceral sensations. *Behav Res Ther*. 2011;49:413-421.
31. Emerson L-M, Heapy C, Garcia-Soriano G. Which facets of mindfulness protect individuals from the negative experiences of obsessive intrusive thoughts? *Mindfulness*. 2018;9:1170-1180.
32. Nigol SH, Di Benedetto M. The relationship between mindfulness facets, depression, pain severity and pain interference. *Psychol Health Med*. 2019;1-11.
33. Wolitzky-Taylor K, Craske MG, Labus JS, et al. Visceral sensitivity as a mediator of outcome in the treatment of irritable bowel syndrome. *Behav Res Ther*. 2012;50:647-650.
34. Ljotsson B, Hesser H, Andersson E, et al. Mechanisms of change in an exposure-based treatment for irritable bowel syndrome. *J Consult Clin Psychol*. 2013;81(6):1113-1126.
35. Longarzo M, Quarantelli M, Aiello M, et al. The influence of interoceptive awareness on functional connectivity in patients with irritable bowel syndrome. *Brain Imaging Behav*. 2017;11:1117-1128.
36. Kano M, Muratsubaki T, Morishita J, et al. Influence of uncertain anticipation on brain responses to aversive rectal distension in patients with irritable bowel syndrome. *Psychosom Med*. 2017;79:988-999.
37. Creswell JD, Lindsay EK, Villalba DK, et al. Mindfulness training and physical health: mechanisms and outcomes. *Psychosom Med*. 2019;81:224-232.
38. Branstrom R, Kvillemo P, Brandberg Y, et al. Self-report mindfulness as a mediator of psychological well-being in a stress reduction intervention for cancer patients–a randomized study. *Ann Behav Med*. 2010;39:151-161.
39. Grossman P. On the porosity of subject and object in "mindfulness" scientific study: Challenges to "scientific" construction, operationalization and measurement of mindfulness. *Curr Opin Psychol*. 2018;28:102-107.
40. Goldberg SB, Wielgosz J, Dahl C, et al. Does the five facet mindfulness questionnaire measure what we think it does? Construct validity evidence from an active controlled randomized clinical trial. *Psychol Assess*. 2016;28:1009.


**How to cite this article:** Naliboff BD, Smith SR, Serpa JG, et al. Mindfulness-based stress reduction improves irritable bowel syndrome (IBS) symptoms via specific aspects of mindfulness. *Neurogastroenterol Motil*. 2020;32:e13828. https://doi.org/10.1111/nmo.13828