An experimental investigation of the relation between catastrophizing and activity intolerance

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Abstract

The present study examined the value of a measure of catastrophizing as a predictor of activity intolerance in response to delayed onset muscle soreness (DOMS). A sample of 50 (17 men, 33 women) sedentary undergraduates participated in an exercise protocol designed to induce muscle soreness and were asked to return 2 days later to perform the same physical maneuvers. Participants performed five strength exercises that emphasized the eccentric component of the muscle contraction in order to induce DOMS. Dependent variables of interest were the proportion reduction in total weight lifted, and the number of repetitions. Analyses revealed that catastrophizing, assessed prior to the first exercise bout, was significantly correlated with negative mood, pain and with reduction in weight lifted. Regression analyses revealed that catastrophizing predicted reductions in weight lifted even after controlling for pain and negative mood. These findings extend previous research in demonstrating that catastrophizing is associated with objective indices of activity intolerance associated with pain. Implications of these findings for understanding pain-related disability are addressed. © 2002 International Association for the Study of Pain. Published by Elsevier Science B.V. All rights reserved.

Keywords: Pain; Catastrophizing; Activity; Exercise

1. Introduction

Over the past decade, ‘pain catastrophizing’ has emerged as one of the most robust and reliable psychological predictors of pain experience. Across numerous clinical and experimental conditions, catastrophizing has been associated with heightened pain, emotional distress, and a variety of pain-related outcomes, including disability (Sullivan et al., 2001). The observed relation between catastrophizing and pain-related disability has led to suggestions that catastrophizing might represent a risk factor for the development of pain-related disability (Sullivan et al., 2001; Vlaeyen and Linton, 2000; Waddell, 1998). To date however, the research linking catastrophizing to pain-related disability has been primarily cross-sectional in design, and has relied almost exclusively on self-reported disability. There is a need for prospective research addressing the association between catastrophizing and objective indices of pain-related disability. It is toward this end that the current research was directed.

1.1. Catastrophizing and pain-related outcome

Catastrophizing is an individual difference variable that has been characterized as ‘an exaggerated negative mental set brought to bear during actual or anticipated painful experience’ (Sullivan et al., 2001). Research has supported a multidimensional conceptualization of catastrophizing, comprising elements of rumination (‘I can’t stop thinking about how much it hurts’), magnification (‘I’m afraid that something serious might happen’), and helplessness (‘There is nothing I can do to reduce the intensity of the pain’).

Although little is currently known about the factors that underlie the development or maintenance of catastrophizing, research has demonstrated repeatedly that the tendency to catastrophize in response to aversive stimulation contributes to negative emotional and physical outcomes (Sullivan et al., 2001). Early studies in this area focused primarily on the impact of catastrophizing on pain experience and emotional distress (Chaves and Brown, 1978, 1987; Spanos...
et al., 1979; Rosenstiel and Keefe, 1983). In more recent work, catastrophizing has been associated with several pain-related outcomes including duration of hospitalization (Gil et al., 1992), analgesic consumption (Bédard et al., 1997; Jacobsen and Butler, 1996), reduced involvement in activities of daily living (Keefe et al., 1989), and occupational disability (Burton et al., 1995; Sullivan et al., 1998).

On the basis of the emerging pattern of findings, it has been tempting to propose that catastrophizing might represent a risk factor for the development of disability subsequent to illness or injury (Sullivan et al., 1998, 2001; Waddell, 1998; Vlaeyen and Linton, 2000). However, a compelling test of the risk value of catastrophizing has yet to be conducted. Several factors limit the nature of conclusions that can be drawn from the existing literature. First, the bulk of research has been cross-sectional in design thus precluding inferences about the causal status of catastrophizing (e.g. Rosenstiel and Keefe, 1983; Sullivan et al., 1998). Even when prospective designs have been utilized, measures of catastrophizing have been administered only following the development of pain-related injury or illness (Keefe et al., 1989; Burton et al., 1995). Finally, research on catastrophizing and disability has relied almost exclusively on the use self-report measures of functional disability (Keefe et al., 1989; Burton et al., 1995; Martin et al., 1996; Robinson et al., 1997).

On the basis of research conducted to date, it is not possible to state with confidence that catastrophizing predicts objectively defined limitations in activity. Unless more precision can be brought to discussions of the role of catastrophizing in the development or maintenance of pain-related disability, theoretical and clinical advance will be hampered. The present research sought to address the predictive value of catastrophizing within an experimental context where healthy subjects were exposed to a pain-inducing procedure and then required to complete a strenuous physical activity protocol. The primary goal of the research was to determine whether scores on a measure of catastrophizing could prospectively predict objectively defined activity intolerance related to pain.

1.2. The present research

To address the association between catastrophizing and activity intolerance, a sample of healthy sedentary undergraduates were recruited and were guided through a strenuous exercise protocol. A strenuous exercise bout consisting of repeated lifting (i.e. concentric contraction) and lowering (i.e. eccentric contraction) of heavy loads was used to induce muscle pain (Vecchiet et al., 1999). Participants returned to the laboratory/gym 48 h later to participate in a second exercise bout involving the same physical maneuvers as the first exercise bout. This protocol was chosen as it has been shown to induce what is known as exercise-induced delayed onset muscle soreness (DOMS) which is characterized by soreness, swelling, stiffness and strength loss in the 24–48 h period following a strenuous bout of exercise (Armstrong, 1984; Clarkson and Tremblay, 1988). The muscle soreness that develops in the 48 h period following strenuous exercise is the result of structural damage to the involved muscle that produces a localized inflammatory response. Further edema and swelling contribute to localized ischemia, which produces pain upon movement or tactile stimulation. The sensations associated with DOMS have been described as burning and aching pain (Vecchiet et al., 1999).

Dependent variables of interest were the proportion reduction in weight lifted, and change in the proportion of repetitions within each set of strength exercises. On the basis of previous research, it was predicted that (a) pre-exercise scores on a measure of catastrophizing would be associated with pain experienced during the second bout of exercise, and (b) pre-exercise scores on a measure of catastrophizing would be associated with negative mood during the second bout of exercise. The central hypothesis being investigated was that pre-exercise scores on a measure of catastrophizing would be associated with physical intolerance as evidenced by reductions in weight lifted or reductions in number of repetitions.

2. Method

2.1. Participants

Fifty undergraduates (17 men, 33 women) participated in the research in exchange for course credit. Participants ranged in age from 17 to 48 years ($M = 21.1; SD = 6.9$). Individuals were selected for participation only if they had indicated that they engaged in physical exercise less than once per week. Participants were excluded if they were suffering from any musculoskeletal, cardiovascular, or systemic disorder that might be exacerbated by strenuous exercise (e.g. recent injury, chronic pain, heart disease). Participants were excluded if they endorsed any item on the Physical Activity Readiness Questionnaire contraindicating participation in the exercise protocol. These assessments were made in association with the informed consent procedure prior to any exercise.

2.2. Apparatus

2.2.1. Measures

2.2.1.1. Activity readiness. The Physical Activity Readiness Questionnaire (PAR-Q; Health Canada, 1998) is a seven-item self report screening measure of potential contraindications to participation in strenuous activity. The PAR-Q assesses the presence of any factors known to be associated with risk in exercise (e.g. fainting, shortness of breath, circulatory problems, muscle or joint problems). For the purposes of the present research, participants were excluded if they endorsed any item on the PAR-Q.
2.2.1.2. Catastrophizing. The Pain Catastrophizing Scale (PCS: Sullivan et al., 1995) was used to assess catastrophic thinking associated with pain. Respondents were asked to rate the frequency with which they experienced different pain-related thoughts or feelings on 5-point scales with the end points (0) not at all and (4) all the time. The PCS yields a total score and three subscale scores assessing rumination, magnification, and helplessness. The PCS subscales have been shown to have adequate to high internal consistency (Cronbach’s alphas: total PCS = 0.87, rumination = 0.87, magnification = 0.66, and helplessness = 0.78; Sullivan et al., 1995), and to correlate with interview-based methods of assessing catastrophic thinking (Sullivan et al., 1995, 2000).

2.2.1.3. Negative mood. Participants completed a brief measure of mood consisting of nine adjectives drawn from the Profile of Mood States (POMS; McNair et al., 1971). Participants rated the intensity of different moods they experienced on a 11-point scale with the endpoints (0) not at all and (10) extremely. Adjectives were chosen to represent three different mood categories: (1) sadness (sad, discouraged, hopeless); (2) anger (angry, hostile, irritable), and (3) anxiety (anxious, tense, worried). A composite score for negative mood was computed by summing all nine items of the mood scale. The internal consistency coefficient (Cronbach’s alpha; Cronbach, 1951) for the total scale was 0.81.

2.2.1.4. Pain. Participants made ratings of their current pain experience on a 6-point numerical rating scale with the anchors (0) no pain, (1) mild, (2) discomforting, (3) distressing, (4) horrible, and (5) excruciating. The scale was taken from the McGill Pain Questionnaire Present Pain Intensity scale (Melzack, 1975). Participants were also asked to indicate on a body drawing the different areas of the body where they experienced pain.

2.3. Procedure

Participants responded to an advertisement contained in a booklet describing all experiments for which introductory psychology students could participate for course credit. The advertisement for the present study indicated that participation involved engaging in a maximal repetition strength test under the supervision of a trained exercise professional on two separate occasions. Interested participants were asked to contact the study coordinator who provided them with more detailed information on the procedures associated with the study. During the initial telephone contact, participants were screened for inclusion criteria, which included, (1) being 17 years of age or older, (2) being healthy to the degree that maximal exercise testing and structured exercise would not exacerbate any existing health conditions, (3) being sedentary, defined as engaging in sport-related activities once or less per week (cf. Blair and Morrow, 1998), and (4) be willing to commit to the length of the study. Participants meeting these criteria were scheduled for testing. The entire participant sample was recruited over a 2-week period.

Participants were asked to complete the PAR-Q in order to ensure that they did not suffer from any condition that could be exacerbated by strenuous physical activity. On the basis of PAR-Q responses, four potential participants were excluded. An additional five participants were excluded for failure to attend the second exercise session. These participants were replaced in order to maintain a total sample of 50.

Prior to exercise, participants completed the PCS, and rated their current pain. Pain ratings were provided again at the end of the first exercise bout, and prior to the second exercise bout. Negative mood was also assessed prior to the second exercise bout.

2.3.1. Exercise protocol

The procedure used to induce DOMS consisted of five different strength exercises involving repeated concentric and eccentric muscle actions. Upon arrival at the testing facility, each participant completed a standardized warm-up that consisted of flexibility and aerobic exercises which lasted approximately 15 min. Following this warm-up, each participant completed a multiple repetition maximal (mRM) strength test that was comprised of five commonly used strength exercises (i.e. chest press, leg press, lat pull downs, leg flexion, and shoulder press), each being performed for three sets of 8–10 repetitions. Each exercise followed the same protocol that included the participant performing incrementally difficult sets of each resistance exercise until they reached the point of volitional fatigue with 8–10 repetitions on the third set. The relative intensity of this final set was 80% of the predicted one repetition max (i.e. the amount of weight the person could lift only one time) for each participant. The tempo for each repetition was prescribed at 1:2 so that each participant performed the lowering (eccentric) part of each exercise twice as long as the lifting (concentric) part. The emphasis on the eccentric portion of the strength exercise is known to induce DOMS.

Participants returned to the testing facility 48 h later and were put through the same exercise protocol. Of interest was whether the total load lifted (physical force) or the number of repetitions (physical endurance) completed in each set would be reduced as a result of pain symptoms induced by the previous exercise bout.

2.3.2. Data reduction

Two indices of activity intolerance were used. An index of ‘force deficit’ was computed as the proportion reduction in the total load lifted from the initial exercise bout to the exercise test period, averaged across all five exercises. An index of physical endurance was computed as the proportion reduction in exercise repetitions from the initial exercise
bout to the exercise test period, averaged across all five exercises.

3. Results

3.1. Descriptive statistics

Mean scores for catastrophizing, and indices of physical force and physical endurance are presented in Table 1, separately for men and women. Analysis of sex differences revealed no significant effects for catastrophizing, $t(48) = 0.13, \text{ns}$, or physical endurance, $r(48) = -1.1, \text{ns}$. Sex differences were found only for the index of physical force where men lifted significantly more weight during the exercise protocol than women, $r(48) = 5.8, P < 0.001$.

Table 2 presents means and standard deviations of measures of pain over the three time periods (i.e. Day 1 pre-exercise, Day 1 post-exercise, Day 2 pre-exercise). The exercise protocol resulted in a significant increase in pain intensity, $F(2, 98) = 10.2, P < 0.001$, and in number of pain sites, $F(2, 98) = 20.6, P < 0.001$. Tests of simple effects revealed that the increases in pain and number of pain sites occurred between the end of the first exercise bout and beginning of the second (see Table 2).

Correlational analyses addressing the association between catastrophizing and pain-related outcomes are presented in Table 3. Consistent with previous research, the total PCS was significantly correlated with pain intensity ratings. Correlations for Day 1 pre-exercise reflect the concurrent association between catastrophizing and (baseline) pain. Correlations for Day 1 post-exercise and Day 2 pre-exercise reflect the prospective association between catastrophizing and (exercise induced) pain.

Catastrophizing was significantly correlated with the index of physical force deficit (i.e. proportion reduction in total load lifted), but not with the index of physical tolerance (i.e. decrement in number of repetitions). In other words, catastrophic thinking was associated with a reduction in total weight lifted but not in the number of times the weights were lifted. Catastrophizing was not significantly correlated with total load lifted or the number of repetitions for the first exercise bout.

3.2. Prediction of physical force deficit

A hierarchical regression analysis was conducted to address the predictive role of catastrophizing as a determinant of physical force deficit. Catastrophizing was entered in the third step of the analysis, after controlling for pain (Day 2 pre-exercise) and negative mood. As shown in Table 4, pain was marginally associated with physical force deficit, $R^2 = 0.06, P < 0.07$. In the second step of the analysis, negative mood was entered but did not contribute significant variance to the prediction of physical force deficit, $R^2$ change $= 0.01, \text{ns}$. The PCS total score was entered in the final step of the analysis, and contributed an additional 10% of the variance to the prediction of physical force deficit, $P < 0.01$.

A follow-up stepwise regression was conducted to explore the differential predictive value of the three subscales of the PCS. In this analysis, the rumination, magnification and helplessness subscales were allowed to compete for entry in the regression analysis. The helplessness subscale entered in the first step of the analysis, $R^2 = 14, F(1, 48) = 8.1, P < 0.01$. Neither the rumination or magnification subscales met minimal criterion ($P = 0.05$) for entry into the analysis.

4. Discussion

The primary objective of this research was to determine whether a measure of catastrophizing could be used to predict activity intolerance related to pain. The impetus for the research was the apparent dearth of available
evidence linking catastrophizing, prospectively, to objective indices of physical function. The results of the present study suggest that catastrophizing is associated with an objectively defined physical force deficit consequent to pain.

The relation between catastrophizing and physical force deficit appears to be specific to activity associated with pain. There was no significant relation between catastrophizing and maximum load or repetitions during the first exercise bout. It can be inferred from these analyses that catastrophizing, in the absence of pain, is not associated with impaired physical function or with reduced motivation to perform physical maneuvers. However, under conditions where movement is associated with pain, catastrophizing appears to contribute to a reduction in the maximal weight that participants are able or willing to lift.

The findings of the present study suggest that the experience of pain may be a significant contextual factor determining the manner in which catastrophizing will influence behaviour. As noted, catastrophizing was unrelated to physical endurance or force output during the first exercise bout. This finding is consistent with our previous research showing that catastrophizing is not significantly associated with the degree to which individuals are involved in regular exercise or sporting activity (Sullivan et al., 2000). In other words, when not experiencing pain, individuals who catastrophize do not appear to avoid activities that could potentially result in pain. However, when physical movement was performed while experiencing pain, individuals high in catastrophizing significantly reduced their physical output. Pain sensations may have triggered specific worries about producing further pain, or self-defeating cognitions about the ability to cope effectively with the pain. It is possible that the behavioural correlates of catastrophizing may only be evident in situations associated with the experience of pain.

The view that characteristics of the individual interact with characteristics of a stress situation to yield pain-related outcomes has been discussed within the context of ‘diathesis-stress’ formulations of pain (Banks and Kerns, 1996; Kerns and Jacob, 1997). These models suggest that vulnerability factors (i.e. diatheses) are most likely to yield negative outcomes when challenged by vulnerability-relevant contextual factors (i.e. stresses) (Beck et al., 1978; Lazarus and Folkman, 1984; Rudy et al., 1988; Jensen et al., 1991; Banks and Kerns, 1996; Thorn et al., 2002). Although considerable research has been conducted to elucidate the vulnerability factors associated with pain-related disability, the role of vulnerability-relevant contextual factors has not been systematically investigated. The present findings suggest that pain experience may be a vulnerability-relevant contextual factor that contributes to the behavioural expression of pain catastrophizing.

The different dimensions of catastrophizing have been discussed within the framework of Lazarus and Folkman’s (1984) transactional model of stress and coping. Within this framework, primary appraisals refer to the evaluation of threat associated with a particular condition, and secondary appraisals refer to the individual’s evaluation of his or her

Table 3
Correlations between PCS subscales and pain, mood, and force and endurance indices

<table>
<thead>
<tr>
<th>Variables</th>
<th>PCSTotal</th>
<th>Rumin</th>
<th>Magni</th>
<th>Helps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain day 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-exercise</td>
<td>0.46**</td>
<td>0.29*</td>
<td>0.42*</td>
<td>0.46**</td>
</tr>
<tr>
<td>Post-exercise</td>
<td>0.30*</td>
<td>0.12</td>
<td>0.35*</td>
<td>0.34*</td>
</tr>
<tr>
<td>Pain day 2 (pre-exercise)</td>
<td>0.35*</td>
<td>0.23</td>
<td>0.35*</td>
<td>0.33*</td>
</tr>
<tr>
<td>NegMood day 2 (pre-exercise)</td>
<td>0.40**</td>
<td>0.24</td>
<td>0.39**</td>
<td>0.40**</td>
</tr>
<tr>
<td>Proportion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load reduction</td>
<td>0.40**</td>
<td>0.34*</td>
<td>0.26</td>
<td>0.38**</td>
</tr>
<tr>
<td>Rep reduction</td>
<td>0.01</td>
<td>-0.60</td>
<td>-0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>Day 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load lifted</td>
<td>-0.06</td>
<td>-0.04</td>
<td>-0.07</td>
<td>-0.10</td>
</tr>
<tr>
<td>Repetitions</td>
<td>-0.10</td>
<td>-0.08</td>
<td>-0.08</td>
<td>-0.09</td>
</tr>
</tbody>
</table>

Note: PCSTotal, Pain, Catastrophizing Scale, Total Score; Rumin, PCS Rumination; Magni, PCS Magnification; Helps, PCS Helplessness. *P < 0.05, **P < 0.01, N = 50.
ability to deal effectively with the stressful condition. It has been suggested that the different components of catastrophizing may reflect primary and secondary appraisal processes associated with coping with pain (Sullivan et al., 1995, 2001). In particular, magnification and rumination may be related to primary appraisal processes where individuals may focus on and exaggerate the threat value of a painful stimulus. Helplessness has been discussed as a secondary appraisal process where individuals negatively evaluate their ability to deal effectively with painful stimuli.

A question of interest in this research concerns the processes by which catastrophizing impacts on behaviour. Based on previous research, the mediational role of pain intensity and negative mood were examined (Sullivan et al., 2001). The relation between catastrophizing and physical force deficit remained significant even when controlling for level of pain and negative mood experienced during the second exercise bout. This finding parallels previous work on catastrophizing and disability. For example, in a study on the determinants of pain-related disability, Sullivan et al. (1998) reported that catastrophizing was significantly correlated with self-reported disability even when controlling for pain severity and depression. Similarly, Martin et al. (1996) found that catastrophizing was associated with self-reported disability in a sample of patients with fibromyalgia, even when controlling for disease severity and neuroticism.

A number of clinical investigators have noted that pain severity accounts for only a modest degree of variance in pain-related disability, typically less than 10% (Jensen et al., 1999; Sullivan et al., 1998, 2002; Turner et al., 2000, Waddell, 1998). An association of similar magnitude was observed in the present study. As in previous clinical research, catastrophizing was a stronger predictor of pain-related disability than pain itself (Sullivan et al., 2001; Vlaeyen and Linton, 2000). It appears therefore, that even under experimental conditions that are devoid of help-seeking or compensation driven biases in symptom reporting, psychological factors remain important, and independent determinants of pain-related activity limitation.

A follow-up regression analysis indicated that the helplessness subscale was the best predictor of physical force deficit. The items of the helplessness subscale reflect beliefs about the inability to effectively manage the experience of pain (e.g. ‘There is nothing I can do to reduce the intensity of the pain’, or ‘It’s awful and I feel it overwhelms me’). The items of the helplessness subscale have been shown to correlate inversely with questions assessing self-efficacy (Rosenstiel and Keefe, 1983). To date, research has focused primarily in the processes that might underlie the relation between the rumination subscale of the PCS and pain-related outcomes, and little or no attention has been given to how helplessness might impact on pain-related outcomes (Sullivan et al., 2001). One possibility is that helplessness cognitions might impact on the individual’s confidence in his or her ability to perform certain physical tasks, and in turn, reduce the degree of effort invested in the performance of these tasks (e.g. Bandura, 1986). One of the challenges of future research will be to address further the processes by which catastrophizing influences behaviour.

The present findings suggest that catastrophizing may be a risk factor for heightened pain and pain-related disability. Catastrophizing does not appear to be simply a cognitive or emotional reaction to pain. Catastrophizing, measured in a pain-free state predicts pain response to aversive stimulation (Sullivan and Neish, 1999), and catastrophizing is associated with pain-related outcomes, independent of level of pain (Keefe et al., 1989; Sullivan et al., 1998). In other words, the antecedent status of catastrophizing, in relation to pain and pain-related disability is becoming more firmly established. However, the antecedent status of catastrophizing does not imply that catastrophizing is causally related to pain outcomes. Prospective designs of the kind used in this research are subject to many of the interpretive constraints of other types of correlational designs.

Although the present research avoided some of the interpretive limitations of previous research, experimental research comes with its own set of interpretive limitations. The participants in the present research were much younger than individuals who seek help for pain-related conditions. In addition, the pain associated with delayed onset muscle soreness is considerably less intense, and has much lower threat value than the pain associated with many illnesses or aversive medical procedures. Selection biases associated with volunteer participation in a long and physically challenging research study may have also influenced the composition of the sample. For example, the absence of the frequently reported sex differences in pain or catastrophizing suggests that selection biases may have impacted on the composition of the sample. Activity involvement is greater for university men than women, and the use of sedentary individuals may have excluded men with lower levels of catastrophizing (Sullivan et al., 2000). These factors caution against liberal generalization of the findings.

As research accumulates demonstrating that psychological factors are important determinants of pain-related disability, there has been an increasing need for paradigms that can provide a useful forum for addressing how psychological variables impact on physical activity. While a number of experimental paradigms have emerged to address the psychology of pain experience, these paradigms are limited in their ability to address questions concerning the psychology of disability. Although experimental research must face the challenge of ecological relevance, it affords a degree of control that can rarely be achieved in naturalistic settings. In spite of its limitations, the effect sizes of the relations between catastrophizing, pain and force deficit were in the medium range suggesting that they may have meaningful real world implications. In addition, the pain intensity associated with the DOMS procedure is similar in magnitude to that observed in clinical samples of neuropathic pain patients, and slightly lower than that observed in samples of low back pain patients (Melzack, 1975). Future research may
reveal that DOMS paradigms provide a useful analog to pain-related disability that can permit examination of the mechanisms by which psychological variables contribute to emotional and behavioural responses to pain.

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