Low Mindfulness Predicts Pain Catastrophizing in a Fear-Avoidance Model of Chronic Pain*

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Abstract

The relationship between persistent pain and self-directed, non-reactive awareness of present moment experience (i.e., mindfulness) was explored in one of the dominant psychological theories of chronic pain – the *fear-avoidance model* (Vlaeyen JW, Linton SJ. Fear avoidance and its consequences in musculoskeletal pain: A state of the art. Pain 2000; 85:317–332). A heterogeneous sample of 104 chronic pain outpatients at a multidisciplinary pain clinic in Australia completed psychometrically sound self-report measures of major variables in this model: Pain intensity, negative affect, pain catastrophizing, pain-related fear, pain hypervigilance, and functional disability. Two measures of mindfulness were also used, the Mindful Attention Awareness Scale [Brown KW, Ryan RM. The benefits of being present: Mindfulness and its role in psychological wellbeing. J Pers Soc Psychol 2003; 84:822–48] and the Five Factor Mindfulness Questionnaire [Baer RA, Smith GT, Hopkins J, Krietemeyer J, Toney L. Using self-report assessment methods to explore facets of mindfulness. Assessment 2006; 13:27–45]. Results showed that mindfulness significantly negatively predicts each of these variables, accounting for 17–41% of their variance. Hierarchical multiple regression analysis showed that mindfulness uniquely predicts pain catastrophizing when other variables are controlled, and moderates the relationship between pain intensity and pain catastrophizing. This is the first clear evidence substantiating the strong link between mindfulness and pain catastrophizing, and suggests mindfulness might be added to the fear-avoidance model. Implications for the clinical use of mindfulness in screening and intervention are discussed.

1. Introduction

Psychological models of chronic pain, such as the well-supported fear-avoidance model, show that the way people interpret and respond to their pain sensations is a strong determinant of their future pain experience [52, 20]. Cognitions shape not only psychological outcomes such as emotional functioning, but the nervous system activity underlying pain perception [50, 39]. It is therefore unsurprising that maladaptive pain cognitions, such as pain catastrophizing, are associated with emotional and behavioural responses (e.g., fear and avoidance) that predict depression, functional disability and future pain [26].

Figure 1. The fear-avoidance model of chronic pain. Adapted from "Fear avoidance and its consequences in musculoskeletal pain: A state of the art," by J. W. Vlaeyen and S. J. Linton, 2000, *Pain, 85,* p. 329. Used with permission from IASP.

Catastrophizing is a central variable in the fear-avoidance (FA) model (see Figure 1), not only because it is understood as the cognitive route through which fear of pain develops [51], but because this negative evaluation of pain accounts for 7–31% of the variance in pain severity [44]. This suggests that addressing the cognitive distortions that occur through pain catastrophizing may be beneficial in interrupting the fear-avoidance cycle. Cognitive-

behavioural therapy (CBT) for chronic pain has emerged as one approach to challenging these unhelpful cognitions [55]. Another promising approach is the use of so-called 'third wave' psychological models. These are distinct from 'second wave' cognitive behavioural approaches in that they address metacognitive variables such as *mindfulness*, and focus on acceptance of inner experiences, such as thoughts, rather than changing them.

Mindfulness has been defined as "awareness that emerges by way of paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience moment by moment" [23]. Importantly, mindful awareness is flexible, self-regulated and does not involve conceptual processing [3, 54]. Therefore, it is theoretically at odds with the type of attention involved in catastrophizing, which involves interpretation, conceptual processing, judgement and is most often automatically invoked rather than intentional [43].

Mindfulness-based interventions have already been found to produce reductions in pain and emotional distress in uncontrolled studies [21], and recent research suggests mindfulness meditation is effective in enhancing coping ability, emotional functioning and quality of life in heterogeneous chronic pain populations [46, 16], and for patients with fibromyalgia [18], chronic headache [34], and chronic low back pain [33]. One recent study of 105 heterogeneous chronic pain patients found mindfulness significantly predicted lower depression, anxiety, and physical and psychosocial disability, even when other variables were controlled [29].

The present study aimed to build on this emerging research to explore the role of mindfulness in the FA-model of chronic pain. It was predicted that mindfulness would negatively correlate with each of the variables in the fear-avoidance cycle and most strongly with pain catastrophizing. One variable from each link in the FA-cycle was measured – pain intensity, catastrophizing, fear of pain, pain hypervigilance, and functional disability. Since high mindfulness should theoretically counteract the tendency to catastrophize, it was also expected that the relationship between pain intensity and catastrophizing would depend to some extent on one's level of mindfulness. Therefore it was predicted that once other variables were controlled, mindfulness would account for further variance in catastrophizing and would moderate the relationship between pain intensity and pain catastrophizing.

2. Methods

2.1. Participants and procedure

This was a cross-sectional study conducted at the Sir Charles Gairdner Hospital Department of Pain Management, a multidisciplinary chronic pain clinic in Perth, Western Australia. The study was approved by the Human Research Ethics Committees of the hospital and Curtin University of Technology. Participants were chronic pain outpatients recruited while they waited for appointments to see a pain specialist. After reading an information sheet and agreeing to take part anonymously participants completed a battery of self-report measures described below. Where a large number of missing values existed or participants chose to withdraw from the study before finishing the measures, these responses were deemed invalid. A total of 22 invalid and 104 valid responses were collected.

The majority of participants were women (68.3%) and ages ranged from 26 to 94 (M = 54.5, SD = 16.1). The only exclusion criterion was age, with children 17 years or younger not being accepted for ethical reasons. The only inclusion criterion was the presence of chronic pain. This was defined as pain that continues beyond the usual course of healing, taken to mean continuous or intermittent pain for at least three months [32], a time frame also adopted in Elliot and colleagues' [13] epidemiological study of chronic pain. All participants met this criterion, with the duration of pain ranging from 3 to 648 months. The median duration of pain was 89.5 months (M = 125.7, SD = 121.2).

The main site of participants' pain was recorded using the IASP's Axis 1 (regions) coding scheme for chronic pain diagnoses [32]. This was slightly adapted to include *upper back* as a region and to combine *pelvis* and *genitals* into one region. These regions and the frequency of pain in these sites within the sample are shown in Table 1. These sites were grouped into two categories of pain: musculoskeletal and non-musculoskeletal. Musculoskeletal pain predominated in this sample, with the lower back being the most common site of chronic pain.

Table 1

Pain Type and Location of Main Site of Pain in Chronic Pain Patients (N = 104)

	Frequency	Percent
Pain type		
Musculoskeletal	83	79.8
Non-musculoskeletal	21	20.2
Total	104	100.0
Pain location		
1. Head / face	10	9.6
2. Neck	16	15.4
3. Shoulder / arm	2	1.9
4. Chest	1	1.0
5. Upper back	6	5.8
6. Abdomen	5	4.8
7. Lower back	50	48.1
8. Leg	9	8.7
9. Pelvis / genitals	1	1.0
10. Equal multiple sites	4	3.8
Total	104	100.0

Note. Musculoskeletal pain was comprised of pain locations 2, 3, 5, 7, and 8; non-musculoskeletal pain was comprised of pain locations 1, 4, 6, 9, and 10.

2.2. Materials

Aside from preliminary questions assessing age, gender, duration and site of pain, all of the measures used were previously validated self-report instruments. One variable was measured for each step of the fear-avoidance cycle shown in Figure 1, while mindfulness was measured with two instruments. The Five Factor Mindfulness Questionnaire (FFMQ) was used wherever possible in analysis because it allows for examination of the various facets of

mindfulness, which is useful in determining the relative importance of each in the fear-avoidance model. However, since the FFMQ does not yield a total mindfulness score, the Mindful Attention Awareness Scale was used for correlation and moderation analyses, which require a single score.

The Mindful Attention Awareness Scale (MAAS) [4] is a 15-item instrument that measures present-moment awareness of actions, interpersonal communication, thoughts, emotions, and physical states. Total scores range from 1 to 6, with higher scores showing higher levels of mindfulness. The MAAS has been found to have good convergent and discriminant validity, excellent test-retest reliability ($r = .81$, $p < .0001$), and good internal consistency reliability, with a coefficient alpha of .87 [4]. The same internal reliability has been found in clinical samples of cancer patients [5] and chronic pain patients [29]. The MAAS was used as a measure of overall mindfulness in the present study.

The Five-Factor Mindfulness Questionnaire (FFMQ) [1] is a 39-item instrument derived from a factor analysis of five psychometrically sound mindfulness measures. Five distinct mindfulness facets were derived from the factor analysis to yield the following subscales: observing inner experience, describing experience, acting with awareness, non-judging of experience, and non-reactivity to inner experience. Only subscale scores are calculated, with higher scores reflecting higher levels of mindfulness. The FFMQ has been found to have adequate to good reliability, with alpha coefficients ranging from .75 to .91 for the subscales.

The Brief Pain Inventory (BPI) [6] is a 32-item questionnaire assessing background characteristics, pain severity, medication usage and functional disability. Only two subscales relating to variables of interest in the fear-avoidance model (i.e., pain intensity and functional disability) were used in the present study. These were the 4-item pain intensity subscale and 7-item interference subscale. Total scores on each subscale range from 0 to 10, with higher scores reflecting higher pain or disability. In chronic pain patients the BPI has been found to have good convergent validity and internal reliability, with coefficient alphas of .85 for the pain intensity subscale and .88 for the interference subscale [45].

The Positive and Negative Affect Schedule (PANAS) [53] measures positive affect (PA) and negative affect (NA) as discrete, orthogonal dimensions of mood. A psychometrically sound 10-item short form was used in the present study (I-PANAS-SF) [47]. Total scores for NA and PA range from 5 to 25, with higher scores indicating higher

positive or negative affect. The complete I-PANAS-SF was administered but only the negative affect subscale, which has a coefficient alpha of .76 [47], was used in analysis.

The Pain Catastrophizing Scale (PCS) [42] is a 13-item self-report measure of the degree to which people experiencing pain catastrophize, adopting a negative or aversive orientation towards their pain. Total PCS scores range from 0 to 52, with higher scores indicating higher pain catastrophizing. The PCS has a stable three-factor structure, comprised of rumination, magnification and helplessness [42, 49, 11]. Validated in a sample of chronic pain outpatients, these subscales have been shown to have good reliability, with Cronbach alpha coefficients of .85, .75 and .86 respectively [35]. The total PCS score also has good criterion-related validity and excellent internal consistency, with a reliability coefficient of .92 [35].

Pain-related fear was measured with the Tampa Scale for Kinesiophobia (TSK) [25], a 17-item scale assessing fear of movement and (re)injury. Although initially developed for use with chronic lower back pain patients [51] and later validated in other musculoskeletal pain populations [38], recent studies suggest it is a valid measure of pain-related fear in heterogeneous chronic pain samples [8]. Total scores can range from 17 to 68 and higher scores indicate greater pain-related fear. The TSK has been shown to have good construct validity and adequate to good internal reliability, with coefficient alphas ranging from .76 to .84 [51, 9, 36, 15].

Pain hypervigilance was measured with the 16-item Pain Vigilance and Awareness Questionnaire (PVAQ) [28], a broad measure of attention to pain. Total PVAQ scores can range from 0 to 80, with higher scores reflecting greater hypervigilance. The PVAQ has been validated with clinical and non-clinical samples, showing high reliability (internal consistency and test-retest), and good construct and criterion validity [28]. More recent validation with chronic pain samples shows it has excellent reliability, with coefficient alphas between .87 and .92 [31, 37].

3. Results

3.1. Data Screening

Data were entered into the Statistical Package for the Social Sciences (version 15.0 for Windows) and screened for accuracy of the data file. *Expectation maximisation* (EM) was used to generate imputed values for 26 missing values, as recommended by Tabachnick and Fidell (2001). All variables were screened for outliers and normality, resulting in transformations of pain duration and negative affect. All variables therefore met assumption testing for the analyses described below.

3.2. Preliminary Analyses

Means, standard deviations and reliability coefficients for all the primary outcome variables are presented in Table 2. Comparisons with other studies employing the same measures in a chronic pain population (where possible) are also included. As Table 2 shows, all measures had acceptable to excellent internal consistency reliability, demonstrating similar Cronbach's coefficient alphas to those of previous studies. Two-tailed unpaired *t* tests revealed that the present sample scored significantly higher than comparison samples on pain intensity, $t\ (357) = 4.25$, $p < .01$; negative affect, $t\ (513) = 2.52$, $p < .01$; pain catastrophizing, $t\ (953) = 4.10$, $p < .01$; pain hypervigilance, $t\ (493) = 7.43$, $p < .01$; and functional disability, $t\ (357) = 3.69$, $p < .01$. There was no significant difference between the samples on mindfulness, $t\ (207) = 1.80$, $p > .05$, or pain-related fear, $t\ (302) = 1.75$, $p > .05$. In order to get an indication of how mindful the present sample was in comparison to a non-clinical population, scores on the MAAS were compared with those of the non-meditating general sample used to validate the MAAS [4]. This showed the present sample was not significantly less mindful ($M = 3.81$, $SD = .92$) than the community sample ($M = 3.97$, $SD = .64$), $t\ (176) = 1.29$, $p > .05$.

Table 2

Means, Standard Deviations and Cronbach's Coefficient Alphas of Measures Used in the Present Study (N = 104) and Comparison Studies

	Present study			Comparison studies		
Variable	*M*	SD	*α*	*M*	SD	α
Mindfulness (MAAS)	3.81	.92	.87	4.04[a]	.93	.87
Observe experience (FFMQ)	26.29	5.90	.74	-	-	.83 [b]
Describe experience (FFMQ)	25.22	6.84	.85	-	-	.91 [b]
Act with awareness (FFMQ)	26.83	6.42	.86	-	-	.87 [b]
Non-judging of experience (FFMQ)	26.20	7.06	.82	-	-	.87 [b]
Non-reacting to experience (FFMQ)	20.54	5.21	.79	-	-	.75 [b]
Negative affect (I-PANAS-SF)	12.10	4.08	.75	11.27[c]	2.66	.76
Pain intensity (BPI-pain)	5.89	1.85	.84	4.70[d]	2.60	.94
Functional disability (BPI-interfere)	6.04	2.26	.90	4.90[d]	2.80	.94
Pain catastrophizing (PCS)	26.23	12.77	.94	20.90[e]	12.50	.87
Pain-related fear (TSK)	40.22	8.83	.83	42.10[f]	8.90	.84
Pain hypervigilance (PVAQ)	50.23	13.82	.89	40.00[g]	12.10	.87

Note. Comparison studies were [a] [29] (*n* = 105, chronic pain sample); [b] [1] (*n* = 613, undergraduate student sample); [c] [47] (*n* = 411, general sample); [d] [57] (*n* = 255, chronic pain sample); [e] [41] (*n* = 851, chronic pain sample); [f] [15] (*n* = 200, chronic pain sample); and [g] [37] (*n* = 391, chronic pain sample). Comparison means and standard deviations are not available for the recently developed FFMQ.

3.3. Correlation analyses

The interrelationships between mindfulness and major variables in the fear-avoidance model were explored with a series of two-tailed Pearson product-moment correlations. As noted earlier, the MAAS was used to represent mindfulness in these correlations, since it yields a total score, unlike the FFMQ. Table 3 reports the intercorrelations among variables, showing that total mindfulness formed significant negative correlations of medium strength

with each of the outcome variables, according to Cohen's [7] criteria for interpreting the strength of correlations. Therefore mindfulness significantly correlated with variables in each of the major categories of the fear-avoidance model of chronic pain.

Table 3

Intercorrelations Among Mindfulness and Major Variables in the Fear-Avoidance Model of Chronic Pain (N = 104)

Variable	1.	2.	3.	4.	5.	6.
1. Mindfulness (MAAS)	–					
2. Negative affect	-.50	–				
(I-PANAS-SF)	*p*=.000					
3. Pain intensity	-.22	.26	–			
(BPI-pain)	*p*=.026	*p*=.007				
4. Functional disability	-.30	.36	.63	–		
(BPI-interfere)	*p*=.002	*p*=.000	*p*=.000			
5. Pain catastrophizing	-.49	.53	.28	.46	–	
(PCS)	*p*=.000	*p*=.000	*p*=.003	*p*=.000		
6. Pain-related fear (TSK)	-.46	.48	.32	.44	.69	–
	p=.000	*p*=.000	*p*=.001	*p*=.000	*p*=.000	
7. Pain hypervigilance	-.30	.35	.23	.37	.66	.63
(PVAQ)	*p*=.002	*p*=.000	*p*=.017	*p*=.000	*p*=.000	*p*=.000

Note. Significance levels relate to two-tailed Pearson product-moment correlations.

3.4. Regression analyses

A series of simultaneous multiple regression analyses were conducted to determine how well the combined facets of mindfulness predict core variables in the fear-avoidance model. The goal here was to ascertain, using the coefficient of determination (R^2), what proportion of variance in each variable could be explained by variance in the FFMQ's combination of mindfulness facets. Since the FFMQ is a more comprehensive measure of

mindfulness than the MAAS, it was preferable to measure variance with R^2 using simultaneous regression, which allowed for the FFMQ to be used, rather than using r^2 from the MAAS correlations reported in Table 3. Five separate regression equations were generated – one for each outcome variable – with the five mindfulness facets used as predictor variables and entered as a block. These regressions are summarized in Table 4. They reveal that mindfulness most strongly predicts pain catastrophizing, accounting for 41% of its variance, with *non-judging* and *non-reacting to experience* uniquely explaining 7% each. Overall, these two facets of mindfulness explained the most variance in outcome variables in the fear-avoidance model.

Table 4

Proportion of Variance (R^2) in Core Outcome Variables of the Fear-Avoidance Model of Chronic Pain Accounted for by Variance in Combined Mindfulness Facets Using Simultaneous Multiple Regression Analysis (N = 104)

		Contributions of individual predictors							
		B				sr^2			
Dependent variable	R^2	a	b	c	d	a	b	c	d
Disability (BPI-interfere)	.17			-.28*				.05	
Catastrophizing (PCS)	.41	.21*		-.35*	-.32*x	.03		.07	.07
Pain-Related Fear (TSK)	.26		-.28*x		-.31**		.04		.07
Hypervigilance (PVAQ)	.22		-.32**		-.22*x		.06		.03

Note. Pain intensity is not reported since the equation did not reach significance. Each model presented here is significant at $p < .01$. The squared semipartial correlation coefficient (sr^2) is a measure of the amount of variance in the DV attributable to each IV when other variables are controlled. Each sr^2 coefficient is significant at the same level as the corresponding β. Predictor variables were: [a] observe experience (FFMQ), [b] act with awareness (FFMQ), [c] non-judging of

experience (FFMQ), and [d] non-reacting to experience (FFMQ). While all five FFMQ facets were entered into the regressions, the describe experience facet (FFMQ) is not reported because it did not significantly contribute to any of the equations.
* $p < .05$. ** $p < .01$.

In order to test whether mindfulness retained the ability to predict key outcome measures in the fear-avoidance model after variance due to background characteristics and other variables in the model were statistically controlled, a series of hierarchical multiple regression analyses were also conducted. The three variables most strongly linked to mindfulness in simultaneous regressions were used as dependent variables: pain catastrophizing, pain-related fear and pain hypervigilance. Since the FA-model implies a unidirectional path between variables (see Figure 1), the order in which they appear in the model was used to order the hierarchical regression equations. That is, after background characteristics, variables were entered into each equation in the order they appear in the FA-model, beginning with pain intensity. Mindfulness was entered last to assess its unique contribution. The five mindfulness facets in the FFMQ were entered as a block in step 7, as were background characteristics (age, gender, duration of pain) in step 1. Only the FFMQ was used for mindfulness in this analysis because it is a more comprehensive measure and because using both the MAAS and FFMQ would involve overlap, since many of the MAAS items form part of the FFMQ.

After controlling for other variables, mindfulness only significantly improved R^2 when pain catastrophizing was the dependent variable, as shown in Table 5. The final solution accounted for 69% of its variance, with mindfulness adding 5% of this. The squared semipartial correlations (sr^2) show that non-judging of experience was the only mindfulness facet to uniquely predict pain catastrophizing, accounting for 3% of its variance.

Table 5

Hierarchical Multiple Regression Analysis Showing the Unique Contribution of Mindfulness to Explaining Pain Catastrophizing After Background Characteristics and Other Variables in the Fear-Avoidance Model of Chronic Pain are Controlled (N = 104)

Predictor variables	β (final)	sr^2	ΔR^2	R^2
1. Age	-.10	.01	.13**	
Gender	-.03	.00		
Pain duration	-.10	.01		
2. Pain intensity (BPI-pain)	.09	.00	.15***	
3. Negative affect (I-PANAS-SF)	.10	.01	.14***	
4. Pain-related fear (TSK)	.25**	.02**	.14***	
5. Pain hypervigilance (PVAQ)	.34***	.06***	.08***	
6. Functional disability (BPI-interfere)	.01	.00	.01	
7. Observe experience (FFMQ)	.06	.00	.05*	
Describe experience (FFMQ)	-.04	.00		
Act with awareness (FFMQ)	.04	.00		
Non-judging of experience (FFMQ)	-.25**	.03**		
Non-reacting to experience (FFMQ)	-.14	.01		.69***

Note. Variables relating to background characteristics were entered as a block in step 1, as were all mindfulness variables in step 7.

* $p < .05$. ** $p < .01$. *** $p < .001$.

3.5. Moderation analysis

In order to test whether mindfulness moderates the relationship between pain intensity and pain catastrophizing, a moderated multiple regression analysis was performed in the manner recommended by Frazier, Tix and Baron [14]. Pain intensity and mindfulness were standardized in order to reduce problems associated with multicollinearity and a standardized product variable was created to represent the interaction between pain intensity and

mindfulness. As shown in Table 6, the moderated regression showed that the interaction between pain intensity and mindfulness significantly added 3% incremental variance to pain catastrophizing (B = -1.99, $p < .05$). This suggests that mindfulness does indeed moderate between pain intensity and catastrophizing. This can be seen graphically in Figure 2[1], where the slope representing the pain intensity/catastrophizing relationship is steeper when mindfulness is low than when mindfulness is high. That is, when mindfulness is low, pain intensity has a stronger impact on catastrophizing.

Table 6

Moderated Multiple Regression Analysis Showing the Contribution of an Interaction Between Pain Intensity and Mindfulness to Predicting Pain Catastrophizing (N = 104)

Predictor variables	β (final)	ΔR^2	R^2
1. Pain Intensity (BPI-pain)	.34***	.34***	
Mindfulness (MAAS)	-.41***		
2. Pain/Mindfulness interaction	-.18*	.03*	.38***

Note. Predictor variables were standardized.

* $p < .05$. ** $p < .01$. *** $p < .001$.

[1] In Figure 2, mindfulness and pain intensity were transformed into a categorical variables, with the 'low' and 'high' categories created by subtracting and adding one standard deviation to their standardized means respectively.

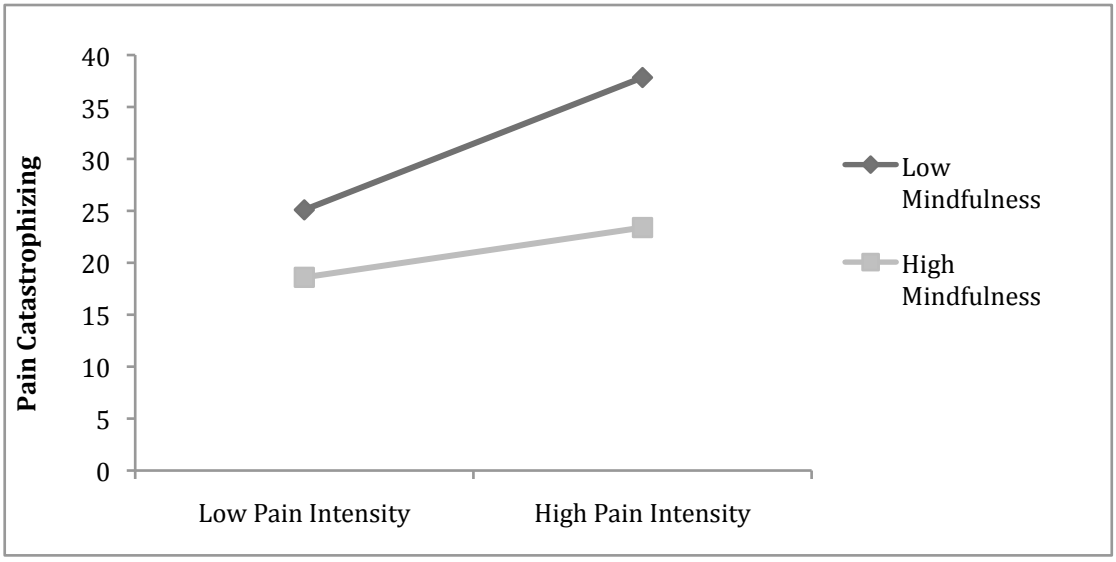

Figure 2. Plot of the moderating effect of mindfulness on the relationship between pain intensity and pain catastrophizing.

3.6. Group differences based on pain type

Since the Tampa Scale for Kinesiophobia (TSK) has been used predominantly with musculoskeletal pain patients rather than a general pain population [38], each of the foregoing analyses was repeated using only data from the 83 musculoskeletal pain patients to check the validity of these results. There were no significant differences in the findings. An independent groups *t* test also found no significant difference between musculoskeletal and non-musculoskeletal pain patients on the TSK, $t\ (102) = .01$, $p > .05$). Furthermore, a reliability analysis of the TSK using scores from only the non-musculoskeletal pain patients ($n = 21$) showed the scale retains good internal consistency reliability ($\alpha = .83$). This suggests the two groups come from the same population and that the TSK can be used in a heterogeneous chronic pain, as suggested by Cook and colleagues [8].

4. Discussion

This study sought to explore the association between mindfulness and major variables in the fear-avoidance model of chronic pain to determine if this recently operationalized construct might play a significant role in the model. Previous research suggested mindfulness would negatively correlate with variables in this model and would uniquely predict pain catastrophizing due to its metacognitive focus on attentional processes. Overall, results showed mindfulness plays a significant, non-redundant role in the fear-avoidance model, accounting for 17–41% of variance in key pain constructs. This is consistent with studies showing mindfulness uniquely predicts major outcome variables in another cognitive-behavioural model of chronic pain [29, 30] and the positive outcomes of using mindfulness therapies to treat chronic pain [21, 24, 46, 16].

As expected, mindfulness formed the strongest negative association with pain catastrophizing in this study, accounting for 41% of its variance. Low mindfulness also uniquely predicted catastrophizing, explaining a further 5% of variance when other variables were controlled. The present findings also support predictions that mindfulness moderates the relationship between pain intensity and pain catastrophizing, suggesting that whether a person engages in negative ruminations about their pain depends to some extent on their ability to stay focused on their present moment experience with a non-judgmental attitude. Although the moderation effect was not large, it suggests that the relationship between pain intensity and catastrophizing is weaker when mindfulness is high. These findings are consistent with results of a recent study showing catastrophizing was among the variables on which chronic pain patients improved after a 10-week Mindfulness-Based Chronic Pain Management course [17]. The present study sheds further light on the strength of this relationship and the key components of mindfulness that appear to counteract catastrophizing – non-reactivity and non-judgmental awareness.

Given the non-redundant role mindfulness was found to have in the version of the fear-avoidance model tested here, it is possible that mindfulness could be added to the model. This updated model should be interpreted as a suggestion for further exploration, since it is based on the results of just one cross-sectional study involving an inexhaustive list of fear-avoidance variables, with a somewhat modest moderation effect. With this caveat in mind, it

is suggested that mindfulness may exert an influence in the model somewhere between pain intensity and pain catastrophizing, as shown in Figure 3.

Figure 3. A revised version of the fear-avoidance model of chronic pain showing the proposed role of mindfulness, which moderates between pain experience and pain catastrophizing. Adapted from "Fear avoidance and its consequences in musculoskeletal pain: A state of the art," by J. W. Vlaeyen and S. J. Linton, 2000, *Pain, 85,* p. 329.

An implication of this revised model is that, just as catastrophic thoughts about pain have been seen as the precursors to pain-related fear [52], low mindfulness might turn out to be a precursor to pain catastrophizing, although it is impossible to make causal connections from correlational research . Integrating this with existing literature on mindfulness, it would seem that the tendency to engage in automatic processing rather than self-regulating one's awareness [3], along with having inflexible attention [54] and lacking awareness of the present moment [22], makes people in pain more susceptible to dwelling on, or ruminating about, their pain, thereby magnifying its threat status. In short, low mindfulness seems to be a fertile ground for the cultivation of negative, distorted thinking about pain.

Conversely, people who are able to direct their attention at will and who have a tendency to focus on what is happening in each moment should, to some extent, be inoculated against the onset of catastrophic thinking about their pain. Indeed, the present study's finding that the relationship between pain and catastrophic thinking depends to some extent on a person's level of mindfulness supports these suggestions. Therefore, there is good reason to expect mindfulness to exert an influence early in the fear-avoidance model, at the stage of interpretation and appraisal of pain signals.

This suggestion is supported by previous research characterising mindfulness as a (meta)cognitive variable relating largely to the regulation of attention [4]. More specifically, through the suspension of conceptual processing [54] mindfulness entails awareness that is non-elaborative [3]. Adrian Wells describes this as awareness involving "low levels of analytical and meaning based appraisals, i.e. inner dialogue" (p.340) [54]. By contrast, pain catastrophizing has been characterised as a type of cognitive distortion [41], drawing on Beck's [2] analysis of catastrophizing in depression. Furthermore, an appraisal model of pain catastrophizing suggests that this cognitive process involves a conceptual evaluation of pain signals, centring on their threat value [44]. Based on these definitions, it is clear that the non-conceptual, appraisal-free state involved in mindfulness precludes the cognitive process of appraisal and threat evaluation involved in pain catastrophizing. Therefore, given that these two constructs are diametrically opposed theoretically, it is no surprise that the present study's empirical findings suggest that people who are mindful tend not to catastrophize about their pain.

This may help to explain why mindfulness-based interventions have shown promise in treating chronic pain [21, 24, 34, 18, 33, 46]. From a fear-avoidance perspective, by inoculating a person against negative, ruminative thinking about their pain, they are less likely to develop fear of pain, and to then avoid activities they expect to be painful. Less avoidance behaviour in turn lowers the risk of depression and functional disability setting in. That is, preventing pain catastrophizing interrupts the fear-avoidance cycle.

The strong association between mindfulness and cognitive aspects of chronic pain also suggests that mindfulness-based interventions for pain could fruitfully pay more attention to cognition. A pain-focused mindfulness intervention might therefore involve more exercises directed at mental events. A greater cognitive focus would encourage pain patients to become "cognitively de-centred" [54] by developing a "metacognitive awareness" of

thoughts merely as transient events in the mind rather than accurate reflections of reality [56]. This is also a key feature of Acceptance and Commitment Therapy (ACT) [19], another so-called 'third wave' psychological intervention incorporating mindfulness and which has also been applied to chronic pain [12]. Such an approach does not aim to challenge or replace maladaptive beliefs like in traditional cognitive therapy but merely to alter a person's relationship to those thoughts by encouraging acceptance.

The present findings also suggest mindfulness may play an important role in screening and early intervention for chronic pain. Since mindfulness was postulated to figure early in the fear-avoidance model (see Figure 2), it seems likely that low mindfulness could be viewed as a vulnerability factor and screened for in much the same way that neuroticism functions as a yellow flag in early pain management [27]. Therefore, a short measure of mindfulness such as the MAAS might be used as a screening tool during acute pain episodes, for example with surgery and trauma patients, around 20% of whom will develop a chronic pain condition [10]. Of course this study does not answer the question of whether the experience of pain itself somehow interacts with other variables to result in low mindfulness. However, this does not alter the implication that mindfulness-based therapies are likely to be especially effective as an early intervention for those identified at risk. This is significant given that the prevention of chronic pain is far more economical and efficacious than treating entrenched chronicity [48]. With this in mind, the increasing popularity of mindfulness practices like yoga and meditation [40] may have positive effects on the epidemiology of chronic pain.

As noted earlier, the present findings and their implications should not be overstated given the cross-sectional nature of this research, and the fact the correlational research using self-report measures is susceptible to response bias such as negative affectivity. However, an attempt was made to control for this in the key hierarchical regressions, which showed the unique role of mindfulness in predicting catastrophizing. Another limitation concerns the inexhaustive list of variables measured. If every named variable in the FA-model was controlled, rather than only one variable from each link in the model, it is possible that more variance would be accounted for and therefore mindfulness may figure less strongly. With this in mind, controlling for depression and avoidance behaviour in future larger studies is recommended. However, more valuable than further correlational studies would be large-scale controlled trials of mindfulness interventions for chronic pain, given the number of

promising small trials and uncontrolled studies mentioned above. Longitudinal studies are also warranted to determine whether low mindfulness predicts the transition from acute to chronic pain when other factors are controlled.

While there is therefore scope for further exploration into the relationship between mindfulness and pain, this study provides important insights into how this metacognitive variable integrates into the well-documented fear-avoidance model. It shows how low mindfulness, particularly a tendency towards awareness that is judgemental and reactive, is a fertile ground in which distorted thinking about one's pain (i.e., catastrophizing) can take root. This significant finding supports the use of mindfulness-based pain treatments since developing the ability to focus one's attention on present-moment experience in a non-judgmental way appears to somewhat inoculate patients against a style of thinking associated poor pain outcomes. Perhaps more pertinently, this research suggests mindfulness may have particular application in the prevention or early treatment of chronic pain, an implication which could have striking public health benefits given the enormous personal, social and economic costs of chronic pain.

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