Pain Catastrophizing Mediates the Effect of Psychological Inflexibility on Pain Intensity and Upper Extremity Physical Function in Patients with Upper Extremity Illness

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Abstract

Background: Psychological inflexibility—the inability to take value-based actions in the presence of unwanted thoughts, feelings, or bodily symptoms—is associated with negative health outcomes including depression and anxiety. Objective: We aimed to determine the association between the general construct of psychological inflexibility and pain intensity, and upper extremity physical function in patients with musculoskeletal illness in an orthopedics practice. We also set out to test multiple-mediator models proposing that psychological inflexibility affects pain intensity and upper extremity physical function directly, as well as indirectly through depression, anxiety, and pain catastrophizing. Methods: One hundred and eight patients with upper extremity illness completed self-report measures of pain intensity, upper extremity physical function, psychological inflexibility, pain catastrophizing, depression, and anxiety in this cross-sectional study. Results: We found that psychological inflexibility affected pain intensity and upper extremity physical function directly and indirectly. Pain catastrophizing but not depression or anxiety mediated the association of psychological inflexibility to pain intensity and upper extremity physical function. Conclusions: Psychological inflexibility plays an important role in understanding the increased pain and decreased upper extremity physical function in patients with musculoskeletal pain. It also suggests that the cognitive error of pain catastrophizing is one of the mechanisms through which the general construct of psychological inflexibility may influence pain intensity and upper extremity physical function. Psychological treatments aimed at decreasing pain and increasing upper extremity physical function should target both pain catastrophizing and psychological inflexibility.

Key Words: pain, physical function, psychological inflexibility, pain catastrophizing, depression, anxiety

INTRODUCTION

Acceptance and commitment therapy (ACT) emphasizes the benefits of acceptance and willingness rather
than a desire to change or control the content of inner states in experiencing bodily sensations, emotions, and thoughts. For patients experiencing pain, ACT encourages engagement in value-driven behaviors even if those activities possibly elicit pain or provoke fear of pain. The central construct targeted within ACT is psychological inflexibility, defined as responding in a reflexive, habitual, or impulsive manner to internal private events (eg, thoughts, emotions, and sensations) or external situations, and often relying on avoidant coping strategies. For patients experiencing pain, this means inability to move beyond thoughts, feelings, and sensations about pain and, as a consequence, avoiding value-related behaviors that may be cognitively fused with pain or fear of pain. In other words, psychological inflexibility allows difficult internal experiences (eg, pain) to limit the extent to which goals and values-related contingencies guide behaviors.

Psychological inflexibility entails 6 overlapping processes: (1) cognitive fusion—when an individual becomes “entangled” with their own thoughts and feelings making them the absolute reality when in fact they are the product of the mind; (2) experiential avoidance—unwillingness to endure any unpleasant thoughts, emotions, and physical sensations, which are pushed away to achieve short-term relief; (3) preoccupation with past or future—overfocusing on thoughts about the past or future without regard for the present moment; (4) inability to take a perspective separate from thoughts and feelings—belief that thoughts and feelings are the same as the person, rather than separate; (5) failures in clarity or pursuit of values—lack of knowledge of own values; and (6) rigid persistence or impulsive avoidance— inability to act on the things that are important. For a person with pain, psychological inflexibility means that automatic negative thoughts triggered by pain become a person’s reality due to inability to develop purposeful contact with their own thoughts and feelings, assess the situation objectively, and focus on one’s goals and values.

An emerging body of research supports the relationship of the general psychological inflexibility construct to negative health outcomes in various populations. Among pain populations, the general psychological inflexibility is associated with disability, anxiety, and quality of life in adolescents with juvenile idiopathic arthritis and plays a central role in the improvement in disability and life satisfaction following ACT for patients with chronic pain after whiplash. Cognitive fusion, a component of psychological inflexibility, is significantly associated with pain catastrophizing. Further, psychological flexibility, the opposite construct, is associated with decreased disability in patients with low-to-moderate pain. However, to our knowledge, the general construct of psychological inflexibility has not been studied in patients with musculoskeletal pain presenting to an orthopedic surgeon.

The main goal of the study is to determine the association of psychological inflexibility to pain intensity and upper extremity physical function in patients who present to an outpatient orthopedic surgical practice with musculoskeletal pain complaints. A second goal of this study is to test potential mechanisms of development of pain and upper extremity physical function in this population. Prior research in this population has shown the pivotal roles of pain catastrophizing, anxiety, and depression in patients with musculoskeletal pain in orthopedic surgical practices have not been studied. We propose that psychological inflexibility will impact pain intensity and upper extremity physical function both directly, as well as indirectly through increased pain catastrophizing, depression, and anxiety. Specifically, we hypothesize that high psychological inflexibility will be independently associated with increased pain catastrophizing, anxiety, depression, and pain intensity, as well as decreased physical function. Pain catastrophizing, anxiety, and depression will mediate the association between psychological inflexibility and upper extremity physical function and pain intensity, while controlling for relevant demographic and clinical covariates.

**METHODS**

**Participants**

One hundred and eight patients with upper extremity illness presenting to the Hand and Upper Extremity Service of Massachusetts General Hospital—a multispecialty large urban teaching hospital—participated in the study. Patients (new and follow-up) were recruited from the practice of 2 orthopedic surgeons (D.R. and S.L.). Consecutive patients were enrolled 2 clinic days a week, during the month of August 2015. Patients had a variety of upper extremity conditions such as distal radius fracture, carpal tunnel syndrome, lateral epicondylitis, De Quervain’s tenosynovitis, and elbow dislocation.
Fifty-two patients were male, while 56 were female. The mean age of patients was 54.07 years. The mean of reported pain duration was 804.91 days. Seventy-three patients had nontrauma-related pain and 35 patients had pain that can be attributed to a recent trauma. The approval was obtained from the institutional review board for this observational cross-sectional study before the enrollment of participants. Inclusion criteria were being at least 18 years old, fluency and literacy in English, and being able to provide informed consent. Exclusion criteria were being pregnant and significant axis I or II psychopathology that would interfere with participation in the study such as active substance abuse, untreated bipolar disorder, schizophrenia, or psychotic symptoms.

Procedures

Potential study participants were approached while they were waiting for their meeting with the treating physician. The study procedures were explained to eligible patients, and informed consent was obtained from those who agreed to participate. The participants were told that their participation was voluntary and that they could stop participation at any time without affecting their medical care. No one requested to discontinue the study. All participants met inclusionary/exclusionary criteria. Participants completed self-report study measures on an encrypted computer. These included demographics, clinical variables (e.g., pain duration), and measures of pain intensity, physical function, psychological inflexibility, pain catastrophizing, depression, and anxiety.

Measures

Patient-Reported Outcomes Measurement Information System. The National Institutes of Health (NIH) developed the Patient-Reported Outcomes Measurement Information System (PROMIS) to standardize and promote the assessment of health outcomes as reported by the patients. Upper extremity physical function, pain intensity, depression, and anxiety PROMIS domains were used in this study to measure patient-reported relevant outcomes. PROMIS item banks are modeled based on unidimensional item response theory, which uses graded response parameters to fit the data and produce scores. PROMIS scores are given as T-scores with a mean of 50 and standard deviation (SD) of 10. Computer Adaptive Testing (CAT) was used to assess all outcomes except pain intensity. CAT optimizes the item bank administration by choosing relevant questions through recruiting a dynamic item selection algorithm to target the next items based on already given responses to previous questions. This prevents unnecessary and redundant items to be administered resulting in lowering the burden on the respondent while increasing the level of efficiency and precision. Participants completed the PROMIS measures via an encrypted computer on https://www.assessmentcenter.net.

PROMIS Scale (v1.0) Pain Intensity 3a. Patient-Reported Outcomes Measurement Information System pain intensity was used to measure pain intensity. It consisted of three questions asking (1) In the past 7 days, how intense was your pain at its worst? (2) In the past 7 days, how intense was your average pain? (3) What is your level of pain right now? Respondents chose the appropriate level of pain for each question from no pain, mild, moderate, severe, and very severe. Using item-level calibrations, assessment center produces scores for each patient based on 50 ± 10 being the mean ± SD of samples from U.S. population.

PROMIS Bank (v1.2) Upper extremity physical function CAT. Patient-Reported Outcomes Measurement Information System Upper Extremity was used to measure physical function in upper extremity. The item bank PROMIS physical function CAT measures the patient’s self-reported level of physical activities. The PROMIS upper extremity is a subdomain of physical function and measures the level of physical function that involves different upper extremity activities such as opening a can with a hand can opener, putting on a pullover sweater, and reaching into a high cupboard. Respondents answered on a scale from “without any difficulty” to “unable to do”. PROMIS upper extremity is a valid and reliable measure compared with QuickDASH. Compared with legacy fixed-item questionnaire like QuickDASH, it is also easier to use and has less burden on patient (mean completion time in second 70 vs. 116 in QuickDASH) and no floor and ceiling effect, and the scores can be comparable to U.S. population norm.

PROMIS Bank (v1.0) Depression CAT. Patient-Reported Outcomes Measurement Information System Depression was used to assess the symptoms of depression. It showed strong convergent validity with the
Patient Health Questionnaire (PHQ)\textsuperscript{31} and the Center for Epidemiological Studies Depression scale (CES-D)\textsuperscript{32} ($r = 0.72$ to $0.84$ across different timelines). However, it has some advantage over PHQ and CES-D psychometrically with increased precision and broader effective range of measurement. Also, due to being administered through CAT, it has less burden on patient with median number of 4 items administered compared with 9 in PHQ and 20 in CES-D.\textsuperscript{33} In another study, PROMIS depression showed a convergent validity ($r = 0.83$) with CES-D and also correlation between each of its item with related item in legacy measure was demonstrated (median $r = 0.72$).\textsuperscript{34}

**PROMIS Bank (v1.0) Anxiety CAT.** Patient-Reported Outcomes Measurement Information System anxiety was utilized to measure anxiety level among participants. It has shown convergent validity ($r = 0.80$) with the general distress subscale of legacy measure the Mood and Anxiety Symptom Questionnaire (MASQ)\textsuperscript{35,36} and each item in PROMIS anxiety has been demonstrated to correlate with relevant item in legacy measure (median $r = 0.65$).\textsuperscript{33} PROMIS anxiety asks about the level of anxiety in the past 7 days and respondents choose the answer from never, rarely, sometimes, often, to always (the same for PROMIS depression). Through item-level calibrations, assessment center calculates the score for anxiety for each patient with 50 ± 10 being the mean ± SD of samples from U.S. population.

**Acceptance and Action Questionnaire-II.** The Acceptance and Action Questionnaire-II (AAQ-II)\textsuperscript{2} was used to assess the general construct of psychological inflexibility. The scale has 7 items scored on a 7-point Likert type scale, from 1 “never true” to 7 “always true”. The construct score is calculated by summation of the individual scores of all 7 items (range: 7 to 49). Higher scores mean greater psychological inflexibility. Across 6 samples, this scale exhibited high internal reliability (mean $\alpha$ coefficient: 0.84; range: 0.78 to 0.88). The 3- and 12-month test–retest reliability studies revealed AAQ-II had 0.81 and 0.79 mean $\alpha$ coefficients, respectively. The AAQ-II also showed proper discriminant validity.\textsuperscript{2}

**Pain Catastrophizing Scale.** The Pain Catastrophizing Scale (PCS) was used to measure catastrophic thinking about pain. This measure asks participants to rate their pain-associated thoughts and feelings when experiencing pain on a 5-point Likert type scale, from 0 “not at all” to 4 “all the time.” The PCS total score is calculated by adding the individual score of all 13 items (range: 0 to 52). Higher scores translate into more amplified negative orientation toward pain. The PCS has good reliability and construct validity.\textsuperscript{37}

**Statistical Approach**

Pearson product–moment correlations were computed to examine zero-order correlations between continuous demographic and descriptive variables (age and pain duration) and study variables (pain intensity, upper extremity physical function, psychological inflexibility, pain catastrophizing, anxiety, and depression) and among study variables themselves. Independent-samples $t$-tests were used to explore the differences in the study variables by dichotomous descriptive and demographic variables (gender and trauma).

**Model Building**

**Identification of Candidate Mediators.** We had hypothesized that pain catastrophizing, anxiety, and depression can potentially mediate the effect of psychological inflexibility (exposure/independent variable) on pain intensity and upper extremity physical function (outcome/dependent variables). Therefore, pain catastrophizing, anxiety, and depression were assessed in zero-order correlations with both exposure and outcome variables. Any of these variables that correlated with both the independent and dependent variables were considered as candidate mediators and included in the model; if they did not meet criteria, they were assessed for potential covariates in the models.

**Identification of Covariates.** Any variable that correlated with a candidate mediator, an outcome variable, or both were considered a covariate and included in models. Demographic and descriptive variables (age, gender, pain duration, and trauma) and ruled-out mediators were all assessed for their potential to be a covariate. We ran the mediation models with or without controlling for covariates and then compared the models.

**Mediation Analysis.** Multiple-mediator models were fit based on the criteria for candidate mediators and covariates. Both the mediation analyses and the quantification of the total, direct, and indirect paths were performed via Hayes’ PROCESS macro tool, (http://
www.processmacro.org), for SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0.; IBM Corporation, Armonk, NY, U.S.A.). The causal steps approach was recruited to establish whether or not the $a_i$ path (effect of independent variable on mediator) and $b_i$ path (effect of mediator on outcome), which together represented a specific indirect effect path ($a_i \times b_i$), were statistically significant. Also, the direct effect ($c'_i$) path (eg, the direct effect of psychological inflexibility on pain intensity controlling for other mediators and covariates) compared with the total effect ($c_i$) path was examined. The effect of the independent variable (psychological inflexibility) on the dependent variable (eg, pain intensity) was fully mediated through a specific mediator in the model when $c'_i$ path was not significant but relevant $a_i$ and $b_i$ paths were. Partial mediation was noted when $c'_i$ path remained significant but was smaller than $c_i$ path in the presence of the significant specific $a_i$ and $b_i$ paths. If either the specific $a_i$ or $b_i$ paths for a candidate mediator were not significant, that theorized candidate mediator was ruled out as an actual mediator.

While the causal steps approach is beneficial for establishing the existence of a mediation effect, it does not investigate the indirect effect directly.\(^{38}\) Therefore, we recruited PROCESS macro to rectify this issue, through the Preacher and Hayes bootstrapping method\(^{38,39}\) that directly estimates and infers the indirect effects. Bootstrapped resampling with 5,000 samples was iterated to get robust bootstrapped standard errors (SE) and 95% bias-corrected accelerated (BCa) CIs for the mediation effects. If bootstrapped CIs crossed zero, the significance of the indirect effect was ruled out. PROCESS macro also produced point estimate of indirect effect through the product of coefficients strategy (a.k.a., Sobel test\(^{40}\)). The bootstrapped CI is superior for mediation analysis as it overcomes the assumption of normality requirement of other methods.\(^{38}\)

The sample size was determined based on Fritz and Mackinnon’s sample size simulation,\(^{41}\) which estimated a minimum sample size of 71, which was required to detect a medium effect size (0.13) with 0.80 power when using a bias-corrected bootstrapped mediation approach for inferring an indirect effect. Fritz and Mackinnon performed the simulation with the assumption of no measurement error. To account for an inherent measurement error existing within any measures, we enrolled a larger sample size of 108 patients (about 50% more). In a large-scale simulation study, it was demonstrated that bootstrapping, especially when incorporating bias correction in it, had the highest power compared with the traditional product of coefficients approach and other methods requiring a smaller sample size to detect an indirect effect.\(^{42}\)

RESULTS

Sample Characteristics and Description

One hundred and eight patients with upper extremity illness were enrolled in this study. Descriptive, demographic, and main study variables are presented in Table 1. Older age correlated with lower pain intensity ($r = -0.174$, $P = 0.036$), lower pain catastrophizing ($r = -0.261$, $P = 0.003$), lower anxiety ($r = -0.200$, $P = 0.019$), and lower depression ($r = -0.252$, $P = 0.004$). Pain duration showed significant correlation with pain intensity ($r = -0.189$, $P = 0.025$) and anxiety ($r = -0.233$, $P = 0.008$). As compared to men, women had lower level of upper extremity physical function ($M (SD) = 32.64 (8.37)$ vs. $38.14 (8.78)$, $t = -3.321$, $P = 0.001$) and higher level of pain intensity ($M (SD) = 50.74 (7.32)$ vs. $48.34 (6.22)$, $t = 1.842$, $P = 0.034$). Patients with pain related to trauma reported less upper extremity physical function than those with pain not associated with trauma ($M (SD) = 32.73 (8.83)$ vs. $36.81 (8.81)$, $t = 2.251$, $P = 0.013$).

Zero-order Bivariate Correlations Among Study Variables

Table 2 displays the correlation coefficients among the study variables. All study variables were intercorrelated except depression ($r = -0.136$, $P = 0.080$), which was not significantly correlated with upper extremity

<table>
<thead>
<tr>
<th>Variables</th>
<th>$n$ (%) or Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>54.07 (16.01)</td>
</tr>
<tr>
<td>Gender (Female)</td>
<td>52 (48.2%)</td>
</tr>
<tr>
<td>Trauma</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>35 (32.4%)</td>
</tr>
<tr>
<td>No</td>
<td>73 (67.6%)</td>
</tr>
<tr>
<td>Pain duration (in days)</td>
<td>804.91 (396.44)</td>
</tr>
<tr>
<td>Pain intensity</td>
<td>49.50 (6.85)</td>
</tr>
<tr>
<td>Physical function</td>
<td>35.49 (8.98)</td>
</tr>
<tr>
<td>Psychological inflexibility</td>
<td>14.56 (7.32)</td>
</tr>
<tr>
<td>Pain catastrophizing</td>
<td>12.30 (9.59)</td>
</tr>
<tr>
<td>Anxiety</td>
<td>52.65 (7.91)</td>
</tr>
<tr>
<td>Depression</td>
<td>47.07 (7.88)</td>
</tr>
</tbody>
</table>

$N$, Number; SD, standard deviation.
Physical function. As all correlation coefficients were below 0.90, multicollinearity was ruled out.

Pain Catastrophizing Mediates the Effect of Psychological Inflexibility on Pain Intensity

Figure 1 shows the multiple-mediator model that was built following criteria delineated in the statistical approach section. In zero-order correlations, pain catastrophizing, anxiety, and depression demonstrated significant correlations \( P < 0.05 \) with psychological inflexibility (dependent variable) and pain intensity (outcome variable), making them eligible candidates to be assessed as mediators. Among the demographic and descriptive variables (age, gender, pain duration, and trauma), gender showed correlation with the outcome, and age and pain duration correlated with both at least 1 candidate mediator and outcome, making them eligible covariates in the model. Trauma was ruled out as a covariate and was not inserted into controlled model for pain intensity, because it did not show correlation with either the outcome or any of candidate mediators.

The multiple-mediator model of the effect of psychological inflexibility on pain intensity was assessed both uncontrolled and controlled excluding the effect of covariates (age, gender, and pain duration). The total effects, direct effects, and specific indirect effects are shown in Table 3. While remaining significant, the total effect \( (c) \) decreased when controlled for covariates \( (b = 0.378, P < 0.001 \text{ vs. } b = 0.335, P < 0.001) \). The direct effect \( (c') \) shrank and became nonsignificant.

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### Table 2. Zero-Order Pearson Product-Moment Correlation of Study Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pain intensity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Physical function</td>
<td>−0.458**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Psychological inflexibility</td>
<td>0.404**</td>
<td>−0.405**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Pain catastrophizing</td>
<td>0.429**</td>
<td>−0.409**</td>
<td>0.612**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Anxiety</td>
<td>0.169*</td>
<td>−0.199*</td>
<td>0.423**</td>
<td>0.420**</td>
<td></td>
</tr>
<tr>
<td>6. Depression</td>
<td>0.182*</td>
<td>−0.136</td>
<td>0.421**</td>
<td>0.328**</td>
<td>0.748**</td>
</tr>
</tbody>
</table>

* \( P < 0.05 \).
** \( P < 0.001 \).

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**Figure 1.** Multiple-mediator model for the effect of psychological inflexibility on pain intensity. Total effect \( (c) \) represents the total effect (direct plus indirect effects) of psychological inflexibility on pain intensity. The indirect effect \( (c') \) is the effect of psychological inflexibility after accounting for mediators and covariates. The \( a \) paths represent the paths between psychological inflexibility (independent variable) and candidate mediators. The effects of candidate mediators on pain intensity (dependent variable) are indexed as \( b \) paths. Covariates are age, gender, and pain duration.
accounting for the effects of covariates and mediator variables compared with only accounting for mediators ($b = 0.203, P = 0.059$ vs. $b = 0.218, P = 0.046$).

Pain catastrophizing partly mediated the effect of psychological inflexibility on pain intensity in the uncontrolled model. Path $a_1$ ($b = 0.802, P < 0.001$) and path $b_1$ ($b = 0.222, P = 0.007$) were significant. While path $c'$ was significant, path $c'$ was smaller than path $c$ (0.378 vs. 0.218). In the controlled model, while path $a_1$ and path $b_1$ were significant ($b = 0.756, P < 0.001$ and $b = 0.205, P = 0.012$), path $c'$ ($b = 0.203, P = 0.059$) became nonsignificant after controlling for covariates. In other words, after controlling for the covariates (age, gender, and pain duration), mediation became complete. The CI and SE for the indirect effect (path $a_1 \times path b_1$) were obtained as 95% BCa bootstrapped CI and robust bootstrapped SE based on 5,000-sample bootstrapping. As the 95% BCa CI did not cross 0, the results demonstrated that the indirect effect paths of psychological inflexibility on pain intensity through pain catastrophizing were significant in both models (uncontrolled; $b = 0.178, 95\%$ BCa CI [0.006, 0.360] and controlled; $b = 0.155, 95\%$ BCa CI [0.006, 0.315]). Sobel test also confirmed the significance of the indirect effect (uncontrolled; $z = 2.573, P = 0.010$ and controlled; $z = 2.383, P = 0.017$). In sum, pain catastrophizing mediated the effect of psychological inflexibility on pain intensity through a specific indirect path controlling for anxiety, depression, age, gender, and pain duration.

Anxiety was not a mediator of the effect in both uncontrolled and controlled models. Path $b_2$, the effect of anxiety on pain intensity, was not significant (uncontrolled; $b = -0.090, P = 0.450$ and controlled; $b = -0.105, P = 0.387$). The 95% BCa CI of the unstandardized coefficient of the indirect effect (path $a_2 \times path b_2$) also crossed the zero mark, which confirmed that the indirect effect path was not significant (uncontrolled; $b = -0.041, 95\%$ BCa CI [-0.161, 0.079] and controlled; $b = -0.044, 95\%$ BCa CI [-0.159, 0.054]). Normal theory approach also failed to show any significant indirect effect through anxiety (uncontrolled; $z = -0.734, P = 0.463$ and controlled; $z = -0.830, P = 0.406$).

Depression was also ruled as a mediator in both uncontrolled and controlled models. The path $b_3$, the effect of depression on pain intensity, was not significant accounting for other candidate mediators in the uncontrolled model and other candidate mediators and covariates in controlled model (uncontrolled; $b = 0.051, P = 0.659$ and controlled; $b = 0.052, P = 0.658$). The 95% BCa CI of the unstandardized coefficient of

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**Table 3. Results of Multiple-mediator Models for the Effect of Psychological Inflexibility on Pain Intensity**

<table>
<thead>
<tr>
<th>Model</th>
<th>Mediator</th>
<th>Path</th>
<th>$b$ (SE)</th>
<th>$t$ Score</th>
<th>$b$ (SE)</th>
<th>95% BCa CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncontrolled</td>
<td>$c$</td>
<td>0.378* (0.083)</td>
<td>4.549</td>
<td>0.178* (0.089)</td>
<td>0.006</td>
<td>0.360 2.573*</td>
</tr>
<tr>
<td></td>
<td>$c'$</td>
<td>0.218* (0.108)</td>
<td>2.023</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$a_1$</td>
<td>0.802* (0.101)</td>
<td>7.970</td>
<td>-0.041 (0.059)</td>
<td>-0.161</td>
<td>0.079 -0.734</td>
</tr>
<tr>
<td></td>
<td>$b_1$</td>
<td>0.222* (0.081)</td>
<td>2.740</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>$a_2$</td>
<td>0.457* (0.095)</td>
<td>4.800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$b_2$</td>
<td>-0.090 (0.118)</td>
<td>-0.759</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>$a_3$</td>
<td>0.454* (0.095)</td>
<td>4.782</td>
<td>0.023 (0.057)</td>
<td>-0.089</td>
<td>0.138 0.431</td>
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<tr>
<td></td>
<td>$b_3$</td>
<td>0.051 (0.116)</td>
<td>0.442</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$c$</td>
<td>0.335* (0.084)</td>
<td>3.972</td>
<td></td>
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<tr>
<td></td>
<td>$c'$</td>
<td>0.203 (0.106)</td>
<td>1.907</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Controlled</td>
<td>$a_1$</td>
<td>0.756* (0.104)</td>
<td>7.251</td>
<td>0.155* (0.078)</td>
<td>0.006 0.315 2.383*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$b_1$</td>
<td>0.205* (0.081)</td>
<td>2.548</td>
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<tr>
<td></td>
<td>$a_2$</td>
<td>0.421* (0.097)</td>
<td>4.337</td>
<td>-0.044 (0.054)</td>
<td>-0.159</td>
<td>0.054 -0.830</td>
</tr>
<tr>
<td></td>
<td>$b_2$</td>
<td>-0.105 (0.121)</td>
<td>-0.868</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>$a_3$</td>
<td>0.411* (0.098)</td>
<td>4.188</td>
<td>0.021 (0.047)</td>
<td>-0.069</td>
<td>0.123 0.429</td>
</tr>
<tr>
<td></td>
<td>$b_3$</td>
<td>0.052 (0.117)</td>
<td>0.443</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

95% BCa CI, 95% Bias-corrected and accelerated confidence interval; SE, standard error. 95% BCa CI and SE for indirect effects were calculated based on 5,000-sample bootstrapping. A 95% BCa CI that does not cross 0 represents a statistically significant indirect effect. Asterisk represents a statistically significant effect. Controlled covariates: age, gender, and pain duration.
the indirect effect (path $a_2 \times path b_2$) contained zero ruling out a significant depression-specific indirect effect path (uncontrolled; $b = 0.023$, 95% BCa CI $[-0.089, 0.138]$ and controlled; $b = 0.021$, 95% BCa CI $[-0.069, 0.123]$). Normal theory test, also, did not show any significant indirect effect through depression (uncontrolled; $z = 0.431$, $P = 0.667$ and controlled; $z = 0.429$, $P = 0.668$).

**Pain Catastrophizing Mediates the Effect of Psychological Inflexibility on Upper Extremity Physical Function**

Figure 2 shows the multiple-mediator model for upper extremity physical function. In zero-order correlations, pain catastrophizing and anxiety showed significant correlations with psychological inflexibility and upper extremity physical function, making them eligible candidates to be assessed as mediator variables. Depression did not correlate significantly with physical function ($r = -0.136$, $P = 0.080$), but met the criteria for inclusion in the model as a covariate because it correlated with both pain catastrophizing and anxiety (candidate mediators). Age, gender, pain duration, and trauma also were put in the model as covariates because they either correlated with a candidate mediator or physical function (outcome).

The multiple-mediator model of the effect of psychological inflexibility on physical function was investigated both uncontrolled and controlling for the effect of covariates (age, gender, pain duration, trauma, and depression). The total effects, direct effects, and specific indirect effects are shown in Table 4. While remaining significant, the total effect ($c$) decreased after controlling for covariates ($b = -0.497$, $P < 0.001$ vs. $b = -0.456$, $P < 0.001$). The direct effect ($c'$) also decreased but remained significant after controlling for the effects of covariates and mediator variables compared with the model that only accounted for mediators ($b = -0.267$, $P = 0.049$ vs. $b = -0.309$, $P = 0.029$).

Pain catastrophizing partly mediated the effect of psychological inflexibility on physical function in the uncontrolled and controlled conditions. Path $a_1$ (uncontrolled; $b = 0.802$, $P < 0.001$ and controlled; $b = 0.732$, $P < 0.001$) and path $b_1$ (uncontrolled; $b = -0.246$, $P = 0.023$ and controlled; $b = -0.239$, $P = 0.020$) were significant. While in both models path $c'$ was significant, path $c'$ was smaller than path $c$ (uncontrolled; $c = -0.497$ vs. $c' = -0.309$ and controlled; $c = -0.456$ vs. $c' = -0.267$). The 95% BCa bootstrapped CI and robust bootstrapped SE based on 5,000 resampling for the indirect effects (path $a_1 \times path b_1$) were calculated for both models. As the 95% BCa CI did not cross 0, the indirect effect of psychological
inflexibility on physical function through pain catastrophizing accounting for anxiety, depression, and other covariates was deemed significant (uncontrolled; $b = -0.197$, 95% BCA CI $[-0.433, -0.014]$ and controlled; $b = -0.175$, 95% BCA CI $[-0.393, -0.027]$). The Sobel test also confirmed the significance of the indirect effect (uncontrolled; $z = -2.208$, $P = 0.027$ and controlled; $z = -2.200$, $P = 0.028$). In other words, pain catastrophizing mediated the effect of psychological inflexibility on upper extremity physical function through a specific indirect path controlling for anxiety, depression, age, gender, pain duration, and trauma.

Anxiety was not a mediator of the effect neither in uncontrolled nor in controlled models. Path $a_2$ was significant in the uncontrolled model, yet after controlling for depression and other covariates, it became nonsignificant ($P < 0.001$ vs. $P = 0.064$). Path $b_2$, the effect of anxiety on physical function, was not significant in both models (uncontrolled; $b = 0.020$, $P = 0.856$ and controlled; $b = -0.101$, $P = 0.502$). The 95% BCA CI of the unstandardized coefficient of the indirect effect (path $a_2 \times path b_2$) also contained the 0, which further confirmed that there is no significant indirect effect path through anxiety (uncontrolled; $b = 0.009$, 95% BCA CI $[-0.110, 0.117]$ and controlled; $b = -0.014$, 95% BCA CI $[-0.107, 0.024]$). Normal theory approach did not also demonstrate any significant indirect effect through anxiety (uncontrolled; $z = -0.566$, $P = 0.572$).

## DISCUSSION

Psychological inflexibility, defined as the inability to take value-based actions in the presence of unwanted thoughts, feelings, or bodily symptoms, is associated with negative health outcomes including depression and anxiety. The purpose of the current study was to determine the association between the general construct of psychological inflexibility and pain intensity and upper extremity physical function in patients with musculoskeletal illness in an orthopedics surgical practice. We also set out to test mediation models proposing that psychological inflexibility impacts pain intensity and upper extremity physical function directly, as well as indirectly through increased depression, anxiety, and pain catastrophizing.

Results of this study support prior research on the association of pain-specific and general psychological inflexibility with pain intensity and physical function and expand it by providing support for these relationships to pain intensity and upper extremity physical function in patients with musculoskeletal pain in an orthopedic surgical practice. The level of psychological inflexibility, which entails the inability to integrate and manipulate new information, defuse from thoughts and act consistent with values rather than based on pain sensations or pain-related thoughts, appears to be a driving force toward negative pain outcomes. Further, this study broadens our understanding of the mechanism through which psychological...
inflexibility may lead to pain intensity and physical function. Although a prior study showed an association of cognitive fusion, a component of psychological inflexibility, to pain catastrophizing, to our knowledge this is the first study supporting the mediating role of pain catastrophizing in the relationship between psychological inflexibility and both pain intensity and upper extremity physical function. We found that psychological inflexibility impacts pain intensity and upper extremity physical function both directly and indirectly through pain catastrophizing.

A large body of research has documented the association of pain catastrophizing to pain intensity and physical function. However, what leads to pain catastrophizing when patients encounter pain is not known. We hypothesized and found support that the level of psychological inflexibility influences the degree to which patients engage in pain catastrophizing when encountering pain sensations, and this impacts their pain and physical function. Possessing greater psychological flexibility (e.g., low psychological inflexibility) may allow patients who experience pain to become aware of the initial, automatic, protective worry when a novel pain symptom develops, defuse such cognitions, and engage in value-driven behaviors, which lead to better outcomes. On the contrary, those high in psychological inflexibility may get stuck in the pain–thought fusion and become unable to accept pain sensations, leading to ruminaton on pain experiences, magnification of pain experiences, and a sense of helplessness in the face of pain (i.e., pain catastrophizing), leading further to higher pain intensity and disability.

Our study also confirms prior research on the relationship of psychological inflexibility to both depression and anxiety, of depression and anxiety to pain intensity, and of anxiety to upper extremity physical function. However, neither depression nor anxiety were supported as mediators when entered together with pain catastrophizing in the mediation models, suggesting that only pain catastrophizing carries the effect of psychological inflexibility on pain and upper extremity physical function in patients with musculoskeletal pain.

We found support that the general psychological inflexibility construct leads to pain catastrophizing, increased pain intensity, and decreased physical function, while prior studies in adults generally used a pain-specific inflexibility measure. To our knowledge, this is the first study that assessed general psychological inflexibility in adult patients with musculoskeletal pain presenting to an orthopedic surgical practice. Our study suggests that a general tendency toward psychological inflexibility is a risk factor for increased pain intensity and decreased physical function when patients experience an upper extremity illness. This is of great significance and suggests that those who measure high on psychological inflexibility may be at risk of not only chronic pain when experiencing an upper extremity illness, but also other negative health outcomes when experiencing other health concerns.

There are some caveats that should be considered when interpreting the results of this study. The cross-sectional design of the study limits any conclusion about the causation or direction of the effects. The relationships could go the other way as well, although both the good model fit parameters and theory go against that. For example, it may be that pain catastrophizing triggered by an orthopedic condition increases psychological inflexibility, which in turn decreases physical function. A longitudinal study is warranted to provide more definitive evidence for the direct and indirect effects of psychological inflexibility on pain intensity and physical function. Pain patients were limited to upper extremity conditions, and results may not necessarily generalize to patients with pain complaints in other body locations. Despite our expectations based on literature, a correlation between depression and upper extremity physical function was not shown. This may be a function of our sample being relatively healthy as depicted by the scores on the PROMIS measures, as well as due to our choice of assessing upper extremity-specific rather than general physical function. Results may be different with patients with higher symptoms of depression and lower levels of physical function, and with a general physical function measure. As pain catastrophizing mediates the effect of psychological inflexibility on pain intensity and upper extremity physical function, there might be other mediators that this study did not address.

Despite these limitations, this study advances our understanding of the mechanisms through which the general construct of psychological inflexibility impacts pain and upper extremity physical function in patients with musculoskeletal pain presenting to an orthopedic surgical practice. The fact that a general rather than a pain-specific psychological inflexibility scale predicts pain intensity and physical function supports the contention that the general rather than symptom-specific cognitive fusion and subsequent experiential avoidance are the root problems that may impact not only pain and pain outcomes, but also other health outcomes. In other
words, increased pain and decreased physical function occur in individuals who are low on general psychological inflexibility; decreased physical function is just one manifestation of the general psychological inflexibility, which, based on theory, can potentially influence the development of other health problems. This study provides further evidence that ACT, with its focus on teaching psychological flexibility, can be effective in helping patients with musculoskeletal pain deal with pain-related disabilities, and suggests that incorporating pain catastrophizing as a potential treatment target (particularly for patients who may have trouble negotiating the complex ACT terminology) may buttress treatment outcomes. Further, by teaching psychological flexibility, ACT for musculoskeletal pain may also improve coping with other health concerns, thus improving well-being and quality of life.

DISCLOSURES

The study did not have any funding source. The authors have no conflict of interest to declare relevant to this study.

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