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Interactive effects of pain catastrophizing and mindfulness on pain intensity in women with fibromyalgia

Kathleen Dorado[1], Kristin L Schreiber[1], Alexandra Koulouris[1], Robert R Edwards[1], Vitaly Napadow[1,2] and Asimina Lazaridou[1]

Abstract

The objective of this study was to examine the association between facets of trait mindfulness, pain catastrophizing, and pain severity in a sample of patients with fibromyalgia. Patients with fibromyalgia completed validated baseline and diary assessments of clinical pain, mindfulness, and pain catastrophizing. Multilevel modeling analyses indicated that the daily association between catastrophizing and pain intensity was moderated by certain mindfulness facets. Our findings suggest that various aspects of mindfulness may interact differently with pain and catastrophizing, which may have implications for the design and testing of interventions targeting mindfulness and catastrophizing in fibromyalgia patients.

Keywords

catastrophizing, chronic pain, fibromyalgia, mindfulness, pain severity

Introduction

Fibromyalgia (FM) is a complex chronic pain disorder characterized by widespread pain and tenderness. The hallmark symptom of FM is persistent disabling pain in numerous body regions, but FM patients experience other symptoms such as sleep disturbances, fatigue, difficulty thinking clearly ("fibro fog"), stress, anxiety, and depression (Dean et al., 2017). The prevalence of FM in the United States is approximately 6.4 percent and the condition is more common in women than men (Marques et al., 2017). Despite this high prevalence, the etiology of the disorder is still unknown, and the diverse nature of FM symptoms suggests a complex biopsychosocial basis.

Negative pain-related cognitions, also known as catastrophizing, are prominent in individuals with FM (Loggia et al., 2015). Catastrophizing is conceptualized as an negative pattern of pain-related thoughts (Lefebvre, 1981; Turk and Rudy, 1996), including cognitions of helplessness, pessimism, rumination about pain, and magnification of pain complaints (Flor et al., 1993; Geisser et al., 1994; Keefe et al., 1989). In patients with FM, catastrophizing is associated with enhanced nociceptive sensitivity and increased severity of FM symptoms (Edwards et al., 2006; Loggia et al., 2015).

Several psychological and biological mechanisms have been proposed to underlie the impact of catastrophizing on FM symptoms. It has been suggested that catastrophizing interferes with beneficial health behaviors, such as exercise, ultimately leading to a worsening of FM symptoms (Edwards et al., 2006; Taylor et al., 2017). The magnifying aspect of catastrophizing about pain may increase a patient's attention to pain symptoms, leading to increased pain perception and unpleasant bodily sensations (Edwards et al., 2006). Furthermore, high catastrophizing in FM patients is associated with greater activation in brain regions associated with emotional and motivational modulation of pain (Gracely et al., 2004; Kim et al., 2015; Loggia et al., 2015). Positive or "resilience" factors may counterbalance or mitigate the deleterious effects of negative cognitive/

[1]Brigham and Women's Hospital, USA
[2]Massachusetts General Hospital, USA

Corresponding author:
Robert R Edwards, Harvard Medical School and Departments of Anesthesiology, Perioperative and Pain Medicine and Psychiatry and Pain Management Center, Brigham and Women's Hospital, 850 Boylston Street, Chestnut Hill, MA 02467, USA.
Email: RREdwards@bwh.harvard.edu

emotional processes such as catastrophizing. For instance, previous research has demonstrated an inverse link between mindfulness and pain intensity in various chronic pain conditions (Ball et al., 2017; Bohlmeijer et al., 2011). Mindfulness has been incorporated into many types of psychological therapy. For example, Mindfulness-Based Stress Reduction (MBSR) therapy incorporates the practices of mindful meditation and has been used to treat patients with chronic pain (Kabat-Zinn, 1982). MBSR integrates different formal mindfulness practices such as meditation, body scan, and yoga exercises (Lauche et al., 2013). Mindfulness-based interventions have been shown to be beneficial for patients with chronic pain and for patients who catastrophize (Hilton et al., 2017; Mun et al., 2014; Schutze et al., 2010; Zeidan et al., 2010, 2012). Although there is some evidence for the efficacy of mindfulness-based practices, a systematic review deemed the evidence insufficient to definitively recommend mindfulness intervention for treating FM symptoms (Lauche et al., 2013).

Mindfulness does not try to reduce negative thoughts but aims at developing awareness and refocusing every time the mind wanders (Cash et al., 2015). Mindfulness is a way of paying attention to the present with non-judgmental awareness (Kabat-Zinn, 1982). It comprises various tenets including attention to external experiences, conversion of internal experiences into words, attending to the present moment, not recognizing thoughts and feelings as negative or positive, and allowing thoughts and feelings to enter and leave the mind (Bohlmeijer et al., 2011). As a result, by adopting alternative, balanced cognitions, the patient's distress and pain are likely to be reduced (Jensen et al., 2018). FM's variety of symptoms and comorbid catastrophizing make its interactions with mindfulness more complicated, in that catastrophizing is a dysfunctional way of being overly aware of pain. Because of this, an exploration of the relationship between different facets of mindfulness and catastrophizing is merited, in order to understand which aspects of mindfulness training may be most useful to individuals with high catastrophizing.

While some evidence has identified cross-sectional inverse associations between catastrophizing and mindfulness (Day et al., 2015; Elvery et al., 2017; Mun et al., 2014), we know very little about how catastrophizing and mindfulness interact to influence FM pain symptoms over time. Evidence in the literature of the relationship between mindfulness and catastrophizing has been mixed. Some studies have demonstrated negative associations between measures of mindfulness and pain catastrophizing (Ball et al., 2017; Bohlmeijer et al., 2011; Cassidy et al., 2012; Day et al., 2015; Schutze et al., 2010). However, some studies have indicated no significant relationship between mindfulness and catastrophizing or have even found inverse relationships between catastrophizing and some mindfulness subscales (De Boer et al., 2014). The relationship between mindfulness and pain catastrophizing in the literature remains inconclusive most likely due to the fact that mindfulness is a multifaceted construct that can be measured in a variety of ways (Turner et al., 2016). It has been posited that these inconclusive findings are a result of a two-component model of mindfulness tenets consisting of awareness and acceptance (Bishop et al., 2004). Research suggests that catastrophizing interacts with awareness and acceptance differently, therefore causing a possibly contrary body of research on mindfulness and catastrophizing interactions (Turner et al., 2016). The aim of the present microlongitudinal study was to examine the associations among mindfulness (and its various aspects), catastrophizing, and pain in patients with FM. We hypothesize that trait mindfulness will moderate catastrophizing effects on average daily pain in patients with FM.

Materials and methods

In total, we invited 120 FM patients for screening. Patients were diagnosed as having FM (as confirmed by physician and medical records) and met the recently proposed American College of Rheumatology criteria, which require the presence of widespread pain as well as a number of somatic and cognitive symptoms (Wolfe, 2010). After screening the 120 FM patients, 88 women met the inclusion and exclusion criteria described below. This study was approved by the Partners Human Research Committee, and written informed consent was obtained from all participants.

Participants were screened for the following criteria. The inclusion criteria were as follows: (1) 18–75 years old, (2) female, (3) Wolfe et al.'s (2011) research criteria for FM diagnosis for at least 1 year, (4) baseline pain intensity of at least 4/10 on average and pain report for at least 50 percent of days, and (5) fluent in English and able to provide written informed consent. The exclusion criteria included (1) comorbid acute pain condition or comorbid chronic pain condition that is rated by the subject as more painful than FM, (2) current use of stimulant medications or the fatigue associated with sleep apnea or shift work (e.g. modafinil), (3) pregnant or nursing, (4) any psychiatric disorder involving a history of psychosis (e.g. schizophrenia, severe personality disorders), (5) psychiatric hospitalization in the past 6 months, (6) current or recent use of recreational drugs, (7) current participation in mindfulness therapy, (8) active suicidal ideation, and (9) lower limb vascular surgery or current lower limb vascular dysfunction.

Procedures

The baseline visit included the informed consent, completion of questionnaires, and confirmation of eligibility (described below). In addition, participants were asked to complete daily diaries for 7 days assessing daily pain and negative cognitions on pain (e.g. catastrophizing). Four

Table 1. Sociodemographic variables.

	N = 88
Age (mean ± SD)	46.24 ± 12.96
% Married	36
% Caucasian	79.1
% Employed (full-time/part-time)	29.1/30.2
% Education levels (college degree)	70.9

SD: standard deviation.

surveys were used to assess key study variables: (1) Revised Fibromyalgia Impact Questionnaire (FIQR), (2) Brief Pain Inventory (BPI), (3) Pain Catastrophizing Scale (PCS), and (4) Five-Facet Mindfulness Questionnaire (FFMQ).

Clinical measures

Sociodemographic data. Sociodemographic information included date of birth, marital status, educational, current occupational status, duration of pain symptoms, and medical comorbidities (Table 1).

Catastrophizing. The PCS (Osman et al., 1997) is a well-validated, widely used, self-report measure of catastrophic thinking associated with pain. The PCS has good psychometric properties in pain patients and controls. PCS includes three subscales: rumination, magnification, and helplessness.

FM symptoms. A validated short-form PCS was used to measure daily pain catastrophizing using two questions from each subscale and calculating their sum (Lee et al., 2018). In order to measure FM symptomatology, we used the FIQR and the BPI. The FIQR is 21-question measure with an 11-point numeric rating scale (NRS) of 0 to 10, with 10 being "worst." The FIQR is divided into three subscales for scoring: (1) "function," (2) "overall impact," and (3) "symptoms," as well as a total overall score to assess the total impact of FM symptoms on a patient's life. The BPI is a 15-item measure, which includes two multi-item subscales that measure (1) pain intensity and (2) pain interference with daily activities (Cleeland and Ryan, 1994); the BPI is well-validated in chronic pain and is frequently recommended as an outcome measure of pain severity and pain interference.

Mindfulness. A validated 24-item version of the Five-Facet Mindfulness Questionnaire-Short Form (FFMQ-SF) was used (Bohlmeijer et al., 2011) to measure mindfulness. The FFMQ examines five aspects of mindfulness: (1) observing (Observe), (2) describing (Describe), (3) acting with awareness (Act with awareness), (4) detachment (Detach) to inner experience, and (5) non-judging (Non-judging) of inner experience and uses a five-point Likert-type scale with answer choices ranging from 1 (never or very rarely true) to 5 (very often or always true) (Baer et al., 2008). Total scores for each subgroup were calculated by summing the items, with reverse scoring for 12 items that were worded in the opposite direction. Internal consistency coefficients have been reported as adequate to high, and intercorrelations between the five facets have been reported to range from .32 to .56, $p < .01$ (Bohlmeijer et al., 2011).

Pain intensity. Patients were asked to report their daily average level of pain intensity (0 "no pain" to 100 "pain as bad as it could be") once a day for a period of 7 days using NRS via the Research Electronic Data Capture (REDCap) system.

Pain catastrophizing. Patients were asked to report their levels of catastrophizing (0 "not at all" to 4 "all the time") once a day for a period of 7 days using a Likert scale via the Research Electronic Data Capture (REDCap)

Data analysis

All analyses were conducted using IBM-SPSS v.24. Descriptive data for continuous variables were presented as means and standard deviations (SDs), and data for categorical variables were presented as percentages (see Table 1). All analyses were conducted using multilevel modeling (MLM) and the MIXED command in SPSS-IBM. MLM is well-suited to handle the hierarchical nested data structure of the proposed study, in which repeated daily assessments (Level 1 units) were nested within participants. MLM is also well-suited to handle the unequal number of data points across participants due to random missing data (Peugh, 2010; Singer et al., 2003), which is typical of longitudinal study designs.

Data cleaning included correction of out-of-range values and checking for potential outliers. In terms of outlier analysis, we first inspected the potential presence of multivariate outlier cases involving main independent variables (IVs: PCS and FFMQ) and the study outcome (i.e. pain intensity). No multivariate outlier cases were detected. We first conducted preliminary analyses examining the potential confounding influence of participants' demographic (i.e. age, ethnicity) characteristics on average pain ratings.

In order to select the covariance structure for multilevel models, we compared different types of covariance structures (i.e. AR1, compound symmetry, Toeplitz) by examining model fit information. Comparison of model fit was based on the Akaike information criterion (AIC) and the Schwarz's Bayesian information criterion (BIC), as recommended (Cheng et al., 2010). Across all models, the best model fit was achieved using the first-order autoregressive (AR1) structure. In addition to providing the best model fit, the AR1 structure permits to account for the autocorrelations between repeated outcome assessments (i.e. pain intensity). For all these reasons, the first-order

Table 2. Pearson correlations between mindfulness traits, daily pain intensity, and catastrophizing.

	FFMQ-Observe	FFMQ-Describe	FFMQ-Detach	FFMQ-Acting with awareness	FFMQ-Non-judging	Daily average pain intensity	Daily catastrophizing	PCS
FFMQ-Observe	–							
FFMQ-Describe	.266**	–						
FFMQ-Detach	.016	.179**	–					
FFMQ-Acting with awareness	.107*	.350**	.232**	–				
FFMQ-Non-judging	−.071	.198**	.134**	.369**	–			
Daily average pain intensity	.020	−.148**	−.062	−.063	−.122*	–		
Daily catastrophizing	−.044	−.315**	−.121*	−.267**	−.390**	.583**	–	
PCS	−.071	−.293**	−.336**	−.358**	−.487**	.419**	.746**	–

PCS: Pain Catastrophizing Scale; FFMQ: Five-Facet Mindfulness Questionnaire.
*$p < .01$; **$p < .001$.

autoregressive (AR1) structure was selected for our multilevel models.

All multilevel models were built using daily pain ratings as the dependent (i.e. outcome) variable. Level 1 PCS (daily pain catastrophizing) and Level 2 FFMQ (mindfulness subscales) were then simultaneously added to the model, which permitted examination of the effects of catastrophizing and mindfulness facets on daily ratings of FM pain severity. As recommended, all Level 1 scores were centered within participants, and Level 2 scores were centered at the grand mean (Enders and Tofighi, 2007; Nezlek, 2001). Model building followed a sequential procedure (Kopala-Sibley et al., 2012; Russell et al., 2011; Wallace and Chen, 2006), which first involved specifying a random intercept and fixed effects for IVs. When significant fixed effects emerged, slopes were then treated as random effects, and model fit was re-evaluated using the likelihood ratio test. Random parameters were dropped if they resulted in a significantly worse model fit (Schwartz and Stone, 1998; Singer, 1998; Singer et al., 2003). All models were carried out using maximum likelihood estimation and included a first-order autoregressive variance covariance matrix (AR1) in order to account for autocorrelations between repeated assessments.

Results

Descriptive statistics

Descriptive statistics for study measures are presented in Table 1. The average age of patients was 46.24 years (SD = 12.96) and all participants were female. Missing data percentages were low with baseline questionnaires missing only 1.7 percent and diary data missing only 17.6 percent. Table 2 shows Pearson correlations among study measures and Table 4 shows the means and standard deviations of the variables measured.

Multilevel models were built to examine the effects of daily catastrophizing scores and mindfulness subscales (FFMQ) on daily pain ratings (see Table 3 and Figures 1 to 3). Multilevel models reveal that there was no significant change in daily pain catastrophizing ($B = -0.23$, standard error (SE) = 0.32, $p > .05$) and daily pain intensity ($B = -0.06$, SE = 0.08, $p > .05$) over the 7 days measured. A separate model was created for each FFMQ subscale where the Level 2 FFMQ subscale scores were added as IVs to the previous model (Table 3).

The main effect of the FFMQ-Observe subscale was not significant ($B = 0.03$, SE = 0.62, $p > .05$) indicating that the pain intensity was not significantly influenced by FFMQ-Observe. The main effect of daily pain catastrophizing on pain intensity was significant ($B = 1.96$, SE = 0.17, $p < .001$) suggesting that pain intensity was significantly influenced by daily pain catastrophizing. There was a significant two-way (catastrophizing*FFMQ-Observe) interaction ($B = -0.12$, SE = 0.06, $p < .05$) indicating an influence of pain catastrophizing and FFMQ-Observe on average pain intensity experienced. As can be seen in the figure, high scores on the Observe subscale appear to act as a buffer against the harmful effects of catastrophizing.

The main effect of the FFMQ-Acting with awareness subscale was not significant ($B = -0.38$, SE = 0.56, ns) indicating that pain intensity was not significantly influenced by FFMQ-Acting with awareness. The main effect of daily pain catastrophizing on pain intensity was significant ($B = 2.02$, SE = 0.17, $p < .001$) suggesting that pain intensity was significantly influenced by daily pain catastrophizing. There was a significant two-way (catastrophizing*FFMQ-Acting with awareness) interaction effect ($B = 0.13$, SE = 0.05, $p < .05$) indicating that there is an influence of pain catastrophizing and FFMQ-Acting with awareness on pain intensity. The positive interaction term suggests that high-catastrophizing patients with higher scores on the Acting with awareness subscale tend to report the highest pain ratings.

The main effect of the FFMQ-Non-judging self-subscale was not significant ($B = -0.54$, SE = 0.38, ns) indicating that pain intensity was not significantly influenced by FFMQ-Non-judging. The main effect of daily pain catastrophizing

Table 3. Multilevel model examining the influence of trait mindfulness and catastrophizing on the average pain ratings of fibromyalgia patients.

Fixed effects	β	SE	T	p value
Intercept	53.1	1.85	28.67	$<.001$
FFMQ-Observe	0.026	0.62	0.043	ns
Daily pain catastrophizing	1.96	0.17	11.22	$\leqslant.001$
FFMQ-Observe × PCS	−0.12	0.06	−2.1	$<.05$
Intercept	52.9	1.82	28.93	$<.001$
FFMQ-Acting with awareness	−0.38	0.56	−0.688	ns
Daily pain catastrophizing	2.02	0.17	11.5	$\leqslant.001$
FFMQ-Acting with awareness × PCS	0.13	0.05	2.3	$<.05$
Intercept	52.9	1.8	29.1	$<.001$
FFMQ-Non-judging	−0.54	0.38	−1.41	ns
Daily pain catastrophizing	2.05	0.17	11.8	$\leqslant.001$
FFMQ-Non-judging × PCS	0.13	0.04	3.4	$\leqslant.001$
Intercept	52.89	1.8	29.3	$<.001$
FFMQ-Describe	−0.71	0.45	−1.59	ns
Daily pain catastrophizing	1.96	0.17	11.2	$\leqslant.001$
FFMQ-Describe × PCS	0.01	0.04	0.25	ns
Intercept	52.9	1.8	28.9	$<.001$
FFMQ-Detach	−0.22	0.42	−0.52	ns
Daily pain catastrophizing	1.96	0.17	11.2	$\leqslant.001$
FFMQ-Detach × PCS	0.01	0.04	0.3	ns

β: unstandardized regression coefficient; SE: standard error; FFMQ: Five-Facet Mindfulness Questionnaire; PCS: Pain Catastrophizing Scale. Daily pain catastrophizing is a Level 1 variable centered within persons. FFMQ-Observe, FFMQ-Acting with Awareness, FFMQ-Non-judging, FFMQ-Describe, and FFMQ-Detach are Level 2 variables centered at the grand mean.

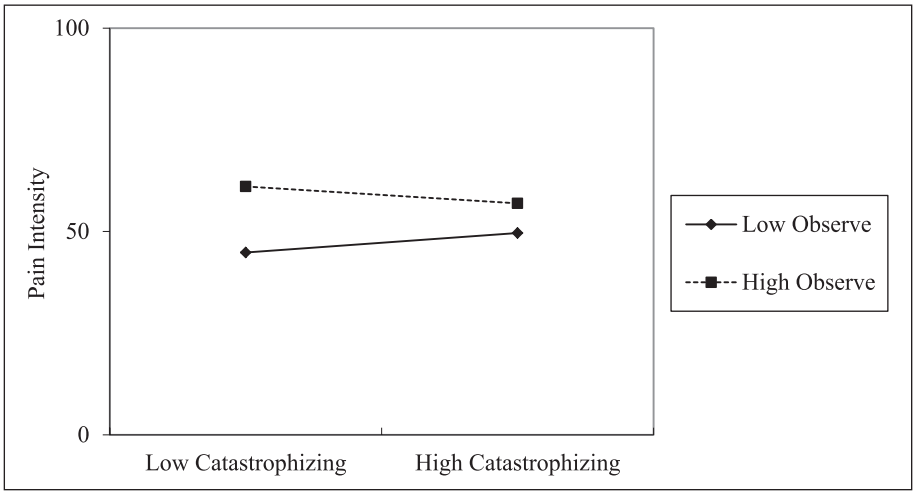

Figure 1. The significant effects of the interaction between FFMQ-Observe and daily catastrophizing on pain intensity.

on pain intensity was significant ($B=2.05$, SE$=0.17$, $p<.001$) suggesting that pain intensity was significantly influenced by daily pain catastrophizing. There was again a significant two-way (catastrophizing*FFMQ-Non-judging) interaction effect ($B=0.13$, SE$=0.04$, $p<.001$) indicating that there is an influence of pain catastrophizing and mindful non-judging on average pain intensity experienced. The nature of this interaction is similar to that for the Acting with awareness subscale; patients who are both high in catastrophizing and who have high non-judgment scores tend to report the highest daily pain ratings.

In addition, separate models were run using the FFMQ-Describe and the FFMQ-Detach subscales. Neither the FFMQ-Describe nor FFMQ-Detach yielded significant results for their main effects ($B=-0.71$, SE$=0.45$, $p>.05$; $B=-0.22$, SE$=0.42$, $p>.05$). FFMQ-Describe and FFMQ-Detach also did not have significant interactions with PCS scores ($B=0.01$, SE$=0.04$, $p>.05$; $B=0.01$, SE$=0.044$, $p>.05$).

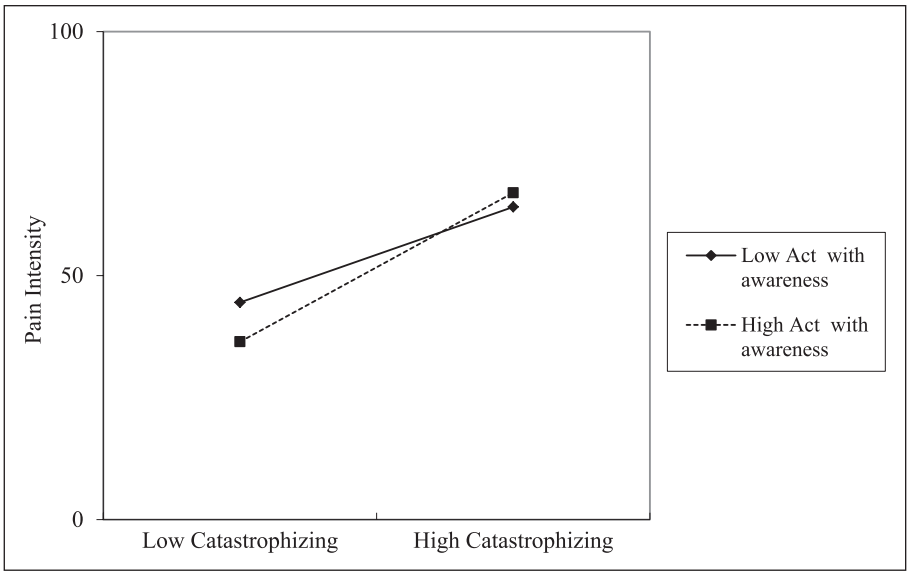

Figure 2. The significant effects of the interaction between FFMQ-Acting with awareness and daily catastrophizing on pain intensity.

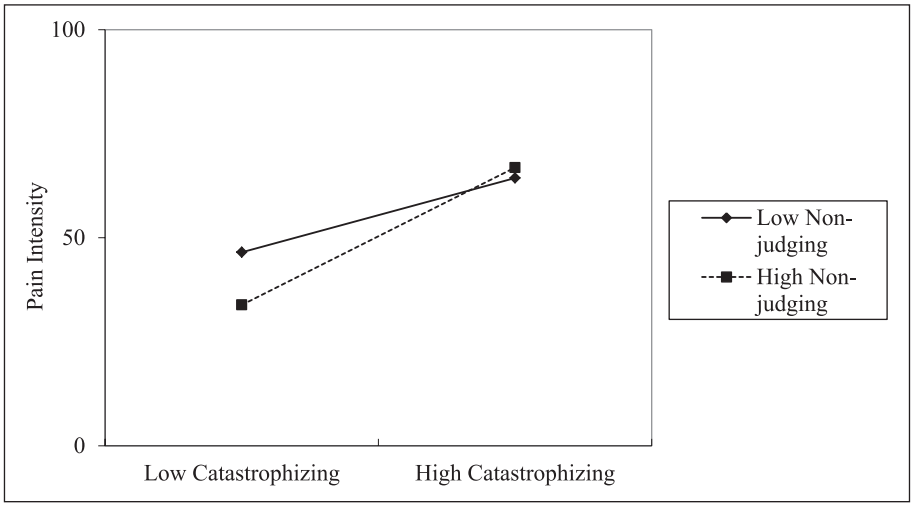

Figure 3. The significant effects of the interaction between FFMQ-Non-judging and daily catastrophizing on pain intensity.

Discussion

In this study, we examined the relationship between mindfulness, catastrophizing, and clinical pain. Results of multilevel analyses indicated that the association between catastrophizing and pain intensity was moderated by certain mindfulness facets (Observe, Acting with awareness, and Non-judging), but not others (Describe, Detach). These findings are congruent with previous reports on the association between catastrophizing, pain, and mindfulness (Jensen et al., 2018). The main finding that emerged from our study was that different facets of mindfulness differentially moderated the impact of catastrophizing on daily pain. Multilevel analyses indicated that higher "Observe" scores were associated with a reduced impact of high catastrophizing on FM pain. This moderating effect of FFMQ-Observe is congruent with prior research (Bohlmeijer et al., 2011). Among the mindfulness facets, Observe is the only one assessing external experiences, as opposed to internal feelings and experiences (Day et al., 2017; Lilja et al., 2013). For patients with chronic pain, particularly high catastrophizers, this external focus may be of benefit, potentially helping them distract their focus away from their painful internal experiences (Johnson, 2005). In fact, a prior study showed that chronic pain patients with high catastrophizing derived more analgesic benefit from a distracting stimulus (Schreiber et al., 2014).

Table 4. Clinical variables (data presented as mean ± SD).

	Patients
BPI (Severity)	5.13 ± 2
BPI (Interference)	5.47 ± 2.3
Daily PCS (total score)	13.54 ± 6.2
Average pain intensity	52.43 ± 18.9
FIQR Function	15.61 ± 6.5
FIQR Overall	11.14 ± 5.7
FIQR Symptoms	29.35 ± 8.2
FIQR Total	56.11 ± 18.8
FFMQ-Observe	15.45 ± 3
FFMQ-Describe	17.13 ± 4
FFMQ-Detach	14.41 ± 4.5
FFMQ-Acting with awareness	16.12 ± 3.4
FFMQ-Non-judging	16.21 ± 4.7

BPI: Brief Pain Inventory; PCS: Pain Catastrophizing Scale; FIQR: Fibromyalgia Impact Questionnaire-Revised; FFMQ: Five-Facet Mindfulness Questionnaire; SD: standard deviation.

In contrast, it seems that the other facets of mindfulness impact the association between catastrophizing and pain in a different way. Specifically, our results indicated that non-judgment and awareness may tend to amplify the negative effects of catastrophizing. This may occur because patients with high levels of these mindfulness characteristics may be more likely to accept negative, catastrophic thoughts and feelings which can lead to increased pain. The thought process associated with the Non-judging facet of mindfulness involves not recognizing thoughts as negative or positive. For patients with pain and high catastrophizing, adopting a non-judging attitude toward these negative thoughts about pain may allow them to have more impact and thus worsen pain (Geisser et al., 2003). Likewise, patients with higher awareness tend to be more aware of their symptoms and experience heightened pain (Picavet et al., 2002). In other words, patients with high levels of catastrophizing and awareness might be more attentive to their daily pain. In light of this, it is not surprising that patients with high catastrophizing and high awareness reported higher pain intensity than patients with low awareness and low catastrophizing.

Because mindfulness is a multidimensional set of skills and facets, and each facet may interact differently with other constructs (Lilja et al., 2013), including catastrophizing (in both positive and negative ways), it is important to distinguish which practices are applied to chronic pain patients, especially FM patients who have high catastrophizing. Previous research has suggested that teaching patients how to mindfully respond to pain-related cognitive content could increase their level of functioning (Day et al., 2017; Jensen, 2011). These results support the efficacy of therapeutic techniques that encourage mindful approaches to pain-related cognitions and emotions (Thorn, 2017; Vowles et al., 2007). Although some of our present results are contrary to existing evidence demonstrating that mindfulness acts as a buffer between negative emotions and pain, the present findings open new avenues in understanding the unique role that mindfulness plays among high pain catastrophizers. The influence of catastrophizing on pain responses is consistent with the findings of several studies (Edwards et al., 2006; Severeijns et al., 2001); however, the unique role of mindfulness makes these findings interesting. Previous research has suggested that cognitive processes in pain models can be divided into two parts: cognitive content and cognitive process (Jensen, 2011; McCracken and Vowles, 2014). Cognitive content refers to what a patient thinks about pain, and cognitive process is the how they think about pain (Day and Thorn, 2014; Jensen, 2011). On one hand, pain catastrophizing scales assess the actual content of thoughts (i.e. "I feel I can't go on"). On the other hand, the mindfulness scales assess the process by which thoughts are understood (i.e., "In difficult situations, I can pause without immediately reacting") (Day et al., 2017; Jensen et al., 2018). Prior research has demonstrated that pain catastrophizing is associated with a dysfunctional thinking and evaluation in the appraisal stage (Thorn et al., 2002). Therefore, patients who usually catastrophize may have difficulty assessing and appraising internal states such as thoughts and emotions. The Non-judging and Awareness aspects of mindfulness require a thoughtful appraisal that patients with high scores in catastrophizing might not be able to perform effectively. The opposite direction moderational relationships between catastrophizing and different FFMQ subscales highlight the nuanced nature of the interactions between these constructs. While an accepting, mindful focus on external stimuli may be beneficial in tempering the effects of catastrophizing, a similar focus on internal states and thoughts may tend to aggravate some aspects of chronic pain for patients who experience high levels of catastrophizing (Picavet et al., 2002).

Collectively, mindfulness-based interventions for chronic pain seem to be effective via reductions in catastrophizing and increases in mindfulness. Although a number of issues remain in need of clarification, including the processes by which mindfulness works, the role of cognitive changes needs to be addressed in future clinical trials. This study has a number of limitations that should be highlighted when interpreting these results. One of the main limitations was the restricted time frame of the study (i.e. 1 week), which prevents us from drawing causal conclusions about long-term associations between these factors. In addition, while the strength of the study consists of daily assessment of pain and catastrophizing, we did not collect daily mindfulness ratings, which limits out ability to evaluate fluctuations in mindfulness over time. Another important limitation is the possibility that the mental skill required to meaningfully differentiate between cognitive content and process may require some practice from the patients' perspective. Thus, as the participants in this study were not treated, asking a naïve patient to "watch" their thoughts or not judge

them may be more meaningful after some instruction or practice. As a result, it would be useful to examine the extent to which significant interactions that emerge with baseline data replicate in the same sample of patients after mindfulness interventions. Despite these limitations, the results of this study provide some insight into the possible associations between catastrophizing and mindfulness in chronic pain populations as well as implications for future clinical interventions. Therefore, strategies designed to reduce pain catastrophizing and increase mindfulness, in a way that is meaningful, in this population can also have a beneficial effect at reducing clinical pain.

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