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Predictive Relationships between Chronic Pain and Negative Emotions: a Four Month Daily Process Study Using Therapeutic Interactive Voice Response (TIVR)

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Abstract

This paper examines temporal relationships between negative emotions and pain in a cohort of 33 patients with chronic musculoskeletal pain enrolled in a telephone-based relapse prevention program [Therapeutic Interactive Voice Response (TIVR)], following 11 weeks of group Cognitive Behavioral Therapy (CBT). Patients were asked to make daily reports to the TIVR system for four months following CBT. Patients' daily reports were analyzed with path analysis to examine temporal relationships between three emotion variables (anger, sadness and stress) and two pain variables (pain and pain control).

As expected, same-day correlations were significant between emotion variables and both pain and pain control. The lagged associations revealed unidirectional relationships between pain and next-day emotions: increased pain predicted higher reports of sadness the following day ($p<0.05$). Conversely, increased pain control predicted decreased sadness and anger the following day ($p<0.05$). Unlike some previous studies, this study did not reveal that an increase of negative emotions predicted increased next-day pain.

We speculate that CBT treatment followed by the relapse prevention program teaches patients how to modulate negative emotions such that they no longer have a negative impact on next-day pain perception. The clinical implications of our findings are discussed.

Keywords

daily diary; chronic pain; emotions; Interactive Voice Response; pain control

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INTRODUCTION

Prior research has consistently demonstrated same-day associations between emotion variables and pain. For example, daily fluctuations in emotion-related variables such as anger, sadness, and stress are positively correlated with same-day fluctuations in the reported severity of pain among chronic pain sufferers.1,6 While causal associations between emotion and pain have been demonstrated in laboratory and treatment outcome research, 2,7,13 discerning causal relationships between emotion-related variables and pain (and vice versa) is more problematic. Unless multiple measurements are taken each day, same-day correlations are irrelevant to a causal inquiry between emotion and pain.

Determining causal relationships between emotion-related variables and pain could be highly beneficial for improving prevention efforts and treatment outcomes. Prospective daily-process research designs (e.g. ascertaining serial daily ratings of both emotion and pain) offer a number of benefits for establishing temporality among the aforementioned relationships.1 However, despite the potential benefits of a daily process approach, there are relatively few such studies exploring temporal relationships between the experience of chronic pain and emotion variables such as anger, sadness, and stress. Moreover, findings across the available studies are inconsistent. For example, in the daily process study of sickle cell pain completed over 91 days, Gil and colleagues showed a bi-directional temporal relationship between changes in mood and stress and episodic fluctuations of sickle cell anemia pain.5 However, an earlier study by Gil and colleagues revealed a unidirectional relationship in which pain predicted stress and mood, but not the reverse in adolescents with sickle cell disease.4 Affleck and colleagues explored the role of daily stress on pain in a sample of 74 patients with chronic rheumatoid arthritis. In contrast to the sickle cell pain studies, the authors “failed to disclose any reliable overall pattern of lagged effects of daily stressors on next-day…pain.”1 In a daily diary study, however, Connelly et al.3 demonstrated that emotional regulation modulates pain fluctuations in patients with rheumatoid arthritis.

We have previously published results from both a pilot study and a later from a randomized controlled trial demonstrating the efficacy of an automated telephone-based relapse prevention program called Therapeutic Interactive Voice Response (TIVR) following an 11-week group Cognitive Behavioral Therapy (CBT) intervention designed for patients suffering from chronic musculoskeletal pain.10,11 As a research tool, the TIVR provides daily data on a variety of emotional, behavioral, and pain variables. The objective of the present paper is to analyze the daily self-reports of emotion-related variables (anger, sadness, and stress) in relation to daily fluctuations in self-reported pain and pain control in patients enrolled in our TIVR treatment protocol for chronic musculoskeletal pain conditions.

The primary goal of the current report is to examine predictive relationships between emotions and pain in patients with chronic musculoskeletal pain during four months of TIVR relapse prevention training after attending 11 weeks of group CBT. Based on previous studies, we hypothesized that there would be significant bidirectional, predictive relationships among levels of pain, pain control and negative emotions.

MATERIALS AND METHODS

Overview

This is a secondary analysis of data collected in two prospective studies of the effectiveness of Therapeutic Interactive Voice Response (TIVR) as a relapse prevention tool for patients with chronic musculoskeletal pain. Results on the primary outcomes have been previously

published independently.10,11 Since the designs of both studies were nearly identical and conducted by the same study team, data from the two studies have been combined for the purposes of the analyses reported herein. Detailed descriptions of the original methods can be found in the two Naylor publications cited above, 10,11 and are briefly summarized here.

Patients with persistent chronic musculoskeletal pain were referred by community physicians to the MindBody Medicine Clinic for group CBT focused on pain coping skills training. Average time since pain onset for these patients was 10 years, typically with an inadequate response to surgery and/or medication. Patients commonly mentioned the desire to decrease pain, improve coping, and reduce medication use as reasons to enroll in the group coping skills training. All of the patients included in this analysis completed 11 weeks of manualized group CBT consisting of weekly 90-minute group sessions. Within the context of the experimental protocol, patients who completed the 11 weeks of group CBT participated in a controlled trial testing TIVR as a method of relapse prevention. The TIVR is a multi-component automated phone system based on Interactive Voice Response technology in which callers are asked prerecorded questions and respond using the telephone keypad. Users can also review and practice coping skills and receive personal monthly messages.

The patients were asked to call the TIVR system once each day for four months to complete a 21-item, daily self-monitoring questionnaire. This daily questionnaire includes questions on intensity of emotions, degree of physical functioning, levels of pain, frequency of coping skills used, and other items referable to the reporting day. The exact wording of the five daily questionnaire items analyzed in this report appears in Table 1. Patients received no financial incentive for calls that they made. TIVR was primarily created as an intervention tool, but since part of the intervention (daily questionnaire) is an IVR-based daily diary, it provides data for causal analyses. As a daily process, the IVR data collection method offers several additional benefits compared to other methods. For example, each call is date- and time-stamped, and patients are not able to make up calls later than 24 hours after they are due. This allows some flexibility while obviating the risk of procrastination and minimizing the later retrospective recall bias inherent in most paper-based diaries.

The other TIVR components consist of on-demand options to review and/or rehearse skills learned in CBT, and to hear personal feedback messages that the CBT therapist records onto the TIVR once each month. This monthly feedback message includes encouragement and support as well as a review of skills and overall progress over the month. Thus, the questionnaire serves as a daily self-assessment tool that provides CBT therapists with the information to create a personalized monthly feedback message for each individual. Please see our prior publications for a more complete description of the TIVR system and its components. 10,11

Participants

A total of 36 patients who participated in our two previously published TIVR studies (10 patients in the first study and 26 patients in the second) were included in this daily data analysis. Because there were no differences in patient recruitment or the study designs, we combined the samples to increase statistical power and generalizability. In both studies, subjects were a consecutive sample of referrals to our MindBody Medicine Clinic for pain coping skills training. Study inclusion criteria were as follows: at least 6 months of musculoskeletal pain; reported pain severity of 4 or more on a the 10-point McGill Pain Questionnaire Short Form;8 ability to perform usual self-care; ongoing health care from a physician including any pharmacological pain management; possession of a touch-tone phone in the home; and age 18 or older. Study exclusion criteria were: current malignancy, radiation therapy, or chemotherapy causing or influencing chronic pain; a pending pain-

related surgical procedure; involvement in a pain-related litigation; psychosis, an uncontrolled DSM-IV Axis I disorder, or a severe personality disorder that would interfere with participation in group therapy; inability to use the telephone-based TIVR due to cognitive or hearing impairment.

In order to assess the direction of effect between the emotion and pain variables, lagged data was used. Specifically, we analyzed whether levels of emotion reported for a particular day showed a consistent relationship with levels of pain and pain control the following day, and vice versa. In order for the data from the TIVR daily questionnaire to be informative for these lagged analyses, we needed phone calls from the same patient on two successive days or "dyads." We decided that subjects should have at least 30 informative dyads to be included in the daily data analysis. Three patients with fewer than 30 dyads (n= 0, 10 and 18 dyads) were excluded from the analysis. The mean number of dyads for the remaining 33 subjects was 83 (range 32 to 128).

Human Studies Procedure

The University of Vermont Institutional Review Board reviewed and approved the research protocol. Signed informed consent was obtained from each research subject.

Methods

Relevant Variables from the TIVR Daily Questionnaire (Table 1)—Patients are asked to score each variable on a 10-point scale from 0=none to 9=worst you've ever had:1) level of Pain, 2) level of Pain Control; 3) level of Anger, 4) level of Sadness, 5) level of Stress.

Data Analysis—The daily TIVR data were modified by the following procedures. The data were de-trended for each patient individually (independent pre-whitening) as described by West and Hepworth.14 De-trending eliminates spurious correlations due to trends and allowed us to focus on the patterns in the day-to-day variations from the mean. The residuals from regression models in which time (i.e., day in study) was the sole predictor were extracted for the pain variables (Pain, Pain Control) and the emotion variables (Anger, Sadness, Stress). The residuals were standardized (i.e., transformed into z scores), again within each subject, since subjects' use of the rating scales could differ. Coefficients of subsequent analyses can be interpreted as standard deviation units.

Path analysis models using AMOS (version 7.0, Amos Development Corp, Spring House, PA, USA, 2007) were conducted to evaluate group level patterns. Subject-level regressions were run with the previous day's ratings (Pain or Pain Control, Anger, Sadness, Stress) predicting next day's ratings (Figure 1). The predictor variables were all correlated. Since the data had been standardized, the means and standard deviations had already been fixed across subjects. The regression coefficients and the correlations were fixed for the multi-subject AMOS models.

RESULTS

Demographic data for the 33 unduplicated patients included in this report are shown in Table 2. The ethnic origins of Vermont residents tend to be fairly homogeneous, thus most of the enrollees were Caucasian (94%). Additionally, most of the patients were women (91%), and the mean age of the sample was 46.9 years. As noted in Methods, patients were asked to call the TIVR every day for 4 months. On average, patients made 94 (73%) of the 120 calls over the 4 month period. For the lagged relationships, only calls occurring on successive days (informative dyads) were used. Of the 94 mean daily TIVR calls per person,

an average of 83 calls (88%), were made on successive days and thus informative for this analysis (Table 3).

Path analysis

1. Same-day Associations—The path analysis confirmed that the emotion-related variables were significantly correlated with both daily reports of pain and pain control on the same day (Table 4A). Thus, patients who reported high levels of anger, sadness, and stress on a given day were much more likely to report higher levels of pain on that day. The inverse relationships were found for pain control.

2. Next-day (lagged) Associations—The within-variable lagged associations (e.g., Anger predicting next-day Anger; Pain predicting next day Pain) were all highly significant (Table 4B). For all variables a rating of one standard deviation higher than average on a given day predicted a rating that was about one-third of a standard deviation higher than average on the following day.

The regression coefficients for the lagged relationships between the emotion variables and Pain or Pain Control are also reported in Table 4B. When the emotion-related variables (sadness, anger, stress) were used as the predictor of next-day pain or pain control, no significant correlations were obtained. When considering Pain as the predictor we found that patients who had higher levels of pain on a given day were much more likely to report greater sadness on the next day. Pain level on a given day, however, was not significantly related to next day anger or stress. When considering Pain Control as the predictor, we found that patients who reported high levels of pain control on a given day were likely to report decreases in anger or sadness the next day. The coefficients are small in comparison to the within-variable lagged relationships. For example, while the latter represents nearly 0.4 of a standard deviation in the case of sadness, pain's impact on sadness is 0.04 of a standard deviation.

DISCUSSION

Daily data were collected as part of a novel relapse prevention study employing Therapeutic Interactive Voice Response (TIVR) after 11-week group coping skills training (CBT) for chronic pain.

We found significant same-day associations between emotion and pain. On days that patients had high levels of anger, sadness, or stress, they were much more likely to report experiencing higher levels of pain. These findings are consistent with prior studies as well as conceptual models of pain, which view pain as a multidimensional experience that includes sensory, cognitive, and emotional components.[9,12] Our data also demonstrated that there were significant same-day associations between emotion and perception of pain control. On days that patients experienced high levels of anger, sadness, or stress, they were much less likely to be able to control their pain. However, no direction of effect can be inferred from these same-day data.

Our results only weakly support previous findings of causal relationships between pain and emotions. The findings of this study indicated that among a group of patients who had been trained in CBT, emotion-related experiences (sadness, anger, stress) on a given day were not predictive of either pain or pain control on the next day. However, we did find that both pain and pain control had a significant, albeit small, impact on anger and/or sadness. We speculate that the lack of any strong emotion-pain associations may be an effect of CBT training since a major goal of CBT for pain management is to alter the lingering effects of negative emotion on pain. CBT uses techniques such as cognitive restructuring that are

designed to help patients identify and challenge overly negative pain-related thoughts and by doing so to dampen the effects of emotions on subsequent pain experiences. Taken together, our findings suggest that emotions need not have persisting, next day effects on perceptions of pain and pain control, particularly in patients who have received training in emotion regulation strategies as part of an overall CBT for pain management protocol.

Many recent studies show that emotions do not simply occur in parallel with pain, but rather that there is an overlap between pain and emotion-related neurophysiological processes. For instance, most modern pain theories (e.g. neuromatrix theory, Price's 4- stage model of pain) maintain that the experience of pain should not be considered as an isolated sensory event but rather as a complex sensory and emotional experience. 9,12 Thus, it is reasonable to expect that an intervention such as CBT, which teaches patients to understand and control both the sensory and emotional aspects of pain, alters both pain sensation and emotional regulation. In addition, we speculate that CBT and TIVR have a greater effect on emotional regulation than on pain sensation. This effect may minimize any impact negative emotions have on next-day pain.

When considering Pain as the predictor we found that patients who had higher levels of pain on a given day were more likely to report greater sadness on the next day. Pain level on a given day, however, was not significantly related to next day anger or stress. Again, these findings are important in that they suggest that, among a group of patients who had undergone CBT for pain management, pain experiences on a given day were not likely (with the exception of sadness) to have lingering, next day effects on mood-related variables. It is possible that patients experiencing pain on a given day engage in pain coping strategies that enhance their perceptions of pain control and thereby are less likely to experience lingering, pain-related emotions the next day. Along these lines, it is interesting that we found that patients who reported high levels of pain control on a given day were significantly less likely to report anger or sadness the next day. Pain control is sometimes overlooked in relation to emotional status, yet it seems particularly relevant in the context of a behavioral intervention (i.e., CBT) which emphasizes changing pain perception and is thus geared as much toward coping with pain in a way that enhances perceptions of pain control as it is toward pain, per se.

We did observe that there were a number of subjects who showed stronger associations between pain and emotions while many of our patients did not. Future research may focus on this subset of subjects.

Clinical implications of this study's findings are twofold: because the changes in pain sensation influence the next day negative emotions, which in turn contribute to creation of vicious cycle of pain with depression and physical inactivity, it is important to treat pain as early and completely as possible. Second, based on previous studies 3,5 and our current results, we conclude that emotional regulation has an impact on pain fluctuations in patients with chronic pain. This would suggest that the beneficial influence of CBT on chronic pain occurs via improvements of emotional regulation. If this is in fact correct, we suggest that physicians who treat chronic pain patients should pay more attention to patients' negative emotions and daily stress related to their struggles, reassure and clarify patients' uncertainties to decrease anxiety and fear, and if necessary refer for individual therapy or groups for coping skills training.

Study Strengths and Limitations

Our subject sample size is modest (n=33), but our observation period of four months is one of the longest reported in the literature for daily process data. We also believe our analytical approach to be innovative in comparison to many published studies in this area. Multi-

subject path analysis allows complex relationships between multiple predictors and outcomes to be modeled within and across subjects simultaneously.

As all patients who participated in this study had just completed 11-week group CBT this study's findings may generalize only to patients with chronic pain who are willing and able to participate in a multi-week group intervention. In addition, the inclusion/exclusion criteria limit the generalizability of study findings to patients with musculoskeletal chronic pain only.

Conclusions

To the best of our knowledge, this is the first study that examines the causal relationship between negative emotions and pain in a population of adults with chronic musculoskeletal pain during a relapse prevention program following group CBT. We analyzed the lagged relationship of negative emotions not only with pain but also with patients' perception of pain control, which is one of the major goals of CBT. Based on daily reports over a four-month period, we have demonstrated: 1) strong within-day relationships between negative emotions, pain, and pain control; 2) strong within-variable serial correlations; 3) that fluctuations in pain and pain control were significantly associated with next-day fluctuations in anger and/or sadness; 4) but that none of the emotion variables predicted next-day pain or pain control. There could be two possible explanations for our study results described in points 3 and 4: 1) changes in negative emotions might not influence next day levels of pain in patients with chronic musculoskeletal pain even before the CBT treatment, or 2) CBT treatment followed by the relapse prevention program (TIVR) that teaches patients how to modulate negative emotions efficiently enough to prevent a negative impact on next day pain perception. This would suggest the beneficial impact of CBT on chronic pain via improvements of emotional regulation. However, since there are no comparative data using our methodology showing the connection between emotion variables and pain prior to CBT we cannot tell for sure whether the unidirectional relationship between pain and the next day negative emotions was in fact an effect of CBT.

Future analyses might try to assess not only the mechanism of the therapeutic effect of CBT combined with TIVR but also to identify the characteristics of treatment responders and non-responders and whether the latter are the subjects who have stronger pain-emotion associations.

Perspective

This study adds to the daily-process literature exploring predictive relationships between pain, pain control and daily emotions. Findings suggest that increased pain adversely impacts next-day emotions, and that increased pain control improves next-day negative emotions.

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Figure 1.
Path Analysis Model

Table 1

Relevant daily questionnaire items

Emotion Variable	Question to Participant
Anger	"Rate your highest level of anger from 0 not at all angry to 9 the angriest you've ever been."
Sadness	"At your worst how sad or blue did you feel from 0 not sad at all to 9 the saddest you've ever been."
Stress	"Rate your highest level of stress from 0 being no stress to 9 the highest level of stress you've ever experienced."
Pain	"Rate your highest level of pain on a scale from 0 completely free of pain to 9 the most severe pain you've ever had."
Pain Control	"Based on all you did to cope how much control do you feel you had over the pain from 0 having no control to 9 complete control."

Table 2

Demographics for the total sample

	n=33
Age	$\bar{x}$ = 46.9 ± 8.56
Gender	
•Females	30 (91%)
Race	
•White/Caucasian	31 (94%)
Martial Status	
•Never Married	6 (18%)
•Married/Living Together	24 (73%)
•Divorced/Separated	3 (9%)
Education in Years	$\bar{x}$ =14.21 ± 2.16
•9–12 years	11 (33%)
•13–16 years	18 (55%)
•17+ years	4 (12%)
•Did not report education	0 (0%)
Employment Status	
•full time employment	10 (30%)
•part-time employment	8 (24%)
•disability	12 (36%)
•unemployed	2 (6%)
•retired	1(3%)
Duration of Pain in Years Diagnoses (primary)	$\bar{x}$ =12.27 ± 8.75
•back pain	10 (30%)
•osteoarthritis	4 (12%)
•fibromyalgia	4 (12%)
•Temporomandibular Joint Disorder/jaw pain	2 (6%)
•headaches	6 (18%)
•post surgical/post trauma muscle pain	7 (21%)

Table 3

Frequency of TIVR use over 4 month study

n=33	
Mean number of calls per person (SD)	94 (24)
Mean number of dyads* per person (SD)	83 (29)
Frequency of daily calls made	
•More than 80% of the daily calls	13 participants
•50–80% of the daily calls	14 participants
•Less than 50% of the daily calls	6 participants

*Number of days with a call on the previous day.

Table 4

Path Analysis Results

Model 1. Pain		Model 2. Pain Control	
A. Same day correlations			
Pain, Anger	0.17**	Pain Control, Anger	−0.17**
Pain, Sadness	0.23**	Pain Control, Sadness	−0.23**
Pain, Stress	0.24**	Pain Control, Stress	−0.21**
Anger, Sadness	0.45**	Anger, Sadness	0.45**
Anger, Stress	0.47**	Anger, Stress	0.47**
Sadness, Stress	0.37**	Sadness, Stress	0.37**
B. Path coefficients (predicting next day ratings)			
Pain → Pain	0.32**	Pain Control → Pain Control	0.35**
Pain → Anger	0.02	Pain Control → Anger	−0.04*
Pain → Sadness	0.04*	Pain Control → Sadness	−0.04*
Pain → Stress	0.02	Pain Control → Stress	−0.02
Anger → Anger	0.30**	Anger → Anger	0.30**
Anger → Pain	0.01	Anger → Pain Control	0.01
Sadness → Sadness	0.39**	Sadness → Sadness	0.39**
Sadness → Pain	0.02	Sadness → Pain Control	0
Stress → Stress	0.32**	Stress → Stress	0.32**
Stress → Pain	0.03	Stress → Pain Control	−0.02

* $p<0.05$

** $p<0.001$