



Observational study

The relationship between chronic musculoskeletal pain, anxiety and mindfulness: Adjustments to the Fear-Avoidance Model of Chronic Pain

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HIGHLIGHTS

- Ruminative anxiety may be a psychological vulnerability for chronic pain.
- Comorbid ruminative anxiety and chronic pain predicted lower mindfulness.
- Mindfulness predicted 8.5–40.9% of variance in Fear-Avoidance Model elements.
- Non-reaction, non-judgment and awareness were unique predictors of chronic pain.
- Mindfulness may treat physical, cognitive and behavioral aspects of chronic pain.

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ABSTRACT

Background and purpose: The Fear-Avoidance Model of Chronic Pain proposed by Vlaeyen and Linton states individuals enter a cycle of chronic pain due to predisposing psychological factors, such as negative affectivity, negative appraisal or anxiety sensitivity. They do not, however, address the closely related concept of anxious rumination. Although Vlaeyen and Linton suggest cognitive-behavioral treatment methods for chronic pain patients who exhibit pain-related fear, they do not consider mindfulness treatments. This cross-sectional study investigated the relationship between chronic musculoskeletal pain (CMP), ruminative anxiety and mindfulness to determine if (1) ruminative anxiety is a risk factor for developing chronic pain and (2) mindfulness is a potential treatment for breaking the cycle of chronic pain.

Methods: Middle-aged adults ages 35–50 years ($N=201$) with self-reported CMP were recruited online. Participants completed standardized questionnaires assessing elements of chronic pain, anxiety, and mindfulness.

Results: Ruminative anxiety was positively correlated with pain catastrophizing, pain-related fear and avoidance, pain interference, and pain severity but negatively correlated with mindfulness. High ruminative anxiety level predicted significantly higher elements of chronic pain and significantly lower level of mindfulness. Mindfulness significantly predicted variance (R^2) in chronic pain and anxiety outcomes. Pain severity, ruminative anxiety, pain catastrophizing, pain-related fear and avoidance, and mindfulness significantly predicted 70.0% of the variance in pain interference, with pain severity, ruminative anxiety and mindfulness being unique predictors.

Conclusions: The present study provides insight into the strength and direction of the relationships between ruminative anxiety, mindfulness and chronic pain in a CMP population, demonstrating the unique associations between specific mindfulness factors and chronic pain elements.

Implications: It is possible that ruminative anxiety and mindfulness should be added into the Fear-Avoidance Model of Chronic Pain, with ruminative anxiety as a psychological vulnerability and mindfulness as an effective treatment strategy that breaks the cycle of chronic pain. This updated

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Fear-Avoidance Model should be explored further to determine the specific mechanism of mindfulness on chronic pain and anxiety and which of the five facets of mindfulness are most important to clinical improvements. This could help clinicians develop individualized mindfulness treatment plans for chronic pain patients.

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1. Introduction

1.1. The Fear Avoidance Model of Chronic Pain

The Fear-Avoidance Model of Chronic Pain (Fig. 1), proposed by Vlaeyen and Linton [1] explains how fear perpetuates chronic pain states [2,3]. The model is applicable to both patients with idiopathic pain and those with specific pain conditions, such as fibromyalgia, migraines, etc. [2]. There are three major components of the model: (1) The sensation of pain elicits a perception of the experience; (2) Most people perceive pain as unpleasant but not catastrophic, allowing for continued, albeit restricted, activity until recovery; (3) People with predisposing psychological factors, however, catastrophize their pain experience, which leads to the fear of pain, avoidance of activities, functional disability, and increased future pain (chronic pain state) [1,2]. According to previous research, negative evaluation of pain accounts for 7.0–31.0% of the variance in pain severity [3]. Therefore, introducing a technique that corrects maladaptive cognitions such as pain catastrophizing and anxious rumination is likely an effective way to break the cycle of chronic pain.

1.2. Mindfulness

Mindfulness is a cognitive behavioral strategy that promotes present-moment awareness of body sensations, such as the experience of pain. In contrast to pain catastrophizing, it is intentional and non-judgmental [3]. Mindfulness meditation reduces symptoms of pain, depression, and anxiety [4–8] while increasing factors such as sleep quality, mindfulness, and psychological well-being [4,5,9]. One study explored the relationship between mindfulness and chronic pain using 104 chronic pain outpatients from a pain clinic in Australia [3]. Results demonstrated that mindfulness was significantly negatively related to pain severity, negative affect, pain catastrophizing, pain-related fear, pain hypervigilance and functional disability, accounting for 17.0–41.0% of the variance. The Schutze et al. study is one of the only studies suggesting that

mindfulness reduces chronic pain by influencing the factors in the Fear-Avoidance Model of Chronic Pain [3]. Although the work of Schutze begins to explain the cognitive mechanism of the ability of mindfulness to reduce chronic pain, the role of ruminative anxiety in the chronic pain response was not considered.

1.3. Objectives

Investigation of middle-aged adults (35–50 years) with CMP using a cross-sectional design will increase knowledge about the relationship between chronic pain, anxiety and mindfulness. H1: Ruminative anxiety is positively related to some or all of the elements of the Fear-Avoidance Model of Chronic Pain (pain catastrophizing, pain-related fear, pain avoidance, functional disability and pain experience) and negatively related to mindfulness. H2a: The five facets of mindfulness significantly predict variance in the elements of the Fear-Avoidance Model of Chronic Pain. H2b: When entering the elements of the Fear-Avoidance Model in the way that they appear, mindfulness and ruminative anxiety will add a significant unique proportion to the R². H3: The severity of pain factors and mindfulness level will differ depending on the presence of comorbid anxiety. H4: Mindfulness moderates the relationship between ruminative anxiety and pain so that in individuals with low mindfulness, the association between ruminative anxiety and components of chronic pain will be stronger than in individuals with high mindfulness.

2. Methods and materials

2.1. Participants

Participants for this study were middle-aged adults (35–50 years) with self-reported CMP. For the purposes of this study, chronic pain was operationalized as subjective symptoms continuing for the past three or more months, as defined by The American College of Rheumatology and the International Association for the Study of Pain [2,10]. Musculoskeletal pain was limited to the following five locations, in an attempt to make the sample relatively homogeneous: back, neck, hip, knee and shoulder. All data was collected between November 2016 and February 2017. Participants were recruited using online, using social media and Amazon Mechanical Turk as recruitment platforms. Individuals were included if they were between 35 and 50 years old and self-reported they had CMP in at least one of the five specified regions. If an individual had major surgery within the past three months, as defined by a medical procedure where a body cavity was invaded, a body part was removed or replaced, or there was a threat to life, they were excluded from participation because their recovery could influence reported pain levels. The IRB at American University approved this study.

Using G*power, a program developed at the University of Düsseldorf, it was determined a sample size of 199 participants would be needed to detect an effect size of 0.15, with an alpha of 0.05 and power of 0.95, in a model with 15 predictors [11]. To satisfy this criteria, it was decided 200 participants would be recruited.

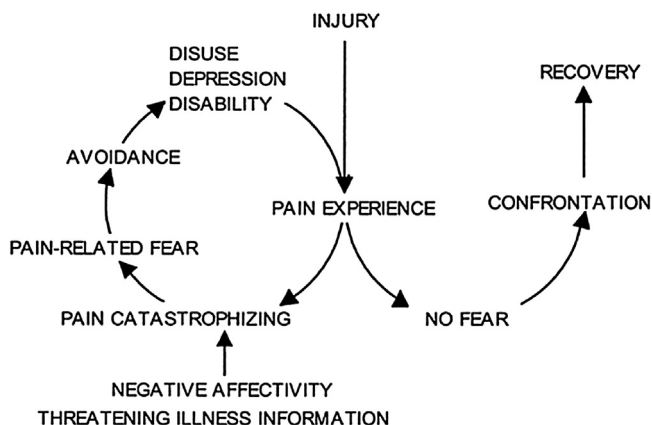


Fig. 1. The Fear-Avoidance Model of Chronic Pain. Note: Vlaeyen and Linton's Fear-Avoidance Model of Chronic Pain was specifically developed to describe the CMP experience [1].

2.2. Procedures

Interested individuals first navigated to screening questions using a link provided on the recruitment sites. They answered screening questions regarding their age, recent medical procedures, location of pain, and length of pain. If inclusion criteria were met, informed written consent was given to the participants online. Those who certified they wanted to complete the study questionnaires then automatically accessed the assessments on Qualtrics software, Version 2.16 (<http://www.qualtrics.com>).

Standard background information regarding age, marital status, employment, race and education was collected. A medical history questionnaire developed by the researcher was administered to collect information about medical diagnosis, current treatments for pain, symptom flares and symptom impact on quality of life. Other lifestyle factors that may affect level of pain were collected, including substance use, clinical depression diagnosis, manual labor, and if the person had moved to a foreign country within the past year [10].

Participants then completed six standardized measures of psychological and physical functioning, as described in the materials section below. The measures took an average of 20 min to complete. All study measures were reviewed after submission, to assure completeness and data quality. If participants chose to withdraw before completing the questionnaires, the responses were deemed invalid. If the data did not pass certified quality checks, the responses were also deemed invalid. All invalid responses were deleted and not used in the analysis.

2.3. Materials

In addition to the screening, demographic and medical history questions, six standardized self-report questionnaires were included in the survey. The Brief Pain Inventory-sf, Pain Catastrophizing Scale, Pain Anxiety Symptom Scale 20, Perceived Stress Scale 10, and Five Facet Mindfulness Questionnaire-sf were recorded as primary outcomes to assess variables in the Fear-Avoidance Model of Chronic Pain, ruminative anxiety and mindfulness. The Pittsburgh Sleep Quality Index was included as a secondary outcome measure to assess relationships between sleep quality and the primary variables.

The Brief Pain Inventory-sf (BPI-sf) is a fifteen item questionnaire assessing pain severity, medication usage and pain interference (i.e. functional disability). The pain severity subscale consists of four items related to the pain experience variable of the Fear-Avoidance Model of Chronic Pain [3]. Questions ask to rate “pain at its worst”, “pain at its least”, “pain on average” and “pain right now” considering the past 24 h. The seven items on the pain interference subscale are related to the disuse/disability variable of the Fear-Avoidance Model of Chronic Pain [3]. Questions ask how much pain has interfered with “enjoyment of life”, “general activity”, “walking ability”, “mood”, “sleep”, “normal work”, and “relations with other people” in the past 24 h. Responses for each item fall between zero to ten, with higher scores indicating more pain severity or interference. The BPI-sf is internally reliable, consistent over time, and has good convergent and predictive validity when used with chronic pain patients [12]. Cronbach’s alpha is 0.85 for the “pain severity subscale” and 0.88 for the pain interference subscale [13].

The Pain Catastrophizing Scale (PCS) consists of 13 questions about negative orientation towards pain [14]. The total score ranges from 0 to 52, with higher scores reflecting higher pain catastrophizing. The scale has good criterion-related, concurrent and discriminant validity when used with adults [15]. The PCS has three subscales: rumination, magnification and helplessness, which all have good internal consistency when used with pain patients [15].

Cronbach’s alpha for the subscales are 0.85, 0.75 and 0.86 respectively and 0.92 for the total score [15]. The PCS was used to measure the pain catastrophizing variable of the Fear-Avoidance of Chronic Pain.

The Pain Anxiety Symptoms Scale (PASS-20) is a 20 item shortened version of the PASS-40 [16]. It measures chronic pain and its relationship to fear, avoidance and anxiety. Responses indicate the frequency that the person experiences the described statement. For example the question “I can’t think straight when I am in pain”, and all other questions, are rated on a scale ranging from zero (never) to five (always), with higher scores indicating increased pain-anxiety symptoms. The total score ranges from 0 to 80, with each subscale score ranging from 0 to 20. Subscales include the (1) cognitive appraisal of pain, (2) escape/avoidance of pain, (3) pain-related fear and (4) physiological anxiety related to pain. The PASS-20 has good internal consistency, reliability, and good predictive and construct validity [17]. Cronbach’s alpha for the subscales ranges from 0.75 to 0.86 and is 0.91 for the total score [17]. In this study the PASS-20 measured pain related fear and avoidance variables of the Fear-Avoidance Model of Chronic Pain.

The Perceived Stress Scale-10 (PSS-10) measures appraisal of different situations as stressful, including how upset, stressed, nervous, and irritated a person has felt [18]. The ten items ask about stress related to unpredictability, uncontrollability, and overload in the past month. For example, “In the last month, how often have you felt that you were unable to control the important things in your life”. Each item is scored from zero (never) to four (very often). Positively stated items are reverse coded to comprise a total score between zero and forty, with a higher score indicating higher perceived stress. Good reliability and convergent validity have been established for the PSS-10, as well as the distinct perceived helplessness and perceived self-efficacy factors [19]. Cronbach’s alpha is 0.89 for the total score, 0.85 for perceived helplessness, and 0.82 for perceived self-efficacy [19]. According to Deckers, a person who is psychologically stressed feels “anxious, nervous... tense” and according to Camara and colleagues, perceived stress and its relation to disease symptoms is fully associated with mood components such as anxiety [18,20]. Perceived stress scores are significantly higher in patients with clinical anxiety and correlated with symptom severity [21]. Furthermore, PSS scores were related to obsessive, but not compulsive, components of OCD, suggesting that perceived stress is a relevant component of ruminative anxiety symptomatology [21]. Given that perceived stress is associated with anxiety and is a component of ruminative anxiety, the PSS was used to measure ruminative anxiety in this study.

The Five Facet Mindfulness Questionnaire-sf (FFMQ-sf) is a 24 item instrument consisting of five components of mindfulness: observing inner experience, describing experience, acting with awareness, non-judging of experience, and non-reactivity to inner experience. Responses range from one (never/very rarely true) to five (very often/always true). Eight of the items are reverse coded. The total score ranges from 0 to 120. Higher scores indicate a higher level of mindfulness, defined as moment-to-moment awareness and non-judgmental acceptance of thoughts, feeling and sensations in the past month [22]. The five factors of the FFMQ-sf are highly correlated with the original version factors. The FFMQ-sf has good internal consistency, convergent, divergent, and content validity [23]. Cronbach’s alpha for the subscales ranges from 0.75 to 0.87 [23]. In this study, the FFMQ was used as a measure of dispositional mindfulness.

The Pittsburgh Sleep Quality Index (PSQI) contains nineteen questions, plus five additional questions if the person has a bed partner or roommate, that assess the quality of sleep in the past month. There are seven subscales, (1) subjective sleep quality, (2) sleep latency, (3) sleep duration, (4) sleep efficiency, (5) sleep disturbances, (6) sleep medication, and (7) daytime dysfunction.

Subscales scores range from 0 (no difficulty) to three (severe difficulty). The sum of the seven subscales are added to create the total score, ranging from 0 to 21, with a higher score indicating a poorer quality of sleep. The PSQI has good construct validity and adequate to good internal consistency [24]. Cronbach's alpha ranges from 0.53 to 0.88 for the subscales and is 0.87 for the total score [25]. The PSQI was recorded as a measure of well-being to determine if sleep quality had any relationship to the primary variables.

2.4. Analyses

Descriptive analyses examined means, ranges and standard deviations for the primary and secondary outcome variables. The frequency of demographic information, medical history and lifestyle questions were analyzed and assessed using ANOVAs for significant relationships to primary and secondary outcomes. Primary outcome variables and the PSQI secondary outcome variable were analyzed using a series of Pearson's correlations to increase understanding of the relationships between pain, anxiety and mindfulness as well as quality of sleep.

The main analysis consisted of hierarchical multiple regressions. Six multiple regression analyses were conducted to establish the amount of variance in the primary and secondary variables that is predicted by mindfulness. Demographic information, medical history and lifestyle factor questions that were significantly related to the outcome remained in the regression in the first block as a covariate. An additional hierarchical multiple regression was conducted to analyze if the five facets of mindfulness could predict variables in the Fear-Avoidance Model of Chronic Pain in the way in which they appear in the model. Covariates were entered in the first block, followed by pain experience, ruminative anxiety, pain catastrophizing, and pain-related fear/avoidance, with the five facets of mindfulness as predictors in the sixth block. Disuse/disability, the main clinical outcome of the Fear-Avoidance Model, was entered as the dependent variable.

ANOVA analyses with ruminative anxiety level as the independent variable were executed to determine if there were effects of ruminative anxiety comorbidity on the different components of pain and mindfulness. Groups were separated into low, medium, and high ruminative anxiety level based on the guidelines of the PSS-10 [26]. Background covariates of significance were controlled for in order to accurately assess the effect of ruminative anxiety level on the primary and secondary outcomes.

Lastly, to determine if mindfulness reduces chronic pain or anxiety through influencing factors of the Fear-Avoidance Model of Chronic Pain, a series of moderation analyses were conducted. Eight moderation analyses were completed, with mindfulness as the moderator to determine if there was an interaction between mindfulness and primary outcomes of pain and anxiety. Specific interaction terms are defined in detail in the results section.

There is no clear criterion for the definition of family tests and for instances in which Bonferroni correction is required. When two or more tests address a common null hypothesis, which can be found significant when only some of the tests are significant, it is suggested that Bonferroni should be used [27]. However, many feel Bonferroni correction is too conservative and increases the rate of Type II error. In a review of the literature, it was found to be most common to not use Bonferroni corrections and least common to use it if the same hypothesis is tested multiple times [27]. Given that in this study tests were performed to evaluate relationships between distinct variables in the Fear-Avoidance Model of Chronic Pain, and not to test the same variables repeatedly, it was determined Bonferroni correction was not needed.

3. Results

3.1. Demographics and medical history

Data was imported from Qualtrics into the Statistical Package for the Social Sciences (SPSS) version 24. All variables were screened for outliers and normality, and found to be normal. No transformations of data were required. Analysis was conducted using only the available data, as missing information was considered missing at random.

Responses were recorded from 201 middle-aged adults (52.7% women, 0.5% transgender; M age = 39.74, SD = 4.661) with self-reported CMP. A little more than half of the participants were White (58.2%), with the remaining reporting Asian (26.4%), Hispanic/Latino (7.0%), American Indian/Alaskan (5.4%), Black/African American (4.5%), and other (2.5%) as race. Of the 201 responses, eight people (4.0%) specified they identified with more than one of the races (biracial).

Most participants held a Bachelor's degree or higher level of education (65.2%). Only 7.0% reported they had less than or equal to a high school diploma or GED, with the remaining 27.8% reported some college but no Bachelor's degree. About half (51.7%) of the sample reported full-time employment, with 14.8% reporting half time employment, 13.0% unemployment or disability and 9.5% homemaker status. Lastly, 11% reported student status, with three (1.5%) people both working and attending school.

The majority of participants were married (57.2%), had children (64.0%), and had health insurance (94.5%). Approximately half of the participants (51.7%, N = 104) reported prior experience with meditation. Of those who meditated, 28.8% had been practicing for less than one year, 50.0% for one to five years, and 13.4% for more than five years. The remaining 7.8% did not report length of meditation time clearly.

Pain medication was the most common type of current medical treatment (82.1%), with 10% of participants attending psychotherapy and 21.9% physical therapy. Interestingly, a large number of participants reported engaging in integrative health practices in the past month, including meditation (37.3%), yoga (26.9%), dieting (35.8%), exercise (68.7%) and acupuncture (3.0%). Only 1.5% of the sample was not in any type of current medical treatment. The majority of participants reported some type of substance use (81.6%), including alcohol, caffeine, nicotine and/or non-prescription drugs. Current pain treatments reported by participants are listed in Table 1.

Many of the participants endorsed a common risk factor for developing pain, such as clinical depression diagnosis (30.3%), manual work (33.8%) and moving to a new country within the past year (2.5%). Symptom flares were present in 73.6% of the sample, with 38.1% reporting flares once a month or less, 58.5% more than once a month, and 3.4% every day. Pain symptoms impacted participant quality of life to a large extent, with only 7.0% responding symptoms impacted quality of life never or almost never, 52.2% sometimes, 24.9% fairly often and 15.9% very often.

Experiencing pain in more than one location was reported by the majority of the sample, 68.2%. In total, 70.6% reported chronic back pain, 36.3% chronic hip pain, 33.8% chronic knee pain, 37.3% chronic shoulder pain, and 43.3% chronic neck pain. The duration of pain was longer than 24 months for those suffering from back pain (54.9%), hip pain (46.6%), knee pain (57.4%), shoulder pain (48.0%), and neck pain (56.3%), with the remaining participants reporting musculoskeletal pain lasting for less than 24 months. When asked to describe the type of chronic pain experienced, 44.4% of those with back pain, 43.8% of those with hip pain, 36.8% of those with knee pain, 38.7% of those with shoulder pain, and 46% of those with neck pain reported persistent/constant pain as compared to intermittent/episodic pain.

Table 1
Current pain treatments.

Medication	N	Integrative	N	Physical therapy	N	Medical procedure	N	Other	N
Anti-depressant	8	Meditation	2	Physical therapy	14	Epidural	1	Pain patches (non-prescription)	5
Muscle relaxant	2	Movement therapy	1	Physiotherapy	6	Injections	6	Vitamins	1
Steroids	1	Dance therapy	1			Surgery	4	Orthopedic braces	1
NSAIDs		Hot water therapy	2					TENS	2
Naproxen	2							Unit/stimulation	
Over the counter	9								
Pain killer		Acupuncture	3					Pain cream (non-prescription)	3
Non-specific	30								
Tramadol	2								
Hydromorphone	1								
Oxycodone	1								
Antibiotic	1	Ayurvedic treatment	6					Marijuana	1
Nerve pain	3	Yoga	3					Psychiatric	1
		Mindful posturing	1					Ice	1
		Chiropractic	4						
		Stretching	2						
		Exercise	2						
		Heat therapy	1						
Total	60	Total	28	Total	20	Total	11	Total	17

Note: This table documents the pain treatments noted by participants in the qualitative response section, to the question “Are you currently receiving treatment for pain or a related health condition? If yes, please describe.”

Table 2
Medical condition specified.

Musculoskeletal	N	Pain disorder	N	Mental health	N	Other	N
Osteoarthritis	8	Migraines	5	Depression	61	Diabetes	2
Adhesive capsulitis	1	Concussion	1	Other mood disorder	1	Stroke	1
Myotonia	1	Fibromyalgia	10	PTSD	1	Hidradenitis suppurativa	1
Degenerative disk disease	10	Sciatica	2	Anxiety (non-specified)	2	Hypertension	1
Ruptured/herniated/compressed disk	16	Pinched nerve	2			Overactive bladder	1
Scoliosis	4	Complex regional pain syndrome	1			Fearfulness	1
Muscle spasm/tension	4	Neuralgia	1			Energy loss	1
Rotator cuff wear	2					Hasimoto's	1
Whiplash	2					High uric acid	1
Rheumatoid arthritis	13					Constipation	1
Ehlers Danlos Syndrome	1					Cyst	1
Torn joint	5					Hypothyroidism	1
Sprain	2						
Break of bone	1						
Bursitis	1						
Lipomas	1						
Tendonitis	2						
Muscular dystrophy	1						
Hallus rigidus	1						
Total	77	Total	22	Total	65	Total	13

Note: This table documents participants' qualitative responses to the question, “Do you have a diagnosis for a medical condition? If yes, what is the condition?” as well as dichotomous responses to the question, “Have you been diagnosed with clinical depression?”.

Diagnosis of a known medical condition was endorsed by 53.2% of the sample, and in that subpopulation 70.1% stated they had a musculoskeletal disorder. A comprehensive list of reported medical conditions can be found in [Table 2](#).

3.2. Preliminary analyses

Means, ranges, and standard deviations for all primary and secondary outcomes are included in [Table 3](#), along with the reliability coefficients. Using one way independent-samples ANOVAs, significant relationships between primary and secondary outcomes and demographic and medical information were assessed. There were no significant effects of participants' marital status or age on primary or secondary outcomes ($p > 0.05$). There were specific effects of gender ($p = 0.005$ – 0.016), race ($p = 0.0001$ – 0.05), education ($p = 0.036$ – 0.047), parental status ($p = 0.048$), meditation experience ($p = 0.004$ – 0.019), pain medication use ($p = 0.004$ – 0.009), and pain vulnerability factors (clinical depression diagnosis, manual labor, moved to a new country within the past year)

($p = 0.005$ – 0.017) on primary and secondary outcomes. Specific ANOVA results are listed in [Appendix A](#). In all future analyses of primary and secondary outcomes, related demographic and medical information was included as a covariate to control for any effects.

3.3. Correlation analyses

The relationship between mindfulness and major variables in the Fear-Avoidance Model of Chronic Pain were explored with a series of one-tailed Pearson product-moment correlations. [Table 4](#) includes results of correlation analyses of all primary measures as well as the secondary measures of sleep quality (PSQI). Correlations were run using the questionnaire total score when possible. For the BPI-sf, there is no total score, so subscale scores for pain severity and pain interference were used.

In general all variables were positively related to each other, with the exception of the mindfulness, which was negatively correlated with the other variables. These results show preliminary support of the hypothesis that ruminative anxiety is positively

Table 3

Means, ranges, standard deviations and Cronbach's alpha for primary and secondary outcomes.

Measure	Theoretical range	Actual range	N	Mean	Standard deviation	Cronbach's alpha
Brief Pain Inventory-sf Pain severity	0–10	0–10	199	3.90	2.09	0.828
Brief Pain Inventory-sf Pain interference	0–10	0–8.75	192	3.88	2.48	0.828
Pain Catastrophizing Scale	0–52	0–39	194	14.68	9.68	0.820
Pain Anxiety Symptom Scale 20	0–80	0–80	192	31.42	18.59	0.884
Perceived Stress Scale 10	0–40	4–34	199	11.73	4.12	0.857
Five Facet Mindfulness Questionnaire-sf	24–120	47–112	188	78.20	11.73	0.584
Pittsburgh Sleep Quality Index	0–21	1–19	194	8.74	3.70	0.677

Note: Cronbach's alpha for internal consistency was calculated for all primary outcomes and the secondary outcome of sleep impairment (PSQI). For the BPI-sf, there is no total score, so subscale scores for pain severity and pain interference were used to calculate internal consistency.

Table 4

Correlation analyses of primary and secondary outcomes.

Measure	1	2	3	4	5	6
(1) BPI-sf severity						
(2) BPI-sf interference	0.717**					
(3) PCS total	0.355**	0.525**				
(4) PASS 20 total	0.358**	0.512**	0.830**			
(5) PSS 10 total	0.256**	0.440**	0.460**	0.447**		
(6) FFMQ-sf total	−0.115	−0.191**	−0.251**	−0.268**	−0.541**	
(7) PSQI total	0.352**	0.393**	0.299**	0.299**	0.445**	−0.383**

Note: Cohen's criteria 11 for interpretation of the coefficient was used to examine relationships between primary and secondary outcomes: small (0.10–0.29); medium (0.30–0.49); large (≥ 0.50).

* Significant at $p < 0.05$.

** Significant at $p < 0.01$.

related to pain elements in the Fear-Avoidance Model of Chronic Pain and negatively related to mindfulness. The relationships between pain and anxiety variables were of small (0.10–0.29) to medium (0.30–0.49) strength, using Cohen's criteria for interpretation of the coefficient [28]. The relationships between mindfulness and measures of pain were small (0.10–0.29), however the relationship between mindfulness and ruminative anxiety was large (≥ 0.50).

3.4. Regression analyses

A series of multiple hierarchical regression analyses were conducted to determine how well the five facets of mindfulness predict core variables in the Fear-Avoidance Model of Chronic Pain. Using the coefficient of determination (R^2), the proportion of variance in each pain and anxiety variable was explained by variance in the five FFMQ-sf facets. Six separate regression analyses were conducted, with the BPI-sf severity, BPI-sf interference, PCS, PASS-20, PSS-10 and PSQI scores as outcomes. The five facets of mindfulness were used as predictors and entered as the second block, with significant demographic and medical covariates entered in the first block.

Tests to see if the data met the assumption of collinearity indicated multicollinearity was not a concern. For all variables, tolerance was greater than 0.1 and VIF was less than 5.

In the regression equations, the total R^2 ranged from 0.085 to 0.412. Participant background variables played a role, significantly affecting the R^2 in three of the six equations. Mindfulness was a significant predictor in five of the six equations, with unique R^2 values ranging from 0.085 to 0.409. In each case the significant regression coefficients were in the predicted direction: higher scores on pain, anxiety and sleep impairment were associated with lower levels of mindfulness. The FFMQ facet non-reactivity to experience was a significant unique predictor in three equations, non-judgment in three equations, and awareness in two equations. Observing and describing were not unique predictors in any equations. The regression variables, beta values and R^2 values are summarized in Table 5.

To test whether mindfulness could predict the variables in the Fear-Avoidance Model of Chronic Pain in the order of which the variables occur, a hierarchical multiple regression analysis was conducted. The last stage of the Fear-Avoidance Model, disuse/disability as measured by the BPI-sf pain interference subscale, was used as the dependent variable. All background variables that were associated with primary outcomes were included as control variables in the first block. These included gender, White race, Asian race, education, parental status, pain medication use, pain vulnerability factors, and meditation experience. The next four blocks followed the order of the Fear-Avoidance Model: (1) pain experienced as measured by BPI-sf severity; (2) Ruminative anxiety as measured by the PSS-10; (3) pain catastrophizing as measured by the PCS; (4) pain-related fear and avoidance as measured by the PASS-20. The five facets of mindfulness—observing, describing, awareness, non-judgment, and non-reaction, were added to the last block as predictors. The final outcome accounted for 70.0% of the variance, with pain severity (45.1%), anxiety (8.6%), and mindfulness (9.8%) adding significant change to the R^2 value. The model reached significance level of $p < 0.0001$. This finding supports the Fear-Avoidance Model of Chronic Pain, with pain experience as a major predictor of disuse/disability. Furthermore, these findings demonstrate that ruminative anxiety and mindfulness account for significant variance (18.4%) and should be considered as distinct components in the Fear-Avoidance Model of Chronic Pain that predict disuse/disability.

3.5. ANOVA analysis of comorbid anxiety

Participants were divided into low, medium and high ruminative anxiety groups using the guidelines established by the PSS-10 [26]. Scores ranging from 0 to 13 are considered low, 14 to 26 medium, and 27 to 40 high ruminative anxiety. The high ruminative anxiety group was more likely to be married ($p = 0.045$), white ($p = 0.011$), and on disability ($p = 0.003$) compared to the lower ruminative anxiety groups. There was no association between ruminative anxiety level and gender, age, education or parental status ($p > 0.05$).

Level of ruminative anxiety was significantly related to all primary outcomes as well as sleep impairment. When controlling for marital status, disability and White race, higher ruminative anxiety level was associated with significantly higher pain severity ($p = 0.004$), pain interference ($p < 0.0001$), pain catastrophizing ($p < 0.0001$), pain-related fear and avoidance ($p < 0.0001$), and sleep impairment ($p < 0.0001$) (Fig. 2). When controlling for marital status, disability and White race, higher ruminative anxiety level was associated with significantly lower mindfulness ($p < 0.0001$). These findings support the hypothesis that higher level of ruminative anxiety is positively related to the pain outcomes in the Fear-Avoidance Model of Chronic Pain but negatively related to mindfulness.

Table 5

Hierarchical multiple regression analyses of relations between mindfulness facets and primary and secondary outcomes.

Outcome	Block	Predictors	β	R^2 (block)	Total R^2				
BPI-sf severity	1	Gender	0.105	0.090**	0.128**				
		Asian race	−0.078						
		Parental status	−0.167 ⁺						
	2	Pain medicine use	0.141	0.038					
		Observing	0.037						
		Describing	−0.100						
		Awareness	0.074						
		Non-judgment	−0.033						
		Non-reaction	−0.149						
BPI-sf interference	1	Observing	0.051	0.085**	0.085**				
		Describing	0.023						
		Awareness	−0.069						
		Non-judgment	−0.024						
		Non-reaction	−0.287***						
PCS total	1	Education	−0.133	0.020	0.155***				
	2	Observing	0.066	0.135***					
		Describing	0.072						
		Awareness	−0.095						
		Non-judgment	−0.286***						
		Non-reaction	−0.183 ⁺						
		PASS-20 total	1			Education	−0.022	0.122**	0.267**
2	Meditation experience		−0.270**	0.145 ⁺					
	Observing		0.136						
	Describing		0.083						
	Awareness		−0.191						
	Non-judgment		−0.298**						
	Non-reaction		−0.094						
PSS 10 total	1	Meditation experience	0.122	0.003	0.412***				
	2	Observing	0.103	0.409***					
		Describing	0.071						
		Awareness	−0.351**						
		Non-judgment	−0.361***						
		Non-reaction	−0.444***						
		PSQI total	1			Gender	0.048	0.232***	0.361***
Education	−0.107								
White race	0.099								
Asian race	−0.228 ⁺								
Pain medicine use	0.116								
Pain vulnerability	0.016								
2	Observing		0.063	0.129**					
	Describing		−0.098						
	Awareness		−0.193 ⁺						
	Non-judgment		−0.145						
	Non-reaction		−0.117						
	BPI-sf interference		1		Gender	−0.087	0.051	0.700***	
					White race	−0.004			
Asian race		−0.013							
Education		0.088							
Pain medicine use		0.116							
Pain vulnerability		−0.066							
Meditation experience		−0.156							
Parental status		0.063							
BPI-sf severity		0.584***							
2		PSS 10 total		0.353 ⁺	0.451***				
3		PCS total	−0.079	0.086 ⁺					
4		PASS 20 total	0.254	0.001					
5		Observing	−0.167	0.014					
6	Describing	0.129	0.098 ⁺						
	Awareness	−0.019							
	Non-judgment	0.234							
	Non-reaction	−0.100							

Note: This table shows results of the hierarchical multiple regression analyses, with the five facets of mindfulness as predictors of variables in the Fear-Avoidance Model of Chronic Pain. Except for pain experience, mindfulness uniquely predicted variance in all the other primary outcomes and sleep impairment (8.5–40.9%). When the primary outcomes were entered into the regression model according to their order in the Fear-Avoidance Model of Chronic Pain (including ruminative anxiety), and the five facets of mindfulness were included as predictors on the last block, 70.0% of the variance in disuse/disability was explained.

* Significant at $p < 0.05$.

** Significant at $p < 0.01$.

*** Significant at $p < 0.001$.

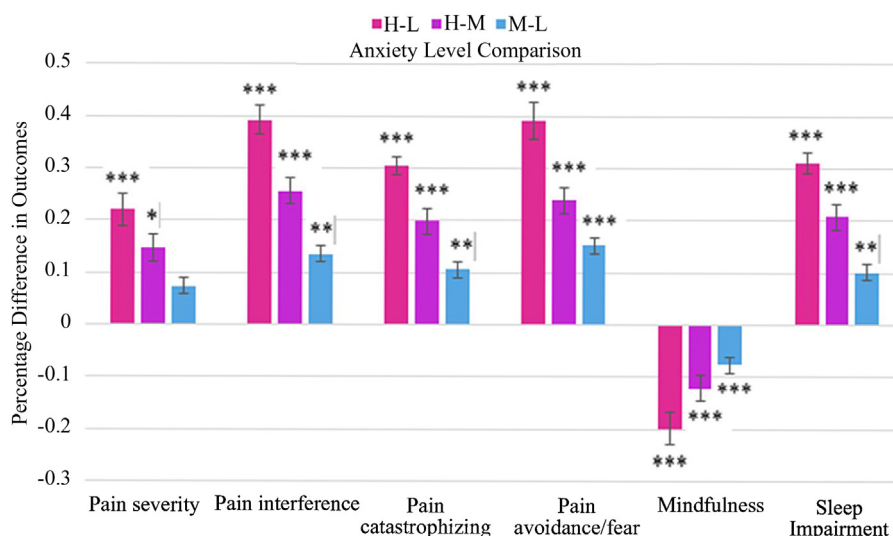


Fig. 2. Ruminative Anxiety Level Influences Primary and Secondary Outcomes. *Note:* The figure displays the mean percentage difference in primary and secondary outcomes given ruminative anxiety level as measured by the PSS-10 (low, medium, high). H-L represents mean percentage differences between high and low ruminative anxiety levels, H-M mean percentage differences between high and medium ruminative anxiety levels, and M-L mean percentage differences between medium and low ruminative anxiety levels. *Significance $p < 0.05$. **Significance $p < 0.01$. ***Significance $p < 0.001$.

Table 6
Moderated regressions of primary outcomes.

Outcome	Block	Predictors	β	Interaction R^2	Total R^2
BPI-sf severity	1	PSS-10	0.0162	0.0250	0.731**
	2	Mindfulness	-0.0126		
	3	Interaction	0.0011		
BPI-sf interference	1	PSS-10	0.1225	0.0016	0.202***
	2	Mindfulness	-0.0010		
	3	Interaction	0.0011		
PCS total	1	PSS-10	0.9213	0.0006	0.210***
	2	Mindfulness	0.0389		
	3	Interaction	-0.0025		
PASS-20 total	1	PSS-10	1.1432	0.0002	0.199***
	2	Mindfulness	-0.1069		
	3	Interaction	0.0025		
BPI-sf interference	1	BPI-severity	0.9270	0.0001	0.530***
	2	Mindfulness	-0.0248		
	3	Interaction	-0.0012		
PCS total	1	BPI-severity	2.7580	0.0012	0.182***
	2	Mindfulness	-0.1241		
	3	Interaction	-0.0151		
PASS 20 total	1	BPI-severity	6.3617	0.0026	0.191***
	2	Mindfulness	-0.2120		
	3	Interaction	-0.0421		
PSS-10 total	1	BPI-severity	0.5545	0.0000	0.335***
	2	Mindfulness	-0.2687***		
	3	Interaction	0.0003		

Note: The interactions between variables in the Fear-Avoidance Model of Chronic pain, anxiety and mindfulness were not significant, $p > 0.05$.

** Significant at $p < 0.01$.

*** Significant at $p < 0.001$.

3.6. Moderation analyses

A series of moderation analyses were conducted to determine if level of mindfulness could influence the relationship between anxiety and chronic pain. Using the PROCESS Procedure 2.13 Beta for SPSS Version 24, the moderated regressions showed that although the total R^2 in all equations was significant ($p < 0.01$), the interactions between variables were non-significant [29]. See Table 6 for more details about the specific interaction terms.

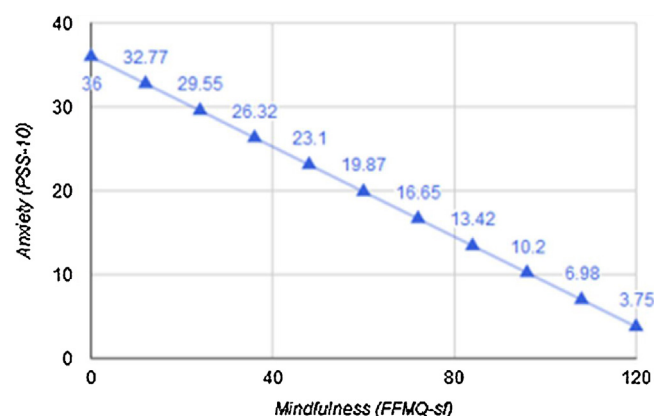


Fig. 3. Conditional relationship between Ruminative Anxiety and Mindfulness. *Note:* The figure depicts the conditional effect between ruminative anxiety and mindfulness, as determined by the moderation analysis. When pain experience is zero, with each increase of one in mindfulness, ruminative anxiety significantly decreased by 0.2687, $p < 0.0001$.

Although the interaction between pain experience (BPI-sf severity) and mindfulness was not a significant predictor of ruminative anxiety, pain experience and mindfulness significantly added 33.59% of the variance to ruminative anxiety: $F(3, 183) = 30.8499$, $p < 0.00001$. Pain experience was not a significant predictor of ruminative anxiety, $p = 0.6599$, however mindfulness was, $p < 0.0001$. There was a significant conditional effect of mindfulness on ruminative anxiety. From the point when pain experience is zero, with each increase of one in mindfulness ruminative anxiety significantly decreased by 0.2687. This equation is modeled graphically in Fig. 3, depicting the slope representing the anxiety-mindfulness relationship when controlling for pain experience.

4. Discussion

4.1. Main findings

This is the first study we are aware of to assess the relationship between ruminative anxiety and mindfulness in regards to the Fear-Avoidance Model of Chronic Pain. Ruminative anxiety,

as measured by the PSS-10, was significantly positively correlated with all components of the Fear-Avoidance Model of Chronic Pain, with moderate Cohen's correlation coefficients (0.30–0.49) for all variables except pain severity (small coefficient, 0.10–0.29) [28]. Mindfulness, as measured by the FFMQ-sf, was significantly negatively correlated with all components of the Fear-Avoidance Model of Chronic Pain except pain severity (not significant), with small Cohen's correlation coefficients (0.10–0.29) [28]. Mindfulness and ruminative anxiety were significantly negatively related, with a large Cohen's correlation coefficient (≥ 0.50) [28]. These findings support H1. The positive correlation between anxiety and pain is supported by the literature [2,22,30–32], as well as the negative correlations between anxiety and mindfulness [4–6,8] and mindfulness and pain components [22,33]. Additionally, results indicating that mindfulness was negatively related to specific components of the Fear-Avoidance Model of Chronic Pain were consistent with previous research [3,16,34].

The hierarchical multiple regression analysis indicated that mindfulness plays a significant role in predicting elements of the Fear-Avoidance Model of Chronic Pain, accounting for between 8.5% and 40.9% of variance in key constructs. Mindfulness predicted the highest amount of variance in ruminative anxiety (40.9%), suggesting the strength of the relationship between these factors. However, mindfulness was not a significant unique predictor of pain severity. The finding that mindfulness is highly related to anxiety but not related to pain severity is consistent with previous research, which has found that mindfulness influences the pain-related distress but not necessary the sensation of pain [22]. When all the elements of the Fear-Avoidance Model of Chronic Pain were added into the regression equation in the order that they occur, 70.0% of the variance in disuse/disability (BPI-sf pain interference) was explained. Mindfulness and ruminative anxiety were both unique predictors, accounting for 9.8% and 8.6% of the variance respectively. The results of the hierarchical multiple regression analyses partially support H2a (with the exception that mindfulness was not a unique predictor of pain severity), fully support H2b, and are consistent with previous work [3,16,34].

Level of ruminative anxiety was a significant predictor of all primary outcomes as well as sleep impairment, as shown by ANOVA analyses. Higher level of ruminative anxiety was significantly related to lower level of mindfulness and higher levels of pain catastrophizing, pain-related fear and avoidance, pain interference, and pain severity. This finding supports H3 and is consistent with previous work stating comorbid anxiety increases musculoskeletal pain symptoms [30]. Furthermore, this is the first study to report that comorbid pain and anxiety is related to significantly decreased levels of mindfulness.

H4 stated mindfulness moderates the relationship between ruminative anxiety and pain so that in individuals with low mindfulness, the association between ruminative anxiety and components of chronic pain will be stronger than in individuals with high mindfulness. As shown in Table 6, moderation analyses showed no significant interaction between mindfulness, ruminative anxiety and pain components and thus failed to support H4. Other research has found that mindfulness moderates the relationship between pain catastrophizing and pain experience [3] and that perceived stress and negative affect mediate the relationship between mindfulness and psychological well-being [34].

4.2. Limitations and future recommendations

The primary limitation of the present study is that the data were cross-sectional, preventing drawing causal effects. Clinical trials investigating mindfulness practices, such as mindfulness meditation, would be better able to determine the nature of the effects of mindfulness on elements of pain and anxiety. Future

studies should assess cause–effect relationships between mindfulness and elements of the Fear-Avoidance Model of Chronic Pain, to determine the cognitive pathways by which mindfulness exerts its beneficial effects on psychological and physical health.

Given that this research is self-report, it is susceptible to response bias or inaccurate reporting. An effort was made to limit inaccurate data by performing quality checks to assess for completeness and accuracy. However, future studies may want to recruit participants from a known pain clinic so that diagnoses can be confirmed. Additionally, researchers may want to meet with participants in person, to ensure that questionnaires are completed accurately and entirely. Furthermore, a large number of participants reported engaging in integrative health practices within the past month, including meditation and yoga. This bias in selection of participants may have influenced results of the study, so that participants were familiar with the concept of mindfulness and had higher levels of dispositional mindfulness than the general population. When the FFMQ-sf was developed, the pre-treatment mean in adults with anxiety and depression was 71.13 (all groups) [23]. In the current study, the FFMQ-sf mean was 78.20. To control for this bias, prior meditation experience was collected and used as a covariate in the analyses. Future studies may want to recruit participants with no prior meditation experience.

In this study, the location, duration, and type of pain (intermittent/constant) was reported. This design was consistent with recommendations from Cimmino and colleagues, in order to gain information about the complete profile of chronic pain [10]. The specific analysis conducted in this study addressed the relationships between anxiety, pain symptoms, and mindfulness. However, future analyses should consider the effects of comorbid chronic pain (CMP in more than one location) on elements of the Fear-Avoidance Model of Chronic Pain, as well as the effects on mindfulness level.

It should be noted that 30.3% of participants indicated they received a diagnosis of clinical depression. Although this information cannot be verified due to the nature of recruitment, it is consistent with previous work that found 26% of patients with CMP had comorbid depression [30]. Future analysis should assess the relationship of depression with ruminative anxiety, mindfulness, and elements of the Fear-Avoidance Model of Chronic pain, especially considering depression is included in Vlaeyen and Linton's model as a factor that predicts pain experience [1].

The conditional effect of mindfulness on level of ruminative anxiety should be interpreted with caution. This relationship only exists when pain severity is zero. In a chronic pain population, this conditional effect is not relevant. However, it may be important to patients who have found effective treatment for their pain but have not addressed their maladaptive cognitions (pain catastrophizing, pain-related fear, ruminative anxiety). Using a mindfulness intervention in this population may reduce maladaptive cognitions about pain, therefore decreasing the chance that these patients would continue to engage in avoidance behaviors after their pain was treated [1]. For this reason, it is important that health care professionals treat not only the physical symptoms of pain, but the associated cognitive rumination as well.

Non-reaction, non-judgment and awareness uniquely predicted variance in the elements of the Fear-Avoidance Model of Chronic Pain as well as variance in ruminative anxiety. Observing and describing facets of mindfulness, however, did not uniquely predict variance in any of the regression analyses. This result was consistent with previous research, which found the non-judgment and awareness facets to be most important in decreasing negative stress appraisal [34]. The result is consistent with the theorized mechanism of mindfulness proposed by Holzel and colleagues, which states: “the goal of mindfulness is to maintain non-judgmental awareness to internal and external experiences,

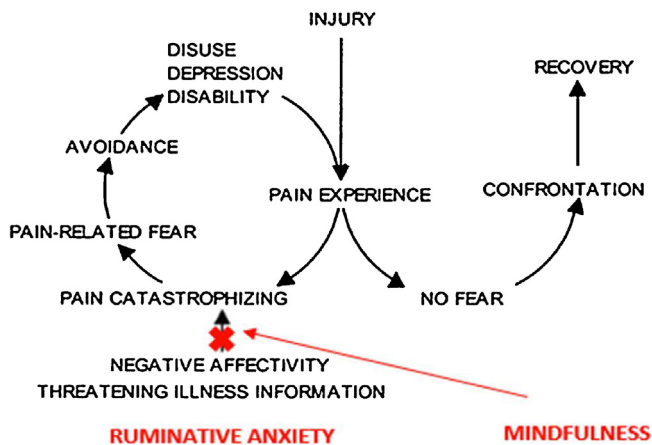


Fig. 4. Proposed changes to the Fear-Avoidance Model of Chronic Pain. *Note:* Mindfulness and ruminative anxiety, as measured by the FFMQ-sf and PSS-10, added significance variance (18.4%) to the regression equation of the Fear-Avoidance Model of Chronic Pain. Ruminative anxiety was positively correlated to the components of pain in the model, and therefore could be considered a psychological vulnerability factor associated with chronic pain. Mindfulness, however, was negatively correlated to ruminative anxiety and pain components, so it could be added as a factor that can disrupt the cycle of chronic pain.

accepting thoughts, sensations and feelings rather than reacting to them – this is the process of self-regulation” [35]. Perhaps observing and describing are not components necessary for the self-regulation of maladaptive cognitions and behaviors. Future research should continue to examine specific mindfulness facets to determine which are most influential in the self-regulation of anxiety and chronic pain.

4.3. Conclusions

The present study provides additional insight into the relationships between anxiety, mindfulness and chronic pain, including the direction and strength of these relationships in a sample of individuals with CMP. The results from this analysis also shed light on how the distinct factors of mindfulness relate to variance in chronic pain and anxiety. Furthermore, it is the first study that we know of to determine that comorbid CMP and high ruminative anxiety is associated with a significantly decreased level of mindfulness.

Vlaeyen and Linton theorized that predisposing psychological factors contribute to pain catastrophizing, serving as a catalyst for chronic pain [1]. However, they did not specify that ruminative anxiety is one of those predisposing psychological factors. Additionally, they did not identify mindfulness as a treatment strategy that could effectively break the chronic pain cycle. Given the significant R^2 change added by both mindfulness and ruminative anxiety, it is possible that these two variables should be added into the Fear-Avoidance Model of Chronic Pain, with ruminative anxiety as a psychological vulnerability and mindfulness as an effective treatment strategy that breaks the cycle of chronic pain [22,33]. This updated model (Fig. 4) should be explored further to determine the specific mechanism of mindfulness on chronic pain and anxiety, whether it be moderation or mediation, and which of the five facets of mindfulness are most important to clinical improvements.

Ethical issues

This study was approved by the IRB at American University in Washington, DC. Informed consent was provided to participants online via Qualtrics. As this was not an interventional study, it was not mandated that it be registered at ClinicalTrials.gov.

Conflicts of interest

There are no conflicts of interest to report.

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Appendix A. Covariates related to primary and secondary outcomes

Outcome	Related covariate	F statistic	Significance level
BPI-sf pain severity	(1) Gender	(1) 4.226	(1) 0.016
	(2) Parental status	(2) 3.966	(2) 0.048
	(3) Pain medicine use	(3) 7.035	(3) 0.009
	(4) Asian race	(4) 3.892	(4) 0.050
BPI-sf pain interference	N/A	N/A	N/A
PCS total	(1) Education	(1) 2.293	(1) 0.047
PASS 20 total	(1) Education	(1) 2.309	(1) 0.046
	(2) Meditation experience	(2) 5.817	(2) 0.004
PSS 10 total	(1) Meditation experience	(1) 4.152	(1) 0.019
FFMQ-sf total	(1) Pain vulnerability	(1) 5.497	(1) 0.005
	(2) Hispanic race	(2) 5.294	(2) 0.023
PSQI total	(1) Gender	(1) 5.383	(1) 0.005
	(2) Education	(2) 2.441	(2) 0.036
	(3) Pain medicine use	(3) 8.271	(3) 0.004
	(4) Pain vulnerability	(4) 4.218	(4) 0.017
	(5) Asian race	(5) 19.685	(5) 0.0001
	(6) White race	(6) 17.508	(6) 0.0001

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