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The role of pain acceptance on function in individuals with disabilities: a longitudinal study

Mark P. Jensen[a,*], Amanda E. Smith[a], Kevin N. Alschuler[a,b], David T. Gillanders[c], Dagmar Amtmann[a], Ivan R. Molton[a]

Abstract
Having higher levels of pain acceptance has been shown to be associated positively with quality of life in patients with chronic pain, but its role in adjustment to chronic pain among individuals with physical disabilities living in the community is not known. Moreover, issues related to item overlap between measures of pain acceptance and measures of patient function have limited the conclusions that can be drawn from previous research in this area. To better understand the role that pain acceptance plays in patient function, we administered measures of pain acceptance, pain intensity, depressive symptoms, and function to 392 individuals with physical disabilities, and the pain, symptom, and function measures were readministered 3.5 years later. Analyses evaluated the main and interaction effects of initial pain acceptance on subsequent changes in pain and function. Having higher levels of pain acceptance—in particular as reflected by a willingness to engage in activities despite pain—resulted in less increase in pain intensity and more improvements in pain interference, physical function, depressive symptoms, and sleep quality. The findings indicate that previous research supporting the importance of pain acceptance to function in patients from health care settings extends to individuals with chronic pain living in the community. Moreover, they indicate that pain acceptance may have long-lasting (up to 3.5 years) beneficial effects on subsequent pain and function and on the association between change in pain and depression. Research to examine the potential benefits of community-based treatments that increase pain acceptance is warranted.

Keywords: Chronic pain, Acceptance, Pain intensity, Physical function, Sleep quality

1. Introduction

Chronic pain is a common problem for many individuals with physical disabilities,[18,44] including individuals with spinal cord injury (SCI),[17] multiple sclerosis (MS), postpolio syndrome (PPS),[33] and muscular dystrophy (MD).[27] Moreover, chronic pain in individuals with disabilities is refractory to many biomedical treatments[20] and can be detrimental to function and quality of life.[44] There continues to be an urgent need to understand the modifiable factors that influence chronic pain and mitigate its impact in this population.

Pain-related beliefs and coping responses have been shown to influence pain and to respond to psychosocial interventions.[32] Historically, however, research has focused disproportionately on the prevention of responses believed to be maladaptive, such as distorted cognitions, beliefs, and coping behaviors. In more recent years, there has been an increased interest in identifying and fostering *adaptive* responses that predict more positive outcomes.

One potentially important psychosocial factor that could contribute to better adjustment to chronic pain is pain acceptance.[41] Pain acceptance can be defined as (1) a willingness to experience pain while also (2) engaging in behaviors consistent with one's values despite pain.[36,39,42] Greater pain acceptance, as operationalized by measures of these 2 domains, has been shown to be associated with less pain intensity, pain-related anxiety, avoidant behavior, depression, and physical disability in cross-sectional studies.[38,55] Acceptance has also been shown to buffer the effect of pain intensity on daily function[25] and to buffer the effects of catastrophic thinking on anxiety, depression, and disability.[53] Intervention studies show that treatments such as Acceptance and Commitment Therapy, Cognitive Behavioral Therapy, Interdisciplinary Pain treatment, and Mindfulness-Based Stress Reduction increase pain acceptance,[1,6,11,19,35,52,54] and that these increases are associated with better treatment outcomes.[6,40,52] Maintenance of these improvements in acceptance has also been shown to be associated with maintenance of treatment-related gains in mood and function.[7]

However, most studies to date have relied on cross-sectional data and are, therefore, unable to examine several important issues, such as the extent to which pain acceptance domains assessed at one time prospectively predict important outcomes assessed later. Moreover, the items usually used to assess the pain acceptance domain of willingness to engage in activities despite pain have conceptual and item overlap with measures assessing outcome domains reflecting disability and pain interference.[36] This confound can inflate the associations found in cross-sectional studies and therefore limit the conclusions that can be drawn. To address these issues, we sought to determine whether pain acceptance at one time predicts a variety of key pain-related domains assessed 3.5 years later using an approach that statistically controls for the potential confound because of item

overlap. We also sought to determine whether pain acceptance has a moderating effect on the associations between a change in pain intensity and change in symptoms and in function over time. We hypothesized significant main effects, such that those individuals reporting higher initial levels of acceptance would report better function (or less increases in dysfunction) over time, and significant interaction effects, such that those endorsing higher levels of acceptance would evidence weaker associations between subsequent changes in pain and function.

2. Methods

2.1. Participants

Study participants were recruited to participate in a longitudinal survey examining secondary conditions in a sample of adults living with long-term physical disability. Eligible individuals were 18 years of age or older, were able to read and understand English, and self-reported a physician's diagnosis of MS, MD, PPS, or SCI. All study procedures were reviewed and approved by the University of Washington Human Subjects Division (HSD# 35664).

2.2. Procedures

Participants were recruited through 3 sources: (1) invitation letters sent to disability-specific research registries (eg, the University of Washington Participant Pool and the University of Rochester MD Registry), (2) invitation letters to former research participants at the University of Washington, and (3) web and print advertisements. After completion of an over-the-phone eligibility screen and information statement, participants were mailed an initial (T1) survey along with a postage-paid return envelope and informed consent form. Research staff then reviewed completed surveys for incomplete or missing information, collected missing data over the phone if necessary, and mailed participation payments of $25. All participants who provided responses to the T1 survey were sent a follow-up survey approximately 3.5 years later (here called the T2 survey). A secondary aim of the longitudinal research project was to collect in-depth data on health and functioning in middle-aged participants, and as a result, individuals between the ages of 45 and 65 also completed 2 additional surveys (spaced between T1 and T2). However, these surveys did not contain variables relevant to the present analysis, came from a much smaller number of participants, and are therefore not included here. Complete data were available for 1877 individuals at T1 and 1594 individuals at T2.

Surveys at both time points included key outcomes, including measures of pain intensity, pain interference, physical function, depressive symptoms, and sleep disturbance (see Section 2.3., below). However, to minimize participant burden, a measure of pain acceptance (the Chronic Pain Acceptance Questionnaire [CPAQ[42]]) was provided only to a randomly selected subset of approximately half of the T1 participants and was not included in the T2 survey. Of the 1877 T1 participants, 928 were selected to receive the CPAQ, and of these, 484 endorsed the presence of chronic pain and completed this measure. Of these 484 individuals, 392 completed both the CPAQ at T1 and subsequent survey at T2 and made up the sample for the present analyses.

2.3. Measures

2.3.1. Pain acceptance

Pain acceptance was assessed using the 20-item CPAQ,[21,42] which can be scored to provide a total pain acceptance score and

was originally designed and believed to assess 2 pain acceptance domains: (1) the degree to which an individual engages in activities regardless of pain (Activity Engagement) and (2) the respondent's willingness to experience pain (Pain Willingness). Although the CPAQ has generally demonstrated acceptable reliability and validity,[21,42] a recent content analysis of the CPAQ noted 2 problems with the CPAQ family of measures. First, most of the items on the Activity Engagement scale have conceptual and item overlap with self-report measures of pain interference and disability. Examples of such items include, "Although things have changed, I am living a normal life despite my chronic pain" and "I am getting on with the business of living no matter what my level of pain is." As a result, the associations between the CPAQ Activity Engagement scale and measures of pain interference or disability are likely to be artificially inflated. To determine the true (unbiased) association between activity engagement and function, it would be necessary to either (1) stastically control for item overlap in the analyses or (2) use criterion measures assessing function domains that do not have item overlap with the activity engagement items (eg, measures of sleep quality or depression). We use both of these strategies to address the issue of item overlap in this study.

A second problem associated with the CPAQ and many other pain acceptance measures is that *all* of the items assessing pain willingness in fact ask the respondent to rate the extent to which they think it is important or necessary to control pain, which is a different construct than pain willingness.[36] The CPAQ scoring instructions require that all of the items be reverse scored before summing. Thus, the CPAQ Pain Willingness scale score represents "not believing that pain control is necessary" more than "willingness to experience pain." Lauwerier and colleagues recommend that the scales using such items should be labeled based on what they are actually measuring and suggest that the items not be reverse scored, and the resulting scale be called *Pain Control*.[36] Because this label is also used for measures assessing pain control attributions,[32] to minimize the chances of confusion, here we use the label *Need for Pain Control* and computed the scale score by summing the items in this scale (ie, we did not reverse score them).

2.3.2. Average pain intensity

Average pain intensity in the past week was assessed using a 0 to 10 numerical rating scale with 0 = "*None*" and 10 = "*Very severe*." Numerical rating scales are commonly used in pain research and have a great deal of evidence supporting their reliability and validity as measures of pain intensity.[29,31] We subtracted the T2 from T1 ratings to create an average pain intensity change score, with positive values representing a decrease in pain intensity and negative values representing an increase in pain intensity.

2.3.3. Pain interference

We used 10 items from the patient reported outcomes measurement information system (PROMIS) pain interference item bank to assess pain interference, using a 6-item short form at T1 (example items, "How much did pain interfere with your day-to-day activities?", "How much did pain interfere with your enjoyment of life?", rated "in the past 7 days," on a 1 ["Not at all"] to 5 ["Very much"]) and the 4 pain interference items from the PROMIS profile 29 at T2 (example items, "How much did pain interfere with your day-to-day activities?", "How much did pain interfere with your household chores?", rated "in the past 7 days," on a 1 ["Not at all"]

to 5 ["Very much"] scale).[2,12] As with all PROMIS instruments, the scores are on a *t*-score metric, with a score of 50 representing the mean of the normative sample (in the case of pain interference, the normative sample was representative of the general U.S. population). Higher scores indicate greater pain interference. The PROMIS pain interference item bank has been validated for its use in adults with MD, MS, PPS, and SCI.[5,16]

2.3.4. Physical function

We assessed physical function using the PROMIS physical function item bank.[12,48] In the T1 survey, we used 10 items from the item bank that the investigators determined would best reflect a broad area of physical function domains in the population being studied (items included, "Are you able to walk more than a mile?", "Are you able to wash and dry your body?", "Are you able to do housework like vacuuming or sweeping floors?" rated as a participant's "usual or average performance" on a 1 ["unable to do"] to 5 ["without any difficulty"] scale) because at the time, the PROMIS short forms had not yet been created. In the T2 survey, we used the 12-item short form that had been developed for mobility aid users (items included, "Are you able to wash and dry your body?", "Are you able to cut your food using eating utensils?", "Are you able to get on and off the toilet?", rated on a 1 ["Without any difficulty"] to 4 ["With much difficulty"] scale).[3] The 10 items in the T1 survey were scored with IRTPRO software, using published item parameters and transformed into the *t*-metric. The T2 survey was scored after published instructions. Scores based on any subset of items from IRT-calibrated item banks are directly comparable. The reliability and validity of scores based on the physical function item bank has been demonstrated in disability populations and in samples of individuals with chronic pain.[9,26]

2.3.5. Depressive symptoms

We assessed depressive symptoms using items from the PROMIS depression item bank.[46,50] Version 1 of the 8-item short form[13] was used in the T1 survey, and the 4-item Profile 29 short form[12] was used in T2 survey (example items shared on both measures, "In the past 7 days…I felt worthless," "…I felt helpless," "…I felt depressed," "…I felt hopeless," rated on a 1 ["Never"] to 5 ["Always"] scale). Both short forms have exhibited excellent validity and reliability.[4,5]

2.3.6. Sleep disturbance

Items to assess sleep disturbance were selected from the PROMIS sleep disturbance item bank.[10] The version 1, 8-item short form[10] was in the T1 survey, and the 4-item short form from the profile 29[12] was used in the T2 survey (example items, "In the past 7 days…My sleep quality was…," rated on a 1 ["Very poor"] to 5 ["Very good"] scale, and "…My sleep was refreshing," rated on a 1 ["Not at all"] to ["Very much"] scale).

2.4. Data analyses

We first computed descriptive statistics (mean, SDs, percentages, as appropriate) for the demographic and study variables to describe the sample. Next, we examined the predictor and criterion variables to ensure that they met the assumptions required for the planned regression analyses. We then conducted 10 hierarchical linear regression analyses to test the study hypotheses. Measures of pain, symptoms, and function (ie, average pain intensity, pain interference, physical function,

depressive symptoms, and sleep disturbance) measured 3.5 years (ie, T2 survey) after T1 were the criterion variables. We centered the predictor variables before these analyses, to avoid multicolinearity that would be created using interaction terms. For each equation, we first entered the T1 score on the criterion domain in the first step. Any predictor variable entered after this step then predicts essentially the T1 to T2 change in the criterion variable (ie, the residual of the T2 criterion controlling for T1 levels[15]), although controlling for the potential confounding effects of the initial levels of the criterion variables. Importantly, this analytic approach addresses the significant issue of item overlap (between measures of acceptance and criterion measures assessing pain interference and disability, specifically[36]) because the residual—what is predicted after control for initial criterion variable scores—no longer represents *amount* of the criterion (eg, disability or pain interference), but *change* in the criterion, and has any variance associated with item overlap with the T1 CPAQ scales removed. The T1 pain acceptance scales (Activity Engagement or Need for Pain Control) were then entered in step 2 (to test for the main effects of pain acceptance on change in symptoms and function) for all of the analyses, followed by the T1 to T2 change in pain intensity (step 3) for all of the analyses except those predicting T2 pain intensity. Finally, the change in pain × activity engagement or change in pain × need for pain control interaction terms, as appropriate, were entered as a block, to test for the hypothesized interaction effects of initial pain acceptance on the associations between change in pain intensity and change in function over time (for all analyses except those predicting T2 pain intensity). In these analyses, we computed variance inflation factors (VIFs) to check for possible multicolinearity. A VIF of 10 or greater is indicative of high multicolinearity among the predictors, which can result in unreliable estimates.[8,34,47] To balance the need for control for the increased risks of type 1 error (determining that an effect is present when, in fact, it is not present in the population) against the risks for type 2 error (concluding that an effect is not present when, in fact, it is present in the population), we set the alpha level at $P < 0.01$ to determine statistical significance and alpha levels of $0.01 < P < 0.05$ to identify trends. In the event that an interaction term was significant or demonstrated a trend, we planned to compute correlation coefficients between change in pain and change in the criterion variable(s) separately for individuals above and below the median in the pain acceptance measures, to help understand the effect.

3. Results

3.1. Participant description and study variable mean and standard deviations

Sample descriptive information are presented in **Table 1**, and the mean and SDs of the study variables from the T1 and T2 surveys are presented in **Table 2**. As can be seen, the average age of the sample was approximately 56 years and most (62%) were women. About the same numbers of participants had SCI (31%), PPS (28%), and MS (26%), but there were fewer participants with MD (15%). Most of the participants described themselves as white (93%).

Initial pain intensity scores indicated that the sample reported moderate (5.09 on the 0-10 scale) pain intensity levels, on average. Higher than normative (50.00) initial scores on the PROMIS pain interference (60.10), depression (54.02), and sleep disturbance (54.59) measures, and lower than normative values on the PROMIS physical function (34.87) measure are consistent with them being a sample of individuals with both chronic pain and physical disabilities.[4,9,22,43] Average pain increased

Number (and rates) of categorical descriptive variables and mean and SD of participant age.

Variable	N (%)	Mean (SD)
Sex		
Men	148 (38)	
Women	244 (62)	
Age (years)		55.66 (12.21)
Diagnosis		
Muscular dystrophy	58 (15)	
Multiple sclerosis	103 (26)	
Postpolio syndrome	111 (28)	
Spinal cord injury	120 (31)	
Race/ethnicity		
White	366 (93)	
Black	10 (3)	
Asian	3 (1)	
American Indian/Native American	2 (1)	
Other	10 (3)	

substantially (approximately 1.13 points, or a little over a half a SD unit) from T1 to T2, but little systematic change was observed on the other symptom and function domains, on average. However, the SDs approached or exceeded a full SD unit for the measures of all of the variables, indicating substantial change in these measures between individual participants; ie, many of the participants reported large changes in these variables over time, with some reporting increases and others decreases on the pain intensity and PROMIS measures. This supports the planned use of regression analyses to identify the personal factors that predict subsequent change over time in pain intensity, pain interference, physical function, depression, and sleep disturbance.

3.2. Regression analyses

3.2.1. Assumptions testing

Based on the criterion requiring that (1) the variables to be used in the regression analyses did not have significant skew, kurtosis, outliers, or heteroscedasticity (based on skew <2.0, kurtosis <2.0, and a visual inspection of the scatter plot of residuals), and that (2) a lack of multicolinearity among the predictor variables (based on correlation coefficients <0.70[49]), all of the variables met the assumptions of multiple regression.

3.2.2. Pain acceptance main effects

The results of the planned regression analyses are presented in **Tables 3 and 4**. For each step of each analysis, the VIF hovered around 1, indicating that multicolinearity was not having a biasing

Mean and SD of the study variables assessed at T1 and T2.

Variable	T1 mean (SD)	T2 mean (SD)	ΔT1-T2 mean (SD)
Need for pain control	24.87 (11.00)		
Activity engagement	43.94 (12.13)		
Average pain intensity	5.09 (1.93)	6.21 (2.45)	−1.13 (2.32)
Pain interference	60.10 (6.29)	59.42 (8.60)	0.67 (7.05)
Physical function	34.87 (8.76)	35.79 (9.93)	−0.92 (5.82)
Depression symptoms	54.02 (8.64)	51.06 (9.11)	2.96 (8.39)
Sleep disturbance	54.59 (9.45)	52.20 (9.02)	2.39 (7.97)

T1-T2 difference scores that are negative indicate an increase in the variable, and scores that are positive indicate a decrease in the variable from T1 to T2 (3.5 years later).

influence on the results. Significant ($P < 0.01$) main effects for pain acceptance at T1 predicting change in the criterion variables were found for 4 of the 10 regression analyses performed; trends ($0.01 < P < 0.05$) were found for 2 more (**Tables 3 and 4**). In every case, higher initial levels of pain acceptance (as reflected by higher scores on Activity Engagement and lower scores on Need for Pain Control) were associated with better outcomes over time; ie, more improvement in depressive symptoms and sleep disturbance, and less increase in pain intensity and pain interference.

3.2.3. Pain acceptance interaction effects

Significant interaction effects, indicating a moderating effect of pain acceptance on the association between change in pain intensity and change in function, did not emerge. However, a trend ($0.01 < P < 0.05$) did emerge in one of the regression equations: activity engagement × change in pain predicting change in depressive symptoms. Correlation analyses performed to examine the nature of this relationship indicated that, as predicted, a positive and significant association between change in pain and change in depression among those with relatively low activity engagement acceptance ($r = 0.17$, $P < 0.05$), and a weaker association between changes in pain and depression among those with relative high activity engagement acceptance ($r = 0.00$, $P =$ NS).

4. Discussion

The findings are consistent with models that hypothesize pain acceptance is an adaptive stance for living with chronic pain. All of the findings were in the hypothesized directions, with (1) higher initial willingness to engage in activities despite pain moderating the strength of the association between subsequent changes in pain intensity and changes in depression, and (2) higher initial pain acceptance predicting subsequent improvements or lack of deterioration in important symptom and function domains over a 3.5-year period. The findings have important clinical and research implications.

From a clinical perspective, the findings suggest that pain acceptance may play a role in determining the trajectory of subsequent function in individuals with disabilities and pain. Previous research suggesting that pain acceptance is associated with important quality of life domains[21,38] and mediates the effect of pain on quality of life,[24,52] and the effects of chronic pain treatment[1,6,11,40,52,54] has focused primarily on individuals seeking treatment of chronic pain. Conclusions from these findings were also limited by the problem of significant item overlap between measures of acceptance and measures of function.[36] The current findings extend this work by showing that pain acceptance may also play a role in individuals with chronic pain who are living in the community (ie, individuals not necessarily receiving pain treatment). Importantly, significant effects emerged, even when controlling for initial scores on the criterion measures, which controls for the possibility of artificial inflation of associations because of the overlap of items assessing acceptance and function at the same time.[36]

The findings suggest the possibility that individuals with chronic pain who are not in active treatment could potentially benefit from community-based interventions that target pain acceptance. Such interventions could include web-based learning programs that teach simple well-being exercises and that require few resources to maintain once they are established (eg, Ref. 45). Clinicians who interact with these individuals when providing

Table 3

Regression models predicting T2 measures of function from the pain willingness scale, controlling for initial measures function (N = 392).

Step: predictor variable	ΔR^2	F (ΔR^2)	β	t	P	VIF
T2 average pain intensity (overall model: $F_{(2,389)}$ = 53.54, $P < 0.001$)						
Step 1: initial average pain intensity	0.21	105.11	0.46	10.25	<0.001	1.00
Step 2: need for pain control	0.00	1.77	0.06	1.33	0.185	1.14
T2 pain interference (overall model: $F_{(4,387)}$ = 80.80, $P < 0.001$)						
Step 1: initial pain interference	0.35	208.69	0.59	14.45	<0.001	1.00
Step 2: need for pain control	0.01	3.32	0.09	1.82	0.069	1.54
Step 3: change in pain intensity	0.10	69.63	−0.31	8.35	<0.001	1.00
Step 4: need for pain control × change in pain	0.00	1.92	−0.05	1.39	0.167	1.01
T2 physical function (overall model: $F_{(4,387)}$ = 198.28, $P < 0.001$)						
Step 1: initial physical function	0.66	759.76	0.81	27.56	<0.001	1.00
Step 2: need for pain control	0.00	2.93	0.05	1.71	0.088	1.03
Step 3: change in pain intensity	0.01	9.95	0.09	3.16	0.002	1.01
Step 4: need for pain control × change in pain	0.00	0.36	0.02	0.60	0.547	1.01
T2 depressive symptoms (overall model: $F_{(4,387)}$ = 48.96, $P < 0.001$)						
Step 1: initial depressive symptoms	0.31	173.48	0.56	13.17	<0.001	1.00
Step 2: need for pain control	0.02	9.73	0.14	3.12	0.002	1.11
Step 3: change in pain intensity	0.01	5.40	−0.10	2.32	0.021	1.01
Step 4: need for pain control × change in pain	0.00	1.16	0.05	1.08	0.283	1.01
T2 sleep disturbance (overall model: $F_{(4,387)}$ = 77.40, $P < 0.001$)						
Step 1: initial sleep disturbance	0.40	254.59	0.63	15.96	<0.001	1.00
Step 2: need for pain control	0.02	11.84	0.14	3.44	0.001	1.04
Step 3: change in pain intensity	0.03	19.46	−0.17	4.41	<0.001	1.01
Step 4: need for pain control × change in pain	0.00	2.49	0.06	1.58	0.115	1.02

VIF, variance inflation factor.

basic or general health care could be taught strategies that could enhance pain acceptance, such as pain neuroscience education interventions (eg, Ref. 37) or skills to let go of efforts to control pain, when such efforts are actually interfering with valued activities. The current findings also suggest that the treatment needs of individuals who are already relatively high in acceptance may differ from those who are low in acceptance, which is consistent with previous research.[53]

One of the interesting patterns that emerged from this study was a tendency for the Activity Engagement scale to evidence a more consistent pattern of significant associations with the symptom and function domains assessed relative to the Need for Pain Control scale. Although most of the research in this area has used the total CPAQ score in their analyses (eg, Refs. 7,25,38,40,52–55), a number of studies have examined the 2 subscales individually. Two studies have shown similar patterns of associations between the 2 CPAQ scales and measures of function.[42,53] However, other recent studies have shown—as we did here—stronger relationships between the Activity Engagement scale and measures of pain-related outcomes, relative to the Pain Willingness scale (here labeled the Need for Pain Control scale).[6,21] The stronger association between activity engagement and outcomes could potentially have been explained by the conceptual overlap between the CPAQ items that measure activity engagement and the criterion variables examined in this research assessing pain interference or disability.[36] However, in this study, we controlled for the initial measures of the outcome

domains (which would include the variance associated with shared item overlap) before examining pain acceptance as a predictor—and significant effects, including significant effects for predicting pain interference from the Activity Engagement scale still emerged.

Moreover, studies examining the immediate effects of psychosocial treatments on both of the pain acceptance domains show substantially greater effects on the CPAQ Activity Engagement scale than Pain Willingness scale.[6,35,52] These findings suggest that it may be easier to foster acceptance in concrete behavioral ways, such as engaging in activities, than to directly alter an individual's stance toward pain. The findings are also consistent with the idea that contextual factors may play an important role in what (and how much) a patient is willing to accept. For example, one study has found that less pain-related behavioral avoidance occurred, when subjects were offered a reward for making painful movement than when they were not offered a reward[14]; contexts that provide rewards for greater activity may be more plentiful than those that provide rewards for pain willingness.

Encouraging pain acceptance—in particular engaging in activities despite pain—is also a central focus of most psychosocial pain treatments, including operant treatment approaches,[23] Acceptance and Commitment Therapy,[41] Motivational Interviewing,[28] hypnosis treatments that include suggestions for activity engagement,[30] in vivo desensitization,[51] interdisciplinary pain treatment,[24] and many others. This fact

Table 4

Regression models predicting T2 measures of function from the from the activity engagement scale (N = 392).

Step: predictor variable	ΔR^2	F (ΔR^2)	β	t	P	VIF
T2 average pain intensity (overall model: $F_{(2,389)}$ = 56.14, $P < 0.001$)						
Step 1: initial average pain intensity	0.21	105.11	0.46	10.25	<0.001	1.00
Step 2: activity engagement	0.01	5.87	−0.12	0.42	0.016	1.13
T2 pain interference (overall model: $F_{(4,387)}$ = 85.97, $P < 0.001$)						
Step 1: initial pain interference	0.35	208.69	0.59	14.45	<0.001	1.00
Step 2: activity engagement	0.03	15.26	−0.20	3.91	<0.001	1.64
Step 3: change in pain intensity	0.09	68.81	−0.31	−8.30	<0.001	1.00
Step 4: activity engagement × change in pain	0.00	0.00	−0.00	0.02	0.986	1.02
T2 physical function (overall model: $F_{(4,387)}$ = 199.59, $P < 0.001$)						
Step 1: initial physical function	0.66	759.76	0.81	27.56	<0.001	1.00
Step 2: activity engagement	0.00	2.93	−0.05	1.71	0.088	1.06
Step 3: change in pain intensity	0.01	10.48	0.09	3.24	0.001	1.00
Step 4: activity engagement × change in pain	0.00	1.57	−0.04	1.25	0.210	1.03
T2 depressive symptoms (overall model: $F_{(4,387)}$ = 48.19, $P < 0.001$)						
Step 1: initial depressive symptoms	0.31	173.48	0.56	13.17	<0.001	1.00
Step 2: activity engagement	0.01	5.30	−0.11	2.30	0.022	1.36
Step 3: change in pain intensity	0.01	4.58	−0.09	2.14	0.033	1.00
Step 4: activity engagement × change in pain	0.01	4.25	0.09	2.06	0.040	1.02
T2 sleep disturbance (overall model: $F_{(4,387)}$ = 74.13, $P < 0.001$)						
Step 1: initial sleep disturbance	0.40	254.59	0.63	15.96	<0.001	1.00
Step 2: activity engagement	0.01	8.18	−0.12	2.86	0.004	1.10
Step 3: change in pain intensity	0.03	17.55	−0.16	4.19	<0.001	1.00
Step 4: activity engagement × change in pain	0.00	0.51	0.03	0.71	0.476	1.02

The statistics associated with step 2 predicting T2 physical function (with the exception of VIF) seem to be the same as those associated with this step (but with the need for pain control as the predictor) presented in Table 3. However, the results of the 2 analyses were slightly different, although they rounded to the same numbers.

VIF, variance inflation factor.

provides even more support for the importance of the construct and the idea that pain acceptance may indeed be a shared mechanism of a number of psychosocial pain treatments.[1,6,11,40,52,54]

The findings pointing to larger effects of activity engagement acceptance also suggest that it may be more useful to focus on this observable expression of pain acceptance than on an expressed willingness to experience pain, to have the most beneficial effects. Thus, simple "acceptance" without a behavioral expression or component may be less likely to lead to positive changes in function. The relative importance of the 2 pain acceptance subfactors (and how they might or might not influence each other) remains an important topic of further study.

The study has a number of limitations that should be considered. First, although the findings supported a role for pain acceptance as a predictor of subsequent changes in a number of important pain-related outcomes, the effect sizes were generally weak. However, it may be useful to keep in mind that these reflect the ability of pain acceptance to predict changes in outcomes over the course of 3.5 years—a relatively long period, where many factors could intervene to influence domains such as pain interference, depression, and sleep quality. The fact that significant effects emerged despite the 3.5-year time span supports the importance of the construct, consistent with its centrality in so many chronic pain theoretical models and treatments. Moreover, we controlled for T1 to T2 change in pain intensity in all of the analyses (except in the analyses predicting

change in pain intensity). Although this approach provides a conservative test for these effects, it also reduces their potential explanatory power. An additional limitation is that this study was performed in the context of a longitudinal and ongoing survey of individuals with disabilities living in the community. Thus, the sample may not be entirely representative of the populations of individuals with disabilities and chronic pain, and these differences could have potentially affected the results in ways we are not able to determine. Also, because the study was observational, the changes we observed in both the predictor and criterion variables may not have been as large as one might expect in a clinical trial, further reducing our ability to detect true effects because of relatively low levels of variation. The study design also involved the exclusive use of self-report measures, which could have potentially artificially increased the strength of the associations found. Future research should include the use of observational measures of outcomes to better understand the role that pain acceptance plays in function.

As mentioned previously, a significant limitation of research in this area is the conceptual and item overlap between measures of the activity engagement domain of acceptance (ie, willingness to engage in activities despite pain) and measures of patient function.[36] We attempted to address this issue in these analyses by controlling for the initial scores of the criterion variables, which should control for the variance in the criterion measure due to item overlap because by definition that variance would be included in the initial measure. Still, having a measure of "willingness to

engage in activities" as a predictor of measures of criterion variables that themselves reflect activity level is clearly problematic. Future researchers should be sure to include measures of criterion variables that have minimal conceptual overlap with the measure(s) of acceptance whenever possible.

Finally, although the results of the current prospective longitudinal study provide some support for a causal influence of pain acceptance on pain, symptoms, and function in individuals with chronic pain, this study's design is still based on observational data. Research to evaluate (1) the causal effects of pain acceptance on patient function and (2) a potentially greater role for the activity engagement component of acceptance is warranted. For example, procedures or treatments could be designed that selectively target activity engagement more than pain willingness and vice versa, and patients could be randomly assigned to each condition in an experiment to determine the causal impact of the procedures, and whether any observed changes in pain acceptance explain the benefits found.

Conflict of interest statement

The authors declare no conflicts of interest related to this study.

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