RUNNING TITLE: Pain acceptance, catastrophizing and function

Does pain acceptance buffer the negative effects of catastrophizing on function in individuals with chronic pain?

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Abstract

Objectives. Pain catastrophizing and pain acceptance are psychological factors that have been shown to be associated with pain-related outcomes and predict multidisciplinary pain treatment outcomes. However, they are rarely examined in the same study. This study aimed to: (a) assess the independent roles of pain catastrophizing and pain acceptance as predictors of pain intensity, pain interference, and depression; and (b) evaluate the potential moderating role of pain acceptance on the association between pain catastrophizing and both pain and function. **Methods**. A sample of 467 adults with chronic pain completed an on-line survey including measures of pain intensity, pain interference, depression, pain catastrophizing, and pain acceptance. **Results**. Pain catastrophizing and pain acceptance were independent predictors of pain interference. Only pain catastrophizing and the activity engagement domain of pain acceptance were independent predictors of pain intensity and depression. Activity engagement moderated the association between pain catastrophizing and depression, indicating a buffering effect on the negative effects of catastrophizing on depression. Pain willingness moderated the association between pain catastrophizing and pain interference, such that endorsing low pain willingness may override any negative effects of pain catastrophizing. **Discussion**. The findings suggest that pain catastrophizing and pain acceptance are independently important to adjustment to chronic pain. Research is needed to determine if treatments that target both for change are more effective than treatments that target only one.

Key-words: Chronic pain, Catastrophizing, Pain acceptance, Moderation, Function, Pain intensity

Introduction

Chronic pain is a prevalent health condition that has a significant negative impact in virtually all aspects of the lives of those with chronic pain and their family members, coworkers, and classmates (1–5). Pain is a multidimensional experience, known to be influenced by a myriad of biological, psychological, social, cultural, and spiritual factors (6–15). Two recent literature reviews on the contributions of psychosocial variables to adjustment to chronic pain experience in adults (7,14) made a distinction between *general* and *pain-specific* psychosocial variables. The general psychosocial variables that have been studied most often include global psychological dysfunction (e.g., depression, anxiety, and global distress), having a history of abuse or trauma, and social/interpersonal processes (e.g., social support) (8,16–20). The most frequently studied *pain-specific* psychosocial variables include kinesiophobia and catastrophizing (both of which are hypothesized to make a negative contribution to pain and its impact) and pain self-efficacy, active pain coping responses, and chronic pain acceptance (all of which are hypothesized to have a positive impact on pain and function) (8,21–26).

Pain catastrophizing (i.e., an exaggerated and overly negative evaluation of actual or anticipated pain which may result in focusing more on the negative characteristics of pain experience) (27,28) has emerged as one of the most consistent predictors of pain and dysfunction in individuals with chronic pain (7,21,22,24,26,29,30). Pain catastrophizing has also been shown to predict pain chronification (31), as well as poorer responses to multidisciplinary pain treatment (26,32). The domain of pain catastrophizing overlaps, at least partially, with a number of other psychosocial domains and processes (e.g., escape-avoidance behaviors, anxiety, pessimism, and helplessness) and has been shown to be positively associated with measures of depression, anxiety and fear of pain (33–36). In addition, pain catastrophizing has been shown to be inversely associated with a number of psychosocial factors such as perceived self-efficacy and optimism, both of which may act as protective factors that are associated with better adjustment to chronic pain (33–35).

Furthermore, pain catastrophizing may interact with other psychosocial processes (e.g., social support) to influence the experience of and adjustment to chronic pain (7,37). One such pain-specific psychosocial variable is *pain acceptance* (23,38–41). Previous research has shown pain acceptance – i.e., a willingness to experience pain while abstaining from trying to avoid and control it and persisting in valued activities despite pain (39,40) – to be negatively associated with pain intensity, pain-related disability and depression, and positively associated with measures of better function in individuals with chronic pain (21–23,39,40,42). Additionally, pain acceptance has been found to predict a positive response to multidisciplinary cognitive behavioral-based pain treatments (7,26), while buffering the effects of pain intensity on pain-related disability (7,43).

Pain catastrophizing and pain acceptance are inversely correlated, suggesting the possibility of mutual influence (21,22,26,33–35,44). Both variables are also hypothesized to represent dispositional vulnerability (catastrophizing) and protective (acceptance) factors influencing pain-related beliefs, as well as affective and behavioral responses to pain (45). Thus, these two variables may be viewed as distinct but related constructs that may work together to influence pain experience and chronic pain-related outcomes (21). In support of this idea, previous findings have shown that pain acceptance: (a) mediates the association between pain catastrophizing and pain-related disability and depression (46); and (b) moderates the association between pain catastrophizing and task performance during painful stimulation (29). However, inconsistent findings with respect to moderation effects have also emerged (21). Given the paucity of research that has examined measures of pain catastrophizing and acceptance in the same study, as well as the inconsistency of the findings, additional research is needed to clarify the unique contributions of pain catastrophizing and pain acceptance to pain intensity and function, and also clarify how they might work together (e.g., the extent to which one mediates and/or moderates the effects of the other), to impact function in individuals with chronic pain.

Given these considerations, the aims of the current study were to (a) examine the independent role of pain acceptance and pain catastrophizing as predictors of pain intensity, pain

interference and depression and (b) evaluate the potential moderating effects of pain acceptance on the association between pain catastrophizing, on one hand, and pain intensity, pain interference and depression, on the other, in a sample of adults with chronic pain. We hypothesized that (a) pain acceptance and pain catastrophizing would make significant and independent contributions to the prediction of pain intensity, pain interference and depression, with catastrophizing being positively associated with pain intensity, pain interference and depression, and pain acceptance being negatively associated with the three variables, and (b) pain acceptance would have a significant buffering effect on the associations between pain catastrophizing and pain intensity, pain interference and depression, such that those individuals with higher levels of pain acceptance would evidence significantly weaker associations between catastrophizing, on one hand, and pain intensity, pain interference and depression, on the other, than those with lower levels of pain acceptance.

Materials and Methods

Participants

The minimum sample size recommended to detect a significant effect in moderation analysis using ordinary least squares multiple linear regression-based trajectory analyses was determined using an a priori power calculation using an online calculator, considering five predictors, and assuming a medium effect size of .15 (Cohen's f^2), an alpha level of .05, and power of .80 (47,48). This calculation indicated that 78 participants would be needed to be able to detect significant effects.

In this study, we used data from a survey study conducted at the University of Washington (Seattle, USA) addressing a number of questions regarding factors that contribute to function in individuals with physical disabilities and chronic pain. One paper has already been published using data from the original survey (49), and others are planned. However, none of the published and planned papers have addressed or will address the hypotheses tested in the current paper. Survey participants were adults with chronic pain and one or more health condition associated with

physical disability (e.g., multiple sclerosis, spinal cord injury, low back pain) who also had access to a computer or smartphone with internet connection. Chronic pain was defined as a constant or recurrent bothersome pain for at least half of the days during the past 3 months.

In total, 2871 prospective participants were invited to participate. Of the 860 (35%) prospective participants who agreed to participate and who completed the screening questions, 18% (*n* =158) did not have chronic pain and were excluded from the study sample. Of the 702 participants providing at least some information, 467 (67%) finished the survey questionnaire. A total of 424 were adults with chronic pain and provided complete data for the measures used in the statistical analysis reported here. Descriptive information about the sample are presented in Table 1. As can be seen, most of the participants were women (*n* = 280, 66%) and Caucasian (*n*= 384, 91%). Participants' age ranged between 22 and 94 years old (*M* = 59.02, *SD* = 11.62). Education level was high, with the majority of the participants having attended at least some college (*n* = 355, 84%). Most participants were either retired (*n* = 172, 41%) or unemployed (*n* = 126, 30%), although smaller subsets were employed (full-time: *n* = 57, 14%; part-time: *n* = 48, 11%), homemakers (*n* = 15, 4%), or students attending school or vocational training (*n* = 5, 1%). The most frequently reported conditions were back pain (*n* = 184, 43%), multiple sclerosis (*n* = 154, 36%), osteoarthritis (*n* = 93, 22%), and spinal cord injury (*n* = 88, 21%).

[Insert Table 1 about here]

Measures

Study participants completed a sociodemographic and clinical history questionnaire assessing sex, age, ethnicity, education level, employment status and health conditions, average pain intensity, physical and psychological function, pain catastrophizing and pain acceptance.

Average pain intensity. Average pain intensity in the previous week was assessed using a 0-10 Numerical Rating Scale (0-10 NRS), where zero indicated "No pain" and 10 indicated "Worst pain possible." Previous research supports the validity, responsiveness and test-retest reliability

[e.g., intraclass correlation coefficient (95% CI) of .95 (.93-.96)] of the scores provided with the 0-10 NRS as a measure of pain intensity (50–52).

Pain interference. Physical function was assessed using the 6-item PROMIS Pain Interference Scale (53). Respondents to the PROMIS Pain Interference Scale are asked to rate how much has pain interfered with their activities during the previous week (sample item: "How much did pain interfere with your day to day activities?") using a Likert scale ranging from 1 ("Not at all') to 5 ("Very much"). Higher scores indicate greater pain interference. Previous research supports the reliability and validity of the PROMIS Pain Interference Scale scores when used with individuals with chronic pain (53). Per standard practice with PROMIS measures, T-scores (i.e., with a mean of 50 and SD of 10 in the reference population) (54) were used. In the current sample, this scale showed excellent internal consistency (Cronbach's alpha = .95).

Depression. Depression was assessed using the 8-item PROMIS Emotional Distress-Depression Scale short-form (53). Respondents to the scale's items indicate the frequency that they have experienced each depressive symptom in the past seven days (sample item: "I felt depressed") using a Likert scale ranging from 1 ("Never") to 5 ("Always"). Higher scores indicate poorer psychological function (i.e., more frequent depressive symptoms). The scores of this measure have been found to be valid and reliable when used with adults with chronic pain (53). T-scores were computed and used in the subsequent data analyses. In the current sample, the scale showed an excellent internal consistency (Cronbach's alpha = .95).

Pain catastrophizing. Pain catastrophizing was assessed using the Pain Catastrophizing subscale of the 2-item per-scale version of the Coping Strategies Questionnaire (CSQ) (55). This scale asks participants to report the frequency that they experienced the two thoughts/feelings described by the items when they had pain (sample item: "It is terrible and I feel it is never going to be any better") on a 7-point Likert scale ranging from 0 ("Never") to 6 ("Always"); higher scores indicate greater pain catastrophizing. Previous research supports the validity and reliability of the scale's scores when used with adults with chronic pain (55). Spearman-Brown coefficient and the

Cronbach's alpha for the CSQ Catastrophizing scale were, in both cases, .85, indicating good reliability in our sample.

Pain acceptance. Pain acceptance was assessed with the 8-item Chronic Pain Acceptance Questionnaire (CPAQ-8; (56)). With the CPAQ-8, respondents are asked to rate the degree to which a pain acceptance statement is true for them on a 7-point Likert scale ranging from 0 ("Never true") to 6 ("Always true"). Items can be used to create scores assessing two subdomains of pain acceptance: Activity Engagement (sample item: "I lead a full life even though I have chronic pain") and Pain Willingness (sample item: "I avoid putting myself in situations where my pain might increase"). Previous research supports the validity and reliability of the CPAQ-8 scores (56). Cronbach's alphas for the CPAQ-8 Activity Engagement and CPAQ-8 Pain Willingness in the current sample were, respectively, .88 and .65, indicating good internal consistency for the Activity Engagement scale scores and borderline internal consistency for the Pain Willingness scale scores.

Procedures

Data collection procedures have been previously described in detail by de la Vega and colleagues elsewhere (49). In short, the study data were collected between October 2016 and June 2017 using REDCap (Research Electronic Data Capture) tools (57) hosted at the University of Washington. REDCap is a secure web-based application designed to support data capture for research studies. Prospective participants were invited to participate via an email containing a brief explanation of the study aims and procedures. The email also included a link to the online survey questionnaire and a brief summary of the contents of the survey. The link directed the participants to two screening questions, to confirm if potential participants had chronic pain. Individuals who met the study inclusion criteria were then presented an informed consent statement. Participants were assured that participation was anonymous and voluntary, that they could drop participation at any time and that they could skip any question that they did not want to answer. Participants who accepted to participate were, then, asked to digitally sign the informed consent. The Institutional

Review Board of the University of Washington reviewed the protocols and considered the study of "minimal" risk and exempt from a full board review.

Data Analysis. We first computed means, standard deviations and zero order correlations coefficients among the study measures for descriptive purposes. We then determined if the assumptions required for the planned analyses were met. Normality of the distributions of study measures was assessed by computing skewness (Sk) and kurtosis (Ku), with values of Sk and Ku lower than 3 and 10, respectively, indicating an absence of severe deviance from a normal distribution (58,59). Normality of residuals' distribution and homoscedasticity of residuals were evaluated graphically, by analyzing a normal probability plot of the residuals (60). Independence of errors was assessed by computing the Durbin-Watson statistic, with values close to 2 indicating absence of violation of these assumptions. Variance inflation factors (VIFs) for the predictor variables were computed to assess multicollinearity, with VIFs lower than 5 indicating absence of multicollinearity (61). Next, we tested the hypothesized independent direct effects of pain acceptance and pain catastrophizing on pain intensity, pain interference and depression, as well as the moderating effect of pain acceptance on the associations between pain catastrophizing, on one hand, and pain intensity, pain interference and depression, on the other. In order to do so, we performed moderation analyses using ordinary least squares (OLS) multiple linear regression-based trajectory analyses, as described by Hayes (62) and Hayes and Matthes (63). Interaction effects were probed using Johnson-Neyman technique for deriving regions of significance (64). Sex and age were included as covariates (62,64). Questionnaires with missing data were excluded from the analyses. All statistical analyses were performed using IBM SPSS Statistics (v. 25, SPSS Inc., Chicago, IL). Moderation effects were estimated and probed using PROCESS macro for SPSS (v. 3.2, freely available at http://www.afhayes.com). Alpha was set at 0.05 for all analyses.

Results

Descriptive statistics of the study variables and their univariate associations

Table 1 presents the descriptive statistics for the study variables. As can be seen, the sample was characterized by moderate pain intensity on average (M = 5.22, SD = 1.94). Pain interference and depression levels were, on average, 49.91 (SD = 10.12) and 50.12 (SD = 10.09) respectively. Pain catastrophizing was, on average, 4.52 (SD = 3.32). CPAQ Activity Engagement was, on average 20.21 (SD = 4.78), while CPAQ Pain Willingness mean was 10.16 (SD = 5.36).

The univariate zero-order associations (Pearson correlations) between the study variables are presented in Table 2. Pain catastrophizing was significantly positively moderately associated with pain intensity (r = 0.43, p < .001), pain interference (r = 0.44, p < .0001) and depression (r = 0.54, p < .001). Also as expected, CPAQ Activity Engagement showed significant moderate to strong negative associations with pain intensity (r = -0.35, p <. 001), pain interference (r = -0.68, p< .001), depression (r = -0.61, p< .001) and pain catastrophizing (r = -0.45, p < .001). However, CPAQ Pain Willingness was only weakly, but significantly, negatively correlated with pain interference (r= -0.10, p = .04), whereas it was weakly negatively and not statistically significantly correlated with pain intensity (r = -0.01, p = .868), depression (r = -0.03, p =. 518) and pain catastrophizing (r = -0.05, p = .329).

[Insert Table 2 about here]

Assumptions testing

Study variables distributions evidenced an absence of severe deviation from normal distribution, with skewness and kurtosis ranging from -0.80 to 0.87 and from -0.89 and 1.34, respectively. The assumptions of residuals' normal distribution, as well as of homoscedasticity of residuals, were met (*cf.* Figure 1). Independence of residuals was supported by Durbin-Watson statistics between 1.88 and 2.02. Absence of multicollinearity was supported by low VIF values for the study predictors (i.e., range, 1.04 to 4.05).

[Insert Figure 1 about here]

OLS multiple linear regression-based trajectory analysis predicting pain intensity

The results of the OLS multiple linear regression analysis predicting pain intensity are summarized in Table 3. As can be seen, the five predictor variables, as a block, made a substantial contribution to the prediction of pain intensity (R^2 = .22, p < .001), with only CSQ Catastrophizing (β = .07, p < .001) and CPAQ Activity Engagement (β= -.03, p < .001) evidencing unique significant direct associations with pain intensity. A statistically significant moderation effect was not found for either CPAQ Activity Engagement or CPAQ Pain Willingness.

[Insert Table 3]

OLS multiple linear regression-based trajectory analysis predicting pain interference

The results of the OLS multiple linear regression analysis predicting pain interference are summarized in Table 4. As can be seen, the five predictor variables, as a block, made a substantial contribution to the prediction of pain interference (R^2 = .50, p < .001), with CSQ-14 Catastrophizing (β = .15, p < .001), CPAQ Activity Engagement (β= -.57, p < .001) and CPAQ Pain Willingness (β = -.14, p < .001) evidencing unique significant direct associations with pain interference. In addition, a statistically significant moderation effect of CPAQ Pain Willingness was found (ΔR^2 = .02, p < .001). Conditional effects of significant interaction effects are depicted in Figure 2.

[Insert Table 4 and Figure 2 about here]

The probe of the statistically significant interaction effect of CPAQ Pain Willingness revealed that pain catastrophizing shows a positive association with pain interference for individuals with moderate and high pain willingness. However, pain interference is uniformly high for those with low pain willingness, regardless of the level of pain catastrophizing.

OLS multiple linear regression-based trajectory analysis predicting depression

Table 5 shows the results of the OLS multiple linear regression analysis predicting depression. As can be seen, the five predictor variables, as a block, made a substantial contribution to the prediction of depression (R^2 = .46, p < .001). However, only CSQ-14 Catastrophizing (β = .34, p < .001) and CPAQ Activity Engagement (β = -.40, p < .001) presented unique significant direct associations with depression. A statistically significant moderation effect of CPAQ Activity

Engagement also emerged (ΔR^2 = .03, p < .001). Conditional effects of significant interaction effects are depicted in Figure 2.

[Insert Table 5]

The probe of the statistically significant interaction effect of CPAQ Activity Engagement revealed that pain catastrophizing is consistently and positively associated with depression across all levels of activity engagement. However, this association becomes stronger as activity engagement becomes lower, and weaker when activity engagement is higher.

Discussion

The current study aimed to evaluate the independent roles of pain acceptance and pain catastrophizing as predictors of pain intensity, pain interference and depression in adults with chronic pain. The study also sought to examine the potential moderating effects of pain acceptance on the association between pain catastrophizing and pain intensity, pain interference and depression.

As hypothesized, pain catastrophizing and pain acceptance were independent predictors of pain interference. However, only pain catastrophizing and the activity engagement domain of pain acceptance were independent predictors of both pain intensity and depression. In every case where significant associations were found, the direction of the association was as predicted. These findings are consistent with the results from previous studies examining the associations among these variables in adults with chronic pain (7,21–24,26,29,39,40,65). These findings are also consistent with pain catastrophizing being a risk factor, and pain acceptance – or at least one of its dimensions (activity engagement) – being a protective factor, in people with chronic pain. Given these well-established findings on the association between pain catastrophizing and pain acceptance, on one hand, and key pain-related outcomes, on the other, an important next step would be to evaluate the causal associations between these variables in the context of longitudinal and experimental studies.

Along these lines, some evidence exists of the potential causal role of pain catastrophizing as a predictor of pain chronification, unfavorable pain trajectory and poor treatment outcome (31,66). Indeed, Pinto and colleagues (66) in a longitudinal study of over five years, found that

presurgical pain catastrophizing was a risk factor for developing prolonged and chronic postsurgical pain after hysterectomy. In another five-year longitudinal study with community-dwelling knee osteoarthritis patients, Helminem and colleagues (67) found baseline pain catastrophizing to be a significant predictor of higher pain intensity five years later. Less research examining the longitudinal associations between pain acceptance and pain-related outcomes exists. Previous studies on this topic suggest that baseline pain acceptance may be a significant predictor of lower pain interference and depressive symptoms in both patients from health care settings and community-dwelling individuals with chronic pain (23). As a group, these findings, when considered in light of the current results, indicate that additional longer longitudinal studies to evaluate both catastrophizing and pain acceptance as predicting subsequent patient function is warranted.

One interesting pattern that emerged from this study was the tendency for the activity engagement component of pain acceptance to show a stronger and more consistent pattern of significant associations with pain intensity, pain interference, depression and catastrophizing; only one significant negative, yet weak, association emerged between pain willingness and pain interference. This is in line with previous research examining the independent roles of the two primary dimensions of pain acceptance (activity engagement and pain willingness) in predicting pain-related outcomes, suggesting that the two dimensions may play different roles. Of the two, activity engagement appears to be the more important domain, at least with respect to its potential impact on function (23,26,68). For example, a recent study by Miró and colleagues (26) examined the roles of changes in catastrophizing and pain acceptance as primary dimensions in explaining changes in a multidisciplinary cognitive behavioral-based treatment outcomes. The authors found that while changes in activity engagement predicted decreases in pain interference (but not depressive symptoms), changes in pain willingness were not associated with either outcome. In another study, activity engagement, but not pain willingness, was significantly associated with decreased pain interference after a mindfulness-based treatment program (68). Yet another study

(23) found a similar pattern of associations, with activity engagement evidencing a stronger pattern of significant associations with pain-related outcomes, including pain intensity, pain interference and depressive symptoms, than pain willingness, after controlling for the initial measures of the pain-related outcomes considered before assessing pain acceptance as a predictor. As a group, these findings suggest the possibility that treatment programs for pain management should focus more on increasing activity engagement than focusing on an expressed willingness to experience pain (23). The relative relevance and the differentiated roles of the two pain acceptance primary dimensions remain a relevant topic for further research.

Our findings provided support only for a buffering effect of the activity engagement component of pain acceptance on the association between pain catastrophizing and depression. Specifically, we found that, while pain catastrophizing was consistently positively associated with depression across all levels of activity engagement, this association becomes weaker as activity engagement becomes higher. If these findings replicate in other samples of individuals with chronic pain, it would suggest the possibility that treatments designed to increase activity engagement despite pain – which is the primary goal of all treatments that involve an operant component, such as multidisciplinary pain treatments (69–72) – may be helpful for reducing depression, in part, because of the buffering effect of increased activity engagement on the impact of catastrophizing on depression. Research testing the mediating effect of treatment-related improvements in activity engagement on the beneficial effects of pain treatments on depression and other outcomes are warranted.

We did not find support for a buffering effect of either component of pain acceptance on the association between catastrophizing and pain intensity and pain interference. Although a significant moderating effect of pain willingness on the association between catastrophizing and pain interference emerged, the nature of this effect was not consistent with pain willingness acting as a buffer. For these associations, we found that individuals with more pain willingness evidenced *stronger* associations between pain catastrophizing and pain interference; pain interference was

uniformly high for those individuals with low pain willingness, regardless of the level of pain catastrophizing. While these findings – that are consistent with the direct effects found – indicate that, in general, it would be best to maximize pain willingness and minimize catastrophizing (i.e., the participants who reported the lest pain interference evidenced this pattern), having low levels of pain willingness may override the negative effects of pain catastrophizing. This suggests the possibility that in order to benefit from treatments that minimize catastrophizing, it would be important to ensure that at least some pain willingness is present. Again, given the lack of previous research examining how catastrophizing and (in this case) pain willingness interact to predict pain intensity and function, we cannot be certain if the pattern that emerged in this study will replicate in other samples. However, if the finding is reliable, an important next step would be to examine the extent to which treatment-related changes in pain willingness influence the role that catastrophizing plays in patient function from pre- to post- chronic pain treatment.

Limitations

This study has a number of limitations that should be considered when interpreting the results. Of critical importance, there is a conceptual and item overlap between measures of physical function (e.g., pain interference), which reflect activity level, and measures of the pain acceptance activity engagement dimension, which assess how willing a person is and how much a person does engage in activities despite pain (73). This overlap was also reflected in the strong association between the measures of these domains in this study, and might explain, at least in part, the lack of any buffering influence of activity engagement on the association between catastrophizing and pain interference. This issue could be addressed in future research by using performance-based measures of physical function (e.g., objective measures of physical activity, such as Actigraphy) that have negligible conceptual and item overlap with measures of pain acceptance. Second, we used the subscale of catastrophizing of the two-item CSQ as a measure of pain catastrophizing. This measure does not allow for the assessment of the different subdomains of pain catastrophizing (i.e., rumination, pain magnification, and perceived helplessness) (74). Therefore we were not able to

examine the extent to which each of these dimensions may play in predicting key pain-related outcomes in this sample. Further research is needed to determine which catastrophizing dimension(s) should be the primary focus of multidisciplinary treatment for pain management in adults. Third, the present study used a cross-sectional design, which does not allow for examining causal relationship between the study variables. Future longitudinal and experimental research is needed to determine if changes in pain catastrophizing and pain acceptance have a causal impact on pain intensity, pain interference and depression. Fourth, the study sample was self-selected and with a high education level. As a result, the extent to which the current findings generalize to all adults with chronic pain, including those who might have lower education levels or decline participation in research studies, are not known. Fourth, the pain willingness subscale of the short 8-item version of the Chronic Pain Acceptance Questionnaire had a borderline internal consistency in this sample. This may be associated with poor inter-relatedness among the items, or with the fact that pain willingness may be an heterogenous construct (75). This could potentially have blurred the effects of pain willingness on pain intensity and depression in this study. Future research is needed to help determine the reliability of the study findings. Finally, ethnic diversity in the sample was low. Indeed, 90% of the study participants were Caucasian, preventing the exploration of the influence of ethnicity on the findings, and limiting the generalizability of the findings to adults with chronic pain from other ethnic groups. In addition, the proportion of female/male participants (66% were women) was not balanced in this sample. Given that catastrophizing is known to be higher in women, and that catastrophizing has been shown to mediate the association between sex and pain-related outcomes (76), the results might have been different if the number of men participating in the study had been higher. However, the prevalence of chronic pain is known to be higher among women (1). Thus, our sample might me more representative of the study population than a sample with proportional number (50%) of female and male participants. Additional research in other more diverse and proportionate samples in regards to ethnicity and sex is needed to assess the reliability and generalizability of the study findings.

Conclusions

Despite the study's limitations, the results provide additional important information regarding the role of pain catastrophizing and pain acceptance to key pain-related outcomes. The findings provide additional support for the relevance of pain catastrophizing and pain acceptance – in particular the importance of the activity engagement of pain acceptance – as vulnerability and protective factors in adults with chronic pain, respectively. The findings also support the conclusion that pain acceptance is not a unitary construct, and that its two primary components have a differentiated role in influencing pain intensity, pain interference and depression. Finally, the data provide new information regarding how pain acceptance and pain catastrophizing might interact to influence pain interference and depression. Specifically, they suggest the possibility that activity engagement might serve as a buffer for the effects of catastrophizing on depression, while low pain willingness may be a vulnerability factor that may need to be addressed before reductions in pain catastrophizing start to impact pain interference. As a result, multidisciplinary treatment for chronic pain management in adults targeting *both* catastrophizing and pain acceptance – especially those encouraging engaging in activities despite pain – may be more beneficial than treatments that focus on just one or the other (22,26). Longitudinal and mediation research in the context of clinical trials is needed to evaluate these hypotheses.

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